Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)

1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)

1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)

1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)

1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)

1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

The following list of formulae may be found useful :

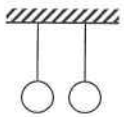
Coulomb's law	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
Electric field strength due to a point charge	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
Electric field between parallel plates (numerically)	$E = \dfrac{V}{d}$

Use the following data wherever necessary :

Acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
Charge of electron	$e = 1.6 \times 10^{-19}$ C
Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$

Part A : HKCE examination questions

1. **< HKCE 1981 Paper II - 26 >**

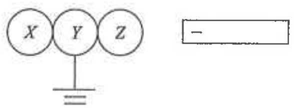


Two light conducting spheres are suspended from two silk threads as shown. If they are found to attract one another, which one of the following conclusions is/are correct ?

(1) They carry similar charges.
(2) They carry opposite charges.
(3) Only one of them is charged.

A. (2) only
B. (3) only
C. (1) & (3) only
D. (2) & (3) only

2. **< HKCE 1982 Paper II - 35 >**

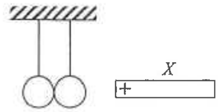


Three metal spheres X, Y and Z are placed in contact as shown. A negatively charged rod is brought near Z. The sphere Y is then earthed while the charged rod is still nearby. Which of the following statements is/are true ?

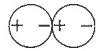
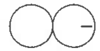
(1) X is negatively charged.
(2) Y is neutral.
(3) Z is positively charged.

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

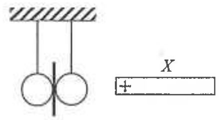
3. **< HKCE 1984 Paper II - 24 >**



Two uncharged metal spheres in contact are suspended by dry cotton threads. When a positively charged rod X is brought near them as shown above, the distribution of charges on the spheres will be

A. 
B. 
C. 
D. 

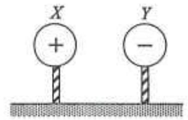
4. **< HKCE 1985 Paper II - 33 >**



Two uncharged metal spheres are suspended by insulating threads as shown in the diagram. A plastic sheet is put between them. When a positively charged rod X is brought near them as shown, which of the following diagrams shows the resulting charge distribution of the spheres ?

A. 
B. 
C. 
D. 

5. **< HKCE 1986 Paper II - 28 >**

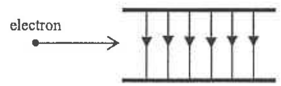


The diagram shows two conducting spheres X and Y mounted on insulating stands. Sphere X carries positive charges and sphere Y carries negative charges. As Y is moved slowly towards X (but without touching X) the total charges on X

A. increase and are positive.
B. remain unchanged.
C. become negative.
D. disappear.

6. **< HKCE 1987 Paper II - 37 >**

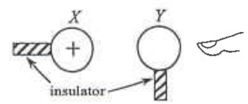
In the figure shown, an electron travels in a horizontal direction and enters a uniform electric field. The direction of the electric field is as shown. What is the direction of the force due to the electric field acting on the electron ?



A. upwards
B. downwards
C. into the page
D. out of the page

7. **< HKCE 1988 Paper II - 28 >**

A positively charged metal sphere X is brought near an uncharged metal sphere Y as shown. Y is then touched momentarily with a finger. X is then taken away. Y is now



A. positively charged.
B. negatively charged.
C. negatively charged on the left side and positively charged on the right side.
D. positively charged on the left side and negatively charged on the right side.

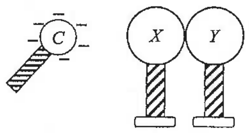
8. < HKCE 1990 Paper II - 30 >

A positively-charged metal sphere is mounted on an insulating stand. When the sphere is earthed with a finger,

A. protons will move from the sphere to the earth.
B. protons will move from the earth to the sphere.
C electrons will move from the sphere to the earth.
D. electrons will move from the earth to the sphere.

9. < HKCE 1991 Paper II - 29 >

In the figure shown, X and Y are two insulated metal spheres in contact with each other. A negatively charged object C is brought near X. X is touched momentarily with a finger, and then X and Y are separated. The charges on X and Y are

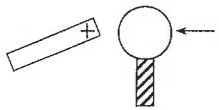


	Sphere X	Sphere Y
A.	positive	positive
B.	positive	negative
C.	negative	negative
D.	positive	zero

10. < HKCE 1992 Paper II - 30 >

A positively charged rod is brought near an insulated uncharged metal sphere as shown in the figure. If the sphere is earthed with a finger,

A. positive charges flow from the earth to the sphere.
B. electrons flow from the earth to the sphere.
C. electrons flow from the sphere to the earth.
D. the sphere is completely discharged.



11. < HKCE 1993 Paper II - 31 >

An uncharged light conducting sphere is suspended by an insulating thread. The metal dome of an operating Van de Graaff generator is brought near the sphere. Which of the following statements best describes the motion of the sphere ?

A. The sphere remains stationary.
B. The sphere moves away from the dome.
C. The sphere moves towards the dome, touches it and remains there.
D. The sphere moves towards the dome, touches it and then moves away.

12. < HKCE 1994 Paper II - 25 >

Which of the following involve(s) the application of electrostatics ?

(1) A photocopier
(2) A precipitator in the chimney of a coal-fired power station
(3) A Van de Graaff generator

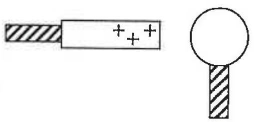
A. (3) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

13. < HKCE 1994 Paper II - 24 >

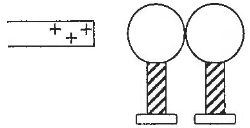
An insulated charged metal rod is brought near an insulated uncharged metal sphere as shown in the figure. Which of the following can charge the sphere ?

(1) Touching the sphere momentarily with a finger.
(2) Touching the sphere momentarily with the rod.
(3) Touching the rod momentarily with a finger and then touching the sphere momentarily with the same finger.

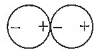
A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

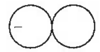


14. < HKCE 1995 Paper II - 29 >



Two insulated uncharged metal spheres X and Y are in contact with each other. A positively charged rod is brought near X as shown above. Which of the following diagrams correctly shows the distribution of charges on the spheres ?

A. 

B. 

C. 

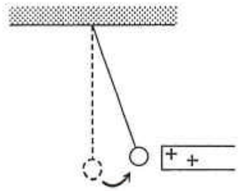
D. 

15. < HKCE 1996 Paper II - 29 >

A small conducting sphere is suspended by an insulated thread. When a positively charged rod is brought near the sphere, the sphere is attracted as shown. Which of the following is/are reasonable deduction(s) ?

(1) The sphere may carry a positive charge.
(2) The sphere may carry a negative charge.
(3) The sphere may be neutral.

A. (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)



16. < HKCE 1997 Paper II - 27 >

The following are the steps to charge an isolated metal sphere by induction, but they are in the wrong order.

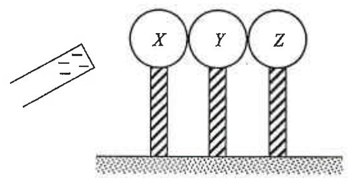
(1) Removing the finger away from the metal sphere.
(2) Touching the metal sphere with a finger.
(3) Bringing a positively charged rod near the metal sphere.
(4) Removing the positively charged rod away from the metal sphere.

Which of the following shows the correct order ?

A. (2), (3), (4), (1)
B. (3), (2), (1), (4)
C. (3), (2), (4), (1)
D. (3), (4), (2), (1)

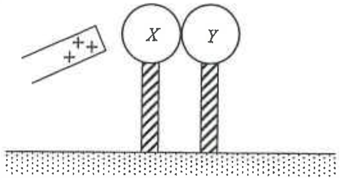
17. < HKCE 1998 Paper II - 29 >

Three insulated uncharged metal spheres X, Y and Z are placed in contact as shown. A negatively charged rod is brought near X and sphere Y is then earthed momentarily. If the charged rod is still near X, which of the following describes the charges on X, Y and Z ?



	Sphere X	Sphere Y	Sphere Z
A.	positive	zero	zero
B.	positive	zero	negative
C.	positive	positive	positive
D.	zero	zero	zero

18. **< HKCE 2000 Paper II - 28 >**



Two insulated uncharged metal spheres X and Y are placed in contact. A positively-charged rod is brought near X as shown above. X is then earthed momentarily. The charged rod is removed and the two spheres are then separated. Which of the following describes the charges on X and Y ?

	Sphere X	Sphere Y
A.	negative	negative
B.	negative	uncharged
C.	positive	positive
D.	uncharged	uncharged

19. **< HKCE 2001 Paper II - 28 >**

Two charged spheres A and B hanging at a point on a ceiling by two identical nylon threads. They remain at rest as shown above. Which of the following statements must be correct ?

(1) Both spheres carry positive charges.
(2) The force acting on B by A is larger than the force acting on A by B.
(3) The mass of A is larger than B.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

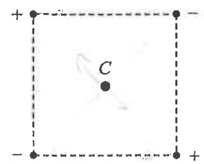
20. **< HKCE 2002 Paper II - 31 >**

A plastic ruler is placed close to a stream of running water coming from an insulated tap. The stream of water is attracted towards the ruler as shown above. Which of the following statements are correct ?

(1) The ruler carries an electric charge.
(2) The ruler and the running water are attracting each other with forces of equal magnitude.
(3) Both positive and negative charges are induced on the running water

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

21. **< HKCE 2003 Paper II - 31 >**



Four point charges of equal magnitude are placed at the four vertices of a square. The signs of the charges are as shown. A point charge C is placed at the centre of the square. What will be the direction of the resultant electrostatic force, if any, acting on C ?

A. →
B. ↑
C. The resultant force acting on C is zero.
D. It cannot be determined since the sign of C is not given.

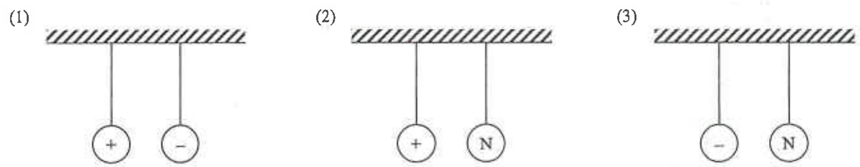
22. **< HKCE 2004 Paper II - 27 >**

Three conducting spheres are suspended by separate nylon threads. When any two of them are brought near each other, they attract each other. Which of the following deductions is correct ?

A. All three spheres are charged.
B. Only one sphere is charged and the other two are uncharged.
C. One sphere is uncharged and the other two carry like charges.
D. One sphere is uncharged and the other two carry unlike charges.

23. **< HKCE 2005 Paper II - 17 >**

Two conducting spheres are hanging freely in air by insulating threads. In which of the following will the two spheres attract each other ? Note : 'N' denotes that the sphere is uncharged.



A. (1) only
B. (2) only
C. (3) only
D. (1), (2) & (3)

24. **< HKCE 2006 Paper II - 22 >**

A rubbed plastic ruler can attract paper scraps before actually touching them. Which of the following descriptions about the charges on the rubbed ruler and the original charges on the paper scraps are possible ?

(1) The ruler and the paper scraps carry opposite charges.
(2) Both the ruler and the paper scraps are uncharged.
(3) The ruler carries charges and the paper scraps are uncharged.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

25. **< HKCE 2007 Paper II - 19 >**

In the above figures, P, Q, R and S are identical light conducting spheres and they are hanging freely by insulating threads of the same length. Which of the following deductions is/are correct ?

(1) P and Q must carry like charges.

(2) R and S must carry unlike charges.

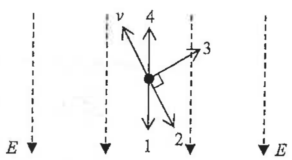
(3) P and Q must carry the same amount of net charges.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

Part B : HKAL examination questions

26. **< HKAL 1982 Paper I - 27 >**

The diagram shows a negative charged particle inside a uniform electric field E pointing in downward direction. At the instant shown, the particle is travelling in the direction of the arrow v. Which of the arrows 1 to 4 gives the direction of the acceleration of the particle at this instant ?



A. 1
B. 2
C. 3
D. 4

27. **< HKAL 1983 Paper I - 20 >**

Two parallel metal plates are placed horizontally with a separation of 0.05 m. A voltage of 2000 V is connected across the plates. An oil drop carrying a charge of -1.6×10^{-19} C is found to be at rest between the plates. Find the mass of the drop.

(Take the acceleration due to gravity to be 10 m s^{-2}.)

A. 1.6×10^{-18} kg.
B. 1.6×10^{-16} kg.
C. 6.4×10^{-14} kg.
D. 6.4×10^{-16} kg.

28. **< HKAL 1983 Paper I - 40 >**

Which of the following statements about the coulomb is/are correct ?

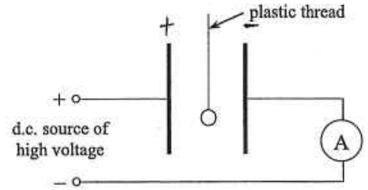
(1) When one coulomb of positive charges flows across a potential difference of one volt from higher to lower potential, one joule of electrical energy is given out.

(2) The force exerted on a charge of 1 coulomb in an electric field of 1 volt per metre is 1 newton.

(3) One coulomb is the total charge of one mole of electrons.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

29. **< HKAL 1985 Paper I - 45 >**



A light conducting ball is placed between two metal plates connected through an ammeter to a d.c. source of high voltage. The ball shuttles back and forth between the plates, making alternate contacts with each plate. Which of the following statements are correct ?

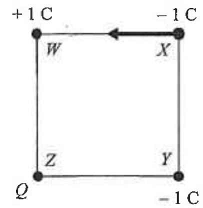
(1) The ball carries charges, sometimes positive, and sometimes negative.

(2) If the separation of the metal plates increases, the frequency of oscillation of the ball decreases.

(3) The galvanometer shows a current flowing always in the same direction.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

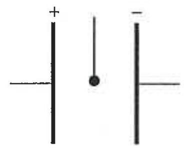
30. **< HKAL 1987 Paper I - 30 >**



Three charge +1 C, −1 C and −1 C are fixed at the corners W, X and Y respectively of a square as shown. A fourth charge, Q, is fixed at Z. If the net electrostatic force acting on the charge at X is indicated by the arrow, what is the magnitude of Q ?

A. $-\sqrt{2}$ C
B. $+\sqrt{2}$ C
C. $-2\sqrt{2}$ C
D. $+2\sqrt{2}$ C

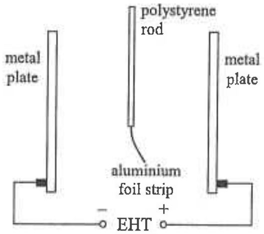
31. **< HKAL 1990 Paper I - 27 >**



A light conducting sphere is hanged from a long insulating thread. It is placed between two oppositely charged metal plates connected to a high voltage supply. If the sphere is given a negative charge, it will

A. move to the positive plate and stick to it.
B. move to the negative plate and stick to it.
C. oscillate, touching each plate in turn, beginning with the positive plate.
D. oscillate, touching each plate in turn, beginning with the negative plate.

32. < HKAL 1993 Paper I - 35 >



Two parallel metal plates are connected to the terminal of an EHT. When a charged aluminium foil strip is placed between the plates, the deflection of the foil is shown in the above figure. Which of the following statements is/are correct ?

(1) The charge on the foil is negative.
(2) If the separation between the two plates decreases, the deflection of the foil increases.
(3) When moving the foil towards the positive plate, the deflection of the foil increases.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

33. < HKAL 2000 Paper IIA - 26 >

Two parallel plates are connected to an E.H.T. supply giving a d.c. voltage of 4.5 kV. If the separation of the two plates is set at 1.5 mm, calculate the acceleration of an electron placed inside the plates.

A. 1.0×10^{9} m s^{-2}
B. 1.2×10^{12} m s^{-2}
C. 1.6×10^{15} m s^{-2}
D. 5.3×10^{17} m s^{-2}

34. < HKAL 2003 Paper IIA - 23 >

The magnitudes of the charges on two identical small metal spheres are in the ratio 5 : 1. The electrostatic force between them is F_1. If they are brought into contact and then separated to their respective original positions, the electrostatic force between them becomes F_2. Which of the following may be the magnitude of the ratio $F_1 : F_2$?

(1) 5 : 9
(2) 5 : 4
(3) 5 : 2

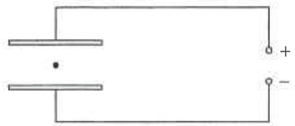
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

35. < HKAL 2005 Paper IIA - 12 >

X, Y and Z are small identical metal spheres. X and Y are fixed at a certain separation in air and they carry charges of the same magnitude. The attractive force between them is F. Sphere Z is initially uncharged. It first touches X and then it touches Y. What is the electrostatic force between X and Y after Z is taken away ?

A. $\frac{1}{4}F$
B. $\frac{1}{8}F$
C. $\frac{3}{4}F$
D. $\frac{3}{8}F$

36. < HKAL 2005 Paper IIA - 13 >

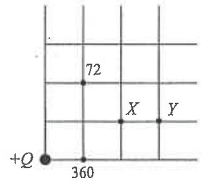


A negatively charged oil drop is kept stationary between two horizontal metal plates connected to a d.c. supply as shown. The oil drop then acquires an additional negative charge. Which of the following changes will be able to hold the oil drop stationary ?

(1) Disconnecting the plates from the supply and moving the plates closer
(2) Keeping the separation between the plates unchanged and increasing the p.d. between the plates
(3) Keeping the p.d. between plates unchanged and moving the plates further apart.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

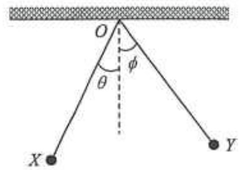
37. < HKAL 2007 Paper IIA - 14 >



The above figure gives the electric field strength (in arbitrary units) at various points near an isolated point charge $+Q$. Which of the following correctly gives the electric field strength (in the same arbitrary units) at X and at Y ?

	electric field strength at X	electric field strength at Y
A.	72	30
B.	72	36
C.	90	30
D.	90	36

38. < HKAL 2007 Paper IIA - 13 >



The figure shows two small charged spheres X and Y suspended by identical nylon threads from a fixed point O. At equilibrium, the threads OX and OY make angles θ and ϕ ($\theta < \phi$) with the vertical. Which of the following conclusions must be correct ?

(1) Both X and Y carry positive charges.
(2) The charge on X is greater than that on Y in magnitude.
(3) The mass of X is greater than that of Y.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

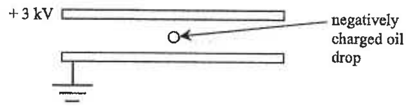
39. < HKAL 2008 Paper IIA - 14 >

A point charge $+Q$ is fixed at point X while another point charge $-2Q$ is fixed at point Y as shown. E_X and E_Y denote the magnitude of the electric field due to the point charge at X and Y respectively. For the points on the line passing through X and Y, how many of them has/have $E_X = E_Y$ and how many has/have zero resultant electric field ?
(No need to consider the points at infinity.)

A. There are 3 points with $E_X = E_Y$ and the resultant field is zero at 2 of them.
B. There are 2 points with $E_X = E_Y$ and the resultant field is zero at both of them.
C. There are 2 points with $E_X = E_Y$ and the resultant field is zero at 1 of them.
D. There is 1 point with $E_X = E_Y$ and the resultant field is zero at that point.

40. < HKAL 2009 Paper IIA - 33 >

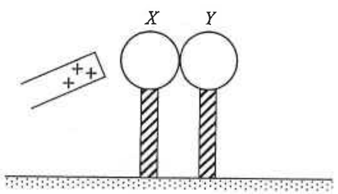
A potential difference of 3 kV is applied across two horizontal metal plates of separation 1.5 cm. A charged oil drop of mass 9.6×10^{-15} kg is kept stationary between the plates as shown. Find the quantity of charge acquired by the oil drop ?
(Take the acceleration due to gravity as 10 m s^{-2}.)



A. 1.6×10^{-19} C
B. 3.2×10^{-19} C
C. 4.8×10^{-19} C
D. 6.4×10^{-19} C

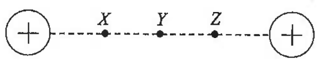
Part C : Supplemental exercise

41. Two insulated uncharged metal spheres X and Y are placed in contact. A positively-charged rod is brought near X as shown. X is then earthed momentarily. The charged rod is then removed. Which of the following describes the charges on X and Y ?



	Sphere X	Sphere Y
A.	negative	negative
B.	negative	uncharged
C.	positive	positive
D.	uncharged	uncharged

42.

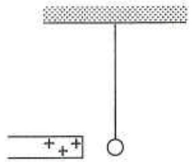


Two identical spheres carrying equal amount of positive charges are placed as shown in the figure above. Which of the following statements are correct ?

(1) At the mid-point Y between the two spheres, it is a neutral point.
(2) If a small negative charge is placed at point X, it experiences a net electric force towards the left.
(3) If a small positive charge is placed at point Z, it experiences a net electric force towards the right.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

43.

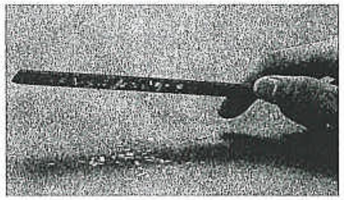


A small neutral conducting sphere is suspended by an insulated thread. When a positively charged metal rod is brought near the sphere, which of the following consequences are correct ?

(1) The sphere is attracted by the charged rod due to the induced charge on the sphere.
(2) The sphere is repelled from the charged rod after touching the charged rod.
(3) The sphere finally carries positive charge.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

44.

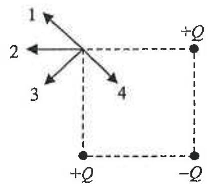


When a plastic ruler is placed close to pieces of small paper, some of them are found to be attracted towards the ruler. Which of the following statements is/are correct ?

(1) The attraction is due to the electric force between the ruler and the pieces of paper.
(2) Those pieces of paper attracted by the ruler remain neutral.
(3) The attraction acting on each piece of paper is greater than the attraction acting on the ruler by that piece of paper.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

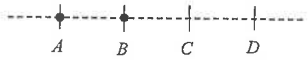
45.



Point charges, each of magnitude Q, are placed at three corners of a square as shown in the diagram. What is the direction of the resultant electric field at the fourth corner ?

A. Direction 1
B. Direction 2
C. Direction 3
D. Direction 4

46.



A, B, C, D are four points on a straight line as shown in the diagram. A point charge $+Q$ is fixed at A. When another point charge $-Q$ is moved from B to C, which of the following statements is/are correct ?

(1) The electrostatic force between the two charges increases.

(2) The magnitude of the electric field strength at the point D increases.

(3) Point B becomes the neutral point.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

47. The charge on the uranium nucleus is 1.5×10^{-17} C and the charge on the α-particle is 3.2×10^{-19} C. What is the electrostatic force between a uranium nucleus and an α-particle separated by 1.0×10^{-13} m ?

A. 4.32×10^{-33} N

B. 4.32×10^{-20} N

C. 4.32×10^{-13} N

D. 4.32 N

48. What is the magnitude of the electric field strength at a distance r from an isolated stationary nucleus of proton number (atomic number) Z ?

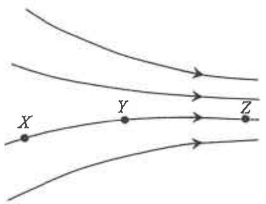
A. $\dfrac{Ze}{4\pi\varepsilon_0 r}$

B. $\dfrac{(Ze)^2}{4\pi\varepsilon_0 r^2}$

C. $\dfrac{Ze}{4\pi\varepsilon_0 r^2}$

D. $\dfrac{Ze^2}{4\pi\varepsilon_0 r}$

49.



The diagram shows a pattern of electric field lines in which X, Y and Z are points marked on one of the field lines. It would be correct to say that

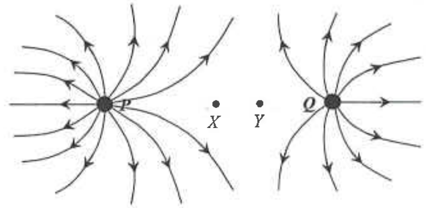
(1) the electric field at X is weaker than that at Z.

(2) a negative charge placed at Z would experience an electric force to the left along the tangent of the field line at Z.

(3) the force exerted on a charge at Y would be greater than if the charge were placed at X.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

50.



The above figure shows the electric field pattern around two point charges P and Q. X is the mid-point between P and Q. Y is a neutral point. Which of the following deductions is/are correct ?

(1) Both charges P and Q are positive.

(2) The magnitude of charge P is greater than that of Q.

(3) The electrostatic force acting on Q by P is greater than that on P by Q.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

51. A charged particle is accelerated across the gap between two parallel plates connected to a constant voltage supply. Neglect the effect of gravity, the kinetic energy gained by the particle in crossing the gap depends on

(1) the mass of the charged particle

(2) the separation between the two parallel plates

(3) the voltage across the two parallel plates

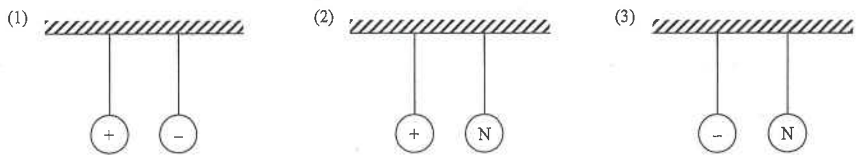
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part D : HKDSE examination questions

52. **< HKDSE Sample Paper IA - 24 >**

Two conducting spheres are hanging freely in air by insulating threads. In which of the following will the two spheres attract each other ?

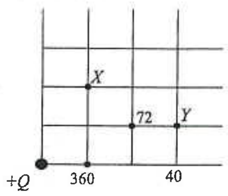
Note : 'N' denotes that the sphere is uncharged.



A. (1) only
B. (2) only
C. (3) only
D. (1), (2) & (3)

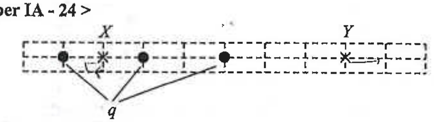
53. < HKDSE Sample Paper IA - 32 >

The figure shows the location of an isolated charge of size $+Q$. The magnitude of the electric field strength is marked at certain points. What is the magnitude of the electric field strength at X and Y ?



	electric field strength at X	electric field strength at Y
A.	72	30
B.	72	36
C.	90	30
D.	90	36

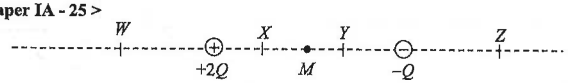
54. < HKDSE Practice Paper IA - 24 >



Three identical point charges q (represented by dots) are situated in the space as shown. Which of the following descriptions about the direction and magnitude of the electric field E at X and at Y is correct ?

	Direction	Magnitude
A.	Same	$E_X > E_Y$
B.	Same	$E_X < E_Y$
C.	Opposite	$E_X > E_Y$
D.	Opposite	$E_X < E_Y$

55. < HKDSE 2012 Paper IA - 25 >



Two point charges $+2Q$ and $-Q$ are situated at fixed positions as shown. M is the mid-point between the charges. W, X, Y and Z are points marked on the line joining these two charges. At which point could the resultant electric field due to the two charges be zero ?

A. W
B. X
C. Y
D. Z

56. < HKDSE 2012 Paper IA - 24 >

P, Q, R, S are charged objects. When two of them are brought close to each other, P and Q repel, R and S also repel while Q and R attract each other. Which of the following descriptions about their charges is/are correct ?

(1) P and R are negatively charged.
(2) Q and S are positively charged.
(3) P is positively charged and S is negatively charged.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

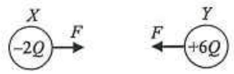
57. < HKDSE 2013 Paper IA - 25 >

Lightning flash may occur when the strength of the electric field (assumed uniform) between a thundercloud and the ground reaches 3×10^6 N C^{-1}. A lightning flash on average discharges about 20 C of charge. If a thundercloud is at a height of 500 m above the ground, estimate the order of magnitude of the energy released in a lightning flash.

A. 10^6 J
B. 10^8 J
C. 10^{10} J
D. 10^{12} J

58. < HKDSE 2013 Paper IA - 24 >

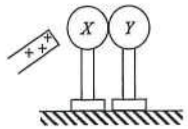
X and Y are two small identical metal spheres carrying charges $-2Q$ and $+6Q$ respectively. When X and Y are separated by a certain distance, the magnitude of the electrostatic force between them is F.



The spheres are brought to touch each other and then placed back to their original positions. The electrostatic force between them becomes

A. $\frac{1}{4}F$, attractive
B. $\frac{1}{4}F$, repulsive
C. $\frac{1}{3}F$, attractive
D. $\frac{1}{3}F$, repulsive

59. < HKDSE 2014 Paper IA - 20 >

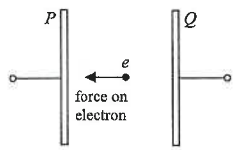


Two insulated uncharged metal spheres X and Y are placed in contact. A positively-charged rod is brought near X as shown. X is then touched by a finger momentarily and the two spheres are then separated by removing Y. The charged rod is removed afterwards. Which of the following describes the charges on X and Y ?

	sphere X	sphere Y
A.	uncharged	uncharged
B.	uncharged	positive
C.	negative	uncharged
D.	negative	negative

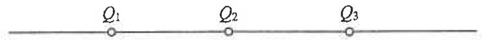
60. < HKDSE 2014 Paper IA - 22 >

Two parallel metal plates P and Q are maintained at a certain p.d. by a battery (not shown in the figure). An electron placed between the plates would experience an electrostatic force of 8.0×10^{-18} N towards P. Which of the following descriptions about the electric field E between the plates is correct ?



A. $E = 0.02$ N C^{-1} from Q to P
B. $E = 0.02$ N C^{-1} from P to Q
C. $E = 50$ N C^{-1} from Q to P
D. $E = 50$ N C^{-1} from P to Q

61. < HKDSE 2014 Paper IA - 21 >



Three point charges Q_1, Q_2 and Q_3 are fixed on a straight line with Q_2 at the mid-point of Q_1 and Q_3. The resultant electrostatic force on each charge is zero. Which of the following can be the sign and the magnitude (in the same arbitrary units) of Q_1, Q_2 and Q_3 ?

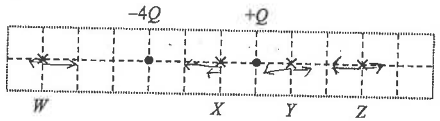
	Q_1	Q_2	Q_3
A.	+2	+1	+2
B.	+2	−1	+2
C.	−4	+1	+4
D.	−4	+1	−4

62. < HKDSE 2015 Paper IA - 21 >

Three conducting balls are suspended by insulating threads. Any two of them are found to attract each other if brought close to each other. Which conclusion below is correct ?

A. Only one ball is uncharged while the other two carry like charges.
B. Only one ball is uncharged while the other two carry unlike charges.
C. Only one ball is charged.
D. All three balls are charged.

63. < HKDSE 2015 Paper IA - 22 >



Two point charges $-4Q$ and $+Q$ are fixed as shown. At which point indicated in the figure is the resultant electric field due to these two charges zero ?

A. W
B. X
C. Y
D. Z

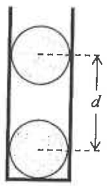
64. < HKDSE 2016 Paper IA - 24 >

Point charges $+4Q$ and $+Q$ are fixed on the x-axis with $+4Q$ at the origin O and $+Q$ at x = 15 cm as shown. The respective electric fields due to the two charges are equal at

A. x = 10 cm.
B. x = 12 cm.
C. x = 20 cm.
D. x = 30 cm.

65. < HKDSE 2017 Paper IA - 22 >

In the figure, two charged conducting spheres of the same mass m are put in a vertical plastic cylinder. The inner wall of the cylinder is smooth. The spheres are separated by a distance d and remain in equilibrium.



Which of the following statements **MUST BE** correct ?

(1) Both spheres carry positive charges.
(2) The amount of charges on the two spheres are the same.
(3) The separation d depends on m.

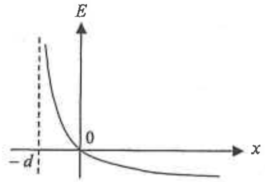
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

66. < HKDSE 2017 Paper IA - 23 >

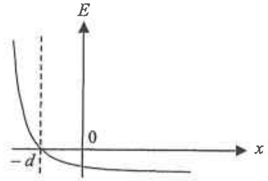
A point charge $+Q$ is fixed at a distance d away from the origin O as shown.

Which of the following graphs best represents the variation of the electric field strength E along the x-axis ? (Take the electric field pointing to the right as positive.)

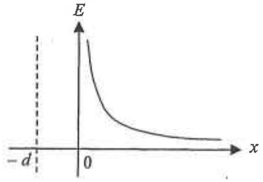
A.



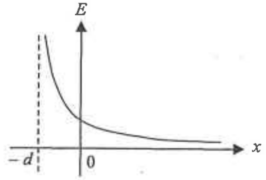
B.



C.



D.



67. <HKDSE 2019 Paper IA-23>

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. D	21. C	31. C	41. A	51. B	61. D
2. C	12. D	22. D	32. C	42. A	52. D	62. B
3. C	13. B	23. D	33. D	43. D	53. B	63. D
4. A	14. C	24. B	34. C	44. C	54. D	64. D
5. B	15. C	25. A	35. B	45. A	55. D	65. B
6. A	16. B	26. D	36. B	46. B	56. B	66. D
7. B	17. A	27. D	37. B	47. D	57. C	67. A
8. D	18. A	28. C	38. B	48. C	58. D	
9. D	19. B	29. D	39. C	49. D	59. C	
10. B	20. D	30. D	40. C	50. B	60. D	

M.C. Solution

1. D

× (1) Repulsion exists between similar charges.
✓ (2) Attraction exists between opposite charges.
✓ (3) Attraction exists between a charged body and an uncharged body.

2. C

Bringing (–) charge towards Z ⇒ (+) charge induced on Z and (–) charge induced on X

Y is earthed ⇒ (–) charge on X moves to the earth but (+) charge on Z is still attracted by the charged rod

Finally, X and Y are neutral and Z is positively charged

3. C

Bringing (+) charged rod towards right ball

⇒ (–) charge induced on right side of the right ball

⇒ (+) charge induced on the left side of the left ball

4. A

Bringing (+) charge towards right ball

⇒ (–) charge induced on right side of the right ball

⇒ (+) charge induced on the left side of the right ball (as plastic sheet does not allow flow of charge)

⇒ (–) charge induced on right side of the left ball

⇒ (+) charge induced on left side of the left ball

5. B

Sphere X is not in contact with other bodies,

thus the total charges on sphere X must remain unchanged.

6. A

Electron carries negative charge, thus the electric force on an electron is opposite to the direction of the E-field.

Therefore, the electron experiences an upwards electric force inside the parallel plates.

7. B

Bringing (+) charged sphere X towards Y and then earthing, negative charges are induced on Y.

When X is removed, Y carries negative charges that would distribute uniformly on the whole surface.

8. D

The (+) charge sphere is earthed

⇒ the sphere becomes neutral

⇒ electrons flow from the earth to the sphere (as proton does not move)

9. D

When the negatively charged object C is brought near X,
(+) charges are induced on the left side of X and (–) charges are induced on the right side of Y.

When X is touched momentarily with a finger,
the (–) charges on Y flows to the earth but the (+) charges on X is still attracted by C.

When X and Y are separated, X carries (+) charges and Y is neutral.

10. B

Bringing (+) charged rod ⇒ (–) charge induced at left side of the sphere and (+) charge at right side of the sphere

Earthed with a finger ⇒ electrons flow from the Earth to the sphere to neutralize the (+) charge at the right side

11. D

When the sphere is brought near, attraction exists between the charged dome and the neutral sphere.

After touching, the sphere shares some like charges and thus repulsion exists to move it away.

12. D

✓ (1) Photocopier makes use of electrostatic charge to give photocopying
✓ (2) Precipitator makes use of electrostatic charge to attract the coal dust
✓ (3) A Van de Graaff generator gives large amount of electrostatic charge for demonstrating

13. B

✓ (1) Bringing positively charged rod near the sphere
$\Rightarrow$ (–) charge induced at the left side and (+) charge induced at the right side of the sphere
$\Rightarrow$ upon earthing, electrons flow to the sphere to neutralize the (+) charge at the right side
$\therefore$ the sphere finally carries negative charges.

✓ (2) Touching the sphere with the rod would make the sphere share some positive charges.

× (3) Positive charges of the rod are discharged upon earthing by the finger
but the human body always remains neutral without carrying net charge
$\therefore$ no charge is shared with the sphere by the finger, thus the sphere remains neutral

14. C

Due to attraction between unlike charges, negative charge is induced at the left side of X.

Due to repulsion between like charges, positive charge is induced at the right side of Y.

15. C

× (1) If the sphere carries (+) charges, repulsion occurs between the sphere and the rod

✓ (2) Attraction exists between unlike charges.

✓ (3) Attraction exists between a charged body and a neutral body.

16. B

(3) : (–) charges are induced on the sphere at the side near the rod while (+) charges appear at the far side

(2) : electrons flow from the earth to the sphere to neutralize the (+) charges

(1) : the finger must be removed first before the removing of the charged rod

(4) : after the rod is removed, the sphere becomes (–) charged.

17. A

When the charged rod is brought near X, (+) charges are induced on X and (–) charges are induced on Z.

After Y is earthed, only the induced (+) charge remains on the left side of X due to the attraction by the (–) charged rod.

Z would become neutral as the negative induced charges would flow to earth during earthing.

18. A

① presence of positively charged rod $\Rightarrow$ (–) charge is induced on X while (+) charge is induced on Y

② X is earthed momentarily $\Rightarrow$ (–) charge on X left but (+) charge on Y is neutralized by electrons from the earth

③ The charged rod is removed $\Rightarrow$ the (–) charge on X is then shared between X and Y

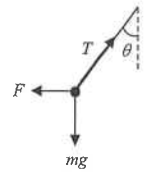
④ Two spheres are separated $\Rightarrow$ both X and Y becomes negatively charged

19. B

× (1) Since the two spheres repel, the two spheres may both carry (+) charge or both carry (–) charge

× (2) Since the force acting on B by A and the force acting on A by B are action and reaction pair,
they must be equal in magnitude but opposite in direction

✓ (3) Assume the electric force F acting on the sphere is approximately horizontal
Resolving the tension into two components



$T\cos\theta = mg$ and $T\sin\theta = F$ $\therefore$ $\tan\theta = \dfrac{F}{mg}$

For sphere A, θ is smaller, $\tan\theta$ is smaller, thus m is greater.

20. D

✓ (1) Water is neutral, as the ruler attracts the water, the ruler must carry an electric charge.

✓ (2) The attractive forces between the running water and the ruler are action and reaction pair,
so they are of equal magnitude.

✓ (3) The side of the running water near the ruler would induce the opposite type of electric charge
while the side of the running water further away from the water would induce the same type of charge

21. C

At the centre, the forces due to the two (+) charges on the point charge C balance each other

while the forces due to the two (–) charges on the point charge C also balance each other, thus resultant force on C is zero.

22. D

Suppose the three spheres are A, B and C such that A is uncharged, B is positively charged and C is negatively charged.

① A and B attract each other since a positively charged body would attract a neutral body.

② A and C attract each other since a negatively charged body would attract a neutral body.

③ B and C attract each other since a positively charged body attracts a negatively charged body.

Thus, one sphere is uncharged and the other two carry unlike charges.

23. D

✓ (1) Two balls carrying unlike charges would attract each other.

✓ (2) A ball carrying positive charge would attract an uncharged ball by induced charge.

✓ (3) A ball carrying negative charge would attract an uncharged ball by induced charge.

24. B

✓ (1) Attraction force exists between two opposite charges.

× (2) No electric force exists between two uncharged objects.

✓ (3) A ruler carrying charge would attract uncharged paper scraps by induced charges on the paper scraps.

25. A

✓ (1) Since repulsion exists between P and Q, they must carry like charges.

× (2) Since attraction exists between R and S, they may carry unlike charges OR one of them carries charge but the other is neutral.

× (3) Even P and Q carry different amount of charges, same force would exist between them.

26. D

As the E-field is in downward direction

The negatively charged particle experiences an upward electric force ($F = -qE$)

Thus, the particle accelerates in upward direction.

27. D

Downward weight = Upward electric force from electric field

$mg = qE = q\dfrac{V}{d}$

$\therefore\ m(10) = (1.6\times10^{-19})\times\dfrac{(2\times10^3)}{(0.05)}$ $\quad\therefore\ m = 6.4\times10^{-16}$ kg

28. C

✓ (1) By $U = qV$ $\quad\therefore\ U = (1\text{ C})\times(1\text{ V}) = 1$ J

✓ (2) By $F = qE$ $\quad\therefore\ F = (1\text{ C})\times(1\text{ V m}^{-1}) = 1$ N

× (3) Charge on 1 mole of electrons $= 6.02\times10^{23}\times1.6\times10^{-19}$ C $= 96320$ C $\neq 1$ C

29. D

✓ (1) After touching (+)-plate, it carries (+) charge. After touching (–)-plate, it carries (–) charge.

✓ (2) $d\uparrow \Rightarrow E\downarrow$ (by $E=\dfrac{V}{d}$) $\Rightarrow F\downarrow$ (by $F=qE$) $\Rightarrow a\downarrow$ (by $a=\dfrac{F}{m}$) $\Rightarrow$ frequency of oscillation $\downarrow$

✓ (3) Carrying (+)-charge to (–)-plate $\Rightarrow$ current flows in clockwise direction

Carrying (–)-charge to (+)-plate $\Rightarrow$ current flows in clockwise direction

30. D

Let the length of the square be r.

Distance between X and Z is $\sqrt{2}\,r$.

$F_W = \dfrac{(1)(1)}{4\pi\varepsilon_o(r)^2} = \dfrac{1}{4\pi\varepsilon_o r^2}$ (to the left) $\qquad F_Y = \dfrac{(1)(1)}{4\pi\varepsilon_o(r)^2} = \dfrac{1}{4\pi\varepsilon_o r^2}$ (upward)

Since the net force on X is to the left, thus the upward force by Y is balanced by the downward component of force by Z

$F_Z\cos45° = F_Y$ $\qquad\therefore\ \dfrac{Q(1)}{4\pi\varepsilon_o(\sqrt{2}r)^2}\cdot\left(\dfrac{1}{\sqrt{2}}\right) = \dfrac{1}{4\pi\varepsilon_o r^2}$ $\qquad\therefore\ Q = 2\sqrt{2}$ C

Since the electric between X and Z is attractive $\therefore$ Z is (+)

31. C

The sphere carries (–)-charge $\Rightarrow$ moves towards and touches (+) plate first

It then shares some (+) charge and moves towards and touches the opposite (–) plate

$\therefore$ The sphere oscillates.

32. C

✓ (1) Since the strip is deflected towards the positive plates, the strip should carry negative charges.

✓ (2) By $E=\dfrac{V}{d}$ $\quad\therefore\ d\downarrow \Rightarrow E\uparrow$ $\quad\therefore$ deflection $\uparrow$

× (3) E-field is constant within 2 charged plates, thus there is no change in deflection of the strip.

33. D

$E = \dfrac{V}{d} = \dfrac{(4.5\times10^3)}{(1.5\times10^{-3})} = 3\times10^6$ V

$F = qE = (1.60\times10^{-19})(3\times10^6) = 4.8\times10^{-13}$ N

$a = \dfrac{F}{m} = \dfrac{4.8\times10^{-13}}{9.11\times10^{-31}} = 5.3\times10^{17}$ m s^{-2}

34. C

Case 1 : Two charges are of the same sign, i.e. $(+5Q)$ and $(+1Q)$.

After sharing, they become $(+3Q)$ and $(+3Q)$.

$F_1 = \dfrac{(5Q)(1Q)}{4\pi\varepsilon_o r^2}$ $\qquad F_2 = \dfrac{(3Q)(3Q)}{4\pi\varepsilon_o r^2}$

$\therefore\ F_1 : F_2 = 5 : 9$

Case 2 : Two charges are of the opposite sign, i.e. $(+5Q)$ and $(-1Q)$.

After sharing, they become $(+2Q)$ and $(+2Q)$.

$F_1 = \dfrac{(5Q)(1Q)}{4\pi\varepsilon_o r^2}$ $\qquad F_2 = \dfrac{(2Q)(2Q)}{4\pi\varepsilon_o r^2}$

$\therefore\ F_1 : F_2 = 5 : 4$

35. B

Since the electrostatic force is attractive, X and Y carry unlike charges.

Let the charge carried by X be $+Q$ and the charge carried by Y be $-Q$.

For sharing of charges, $Q_1 + Q_2 = Q + Q$ where Q is the final charge at each of the two spheres.

After Z touches X, X carries $+\frac{1}{2}Q$ and Z carries $+\frac{1}{2}Q$.

After Z touches Y, Y carries $-\frac{1}{4}Q$ and Z carries $-\frac{1}{4}Q$.

Electrostatic force : $F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_o r^2}$ $\qquad\therefore\ F \propto Q_1 Q_2$ $\qquad\therefore\ F' = \frac{1}{2}\times\frac{1}{4}F = \frac{1}{8}F$

36. B

× (1) After the plates are disconnected from the supply, charges on the plates and thus E-field are unchanged
Thus the electric force is increased by $F = q\,E$ as q is increased. The oil drop then has a net force.

× (2) Increasing the p.d. between the plates would increase the electric field by $E = V/d$.
Thus the electric force is increased by $F = q\,E$ as E is increased. The oil drop then has a net force.

✓ (3) Moving the plates further apart decreases the E-field by $E = V/d$.
The electric force may then remain unchanged by $F = q\,E$ as q is increased but E is decreased.
The unchanged electric force then balances the weight of the oil drop by $q\,E = m\,g$.

37. B

Since point X has the same distance as the point of 72, the electric field at X is 72.

Distance of point Y from $+Q$ is $\sqrt{(3)^2 + (1)^2} = \sqrt{10}$.

Electric field : $E = \dfrac{Q}{4\pi\varepsilon_o r^2}$

Thus, electric field obeys inverse-square law, i.e. $E \propto \dfrac{1}{r^2}$ $\therefore \dfrac{E_2}{E_1} = \left(\dfrac{r_1}{r_2}\right)^2$

Electric field at Y = $360 \times \dfrac{1}{(\sqrt{10})^2} = 36$.

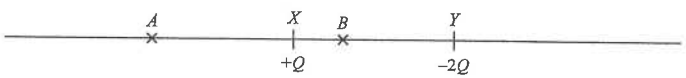
38. B

× (1) They may both carry positive charges OR both carry negative charges.

× (2) The charge on X may be greater OR smaller than that on Y.
However, the forces between them are equal and opposite since they are action and reaction pair.

✓ (3) Since the angle θ is smaller, thus the weight of X is greater.

39. C



By $E = \dfrac{Q}{4\pi\varepsilon_o r^2}$,

E-field depends on the charge Q and distance r.

At point A, charge at X is smaller and distance is closer, charge at Y is greater but distance is longer, thus $E_X = E_Y$.

At point B, charge at X is smaller and distance is closer, charge at Y is greater but distance is longer, thus $E_X = E_Y$.

There are 2 points with magnitude : $E_X = E_Y$.

At point A, E_X is towards the left but E_Y is towards the right, thus the resultant field is zero.

At point B, E_X is towards the right and E_X is also towards the right, thus the resultant field is not zero.

There is 1 point with zero resultant field.

40. C

$E = \dfrac{V}{d} = \dfrac{(3000)}{(0.015)} = 2\times10^5\ \text{V m}^{-1}$

By $m\,g = q\,E$ $\therefore\ (9.6\times10^{-15})(10) = q\,(2\times10^5)$ $\therefore\ q = 4.8\times10^{-19}$ C

To balance the downward weight, the electric force F must be upwards.

Since the direction of E-field is vertically downwards, the charge is negative.

Thus, the charge carried by the oil drop is -4.8×10^{-19} C.

41. A

The positively-charged rod is brought near X	X : negative	Y : positive
X is earthed momentarily	X : negative	Y : uncharged
The charged rod is removed	X : negative	Y : negative

42. A

✓ (1) The mid-point Y is a neutral point, where the electric field due to the two charges balance each other.

✓ (2) Since the left sphere is closer to X, the negative charge is attracted by the left sphere
and thus the net electric force is towards the left

× (3) Since the right sphere is closer to Z, the positive charge is repelled by the right sphere
and thus the net electric force is towards the left

43. D

✓ (1) Some induced negative charges appear at the left side
and induced positive charges appear at the right side of the sphere.
Attraction force then exists between the positive charged rod and the negative induced charges.

✓ (2) After touching the charged rod, the sphere shares some positive charges from the metal rod
and is repelled away.

✓ (3) The sphere is finally positively charged by sharing.

44. C

✓ (1) Electric force exists between the induced charges in the papers and the electric charges in the ruler.

✓ (2) Since both positive and negative charges are induced in the paper, the paper remains neutral.

× (3) Since the two forces are action and reaction pair, they should be equal in magnitude.

45. A

The electric field due to the upper charge is towards the left.

The electric field due to the lower left charge is upwards.

The resultant of these two fields points towards direction 1.

The electric field due to the lower right charge is along direction 4,

however, this field is weaker than the resultant of the other two, thus the overall resultant field is along direction 1.

46. B

× (1) By $F = \dfrac{(Q)(Q)}{4\pi\varepsilon_o r^2} \propto \dfrac{1}{r^2}$ $\therefore\ r\uparrow \Rightarrow F\downarrow$

✓ (2) At point D, E-field due to the positive charge points to the right
and that due to negative charge points to the left.
As the negative charge is nearer to D, the resultant E-field points to the left.
As the $-Q$ is moved nearer to D, E-field due to $-Q$ further increases, and the resultant E increases.

× (3) At the mid point B, the direction of E-field due to both $+Q$ and $-Q$ are towards the right,
thus, it cannot be a neutral point.
[Note that there is no neutral point in this situation.]

47. D

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_o r^2} = \frac{(1.5\times10^{-17})(3.2\times10^{-19})}{4\pi(8.85\times10^{-12})(1.0\times10^{-13})^2} = 4.32\ \text{N}$$

48. C

$$E = \frac{Q}{4\pi\varepsilon_o r^2} = \frac{Ze}{4\pi\varepsilon_o r^2}$$

49. D

✓ (1) The density of electric field lines represents the strength of the electric field.
As the field lines at Z is closer, E-field strength at Z is greater.

✓ (2) Negative charged particle experiences an electric force opposite to the E-field
Thus, electric force on the negative charge points towards the left along the tangent of field line.

✓ (3) Electric field lines at Y is closer than that at X, thus the electric field strength at Y is greater,
therefore, a charge would experience a greater force at Y, by $F = qE$.

50. B

✓ (1) Since the field lines are directed away from the charges, the two charges are positive.

✓ (2) As the neutral point is further away from P, the charge P is greater than that of Q.

× (3) The two forces are action and reaction pair, they must be equal in magnitude.

51. B

× (1) Gain of KE does not depend on the mass.
The larger the mass, the smaller the speed, but the same KE.

× (2) For constant voltage between the two parallel plates,
the gain of KE depends on voltage only but not affects by the separation between the two plates.

✓ (3) Gain of KE = loss of electric PE = qV.
The greater the voltage V, the greater the gain of KE.

52. D

✓ (1) Two balls carrying unlike charges would attract each other.

✓ (2) A ball carrying positive charge would attract an uncharged ball by induced charge.

✓ (3) A ball carrying negative charge would attract an uncharged ball by induced charge.

53. B

Since point X has the same distance as the point of 72, the electric field at X is 72.

Distance of point Y from $+Q$ is $\sqrt{(3)^2+(1)^2} = \sqrt{10}$.

Since electric field obeys inverse-square law,

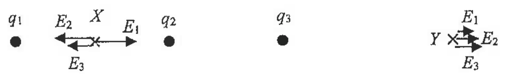
$\therefore\ E \propto \dfrac{1}{r^2}$

$\therefore\ \dfrac{E_2}{E_1} = \left(\dfrac{r_1}{r_2}\right)^2$

Electric field at $Y = 360 \times \dfrac{1}{(\sqrt{10})^2} = 36$.

54. D

Assume that the three charges are all positive (it is arbitrary, same result obtained if assumed negative).
The direction of E-field by a positive charge is away from the charge.

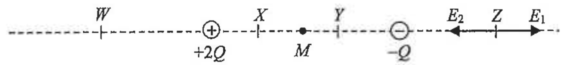


At point X, the electric field due to q_1 and q_2 are in opposite directions and cancel each other,
the net E-field is E_3 and directed towards the left.

At point Y, the electric field due to the three charges are all towards the right,
thus the resultant E-field is rightwards, therefore, the direction of E-field at X and Y are in opposite directions.

The magnitude of E_3 are the same at X and Y, but there are E_1 and E_2 in addition,
thus the resultant E-field at Y is greater than that at X.

55. D



The electric field due to a (+) point charge is away from the charge.

The electric field due to a (–) point charge is towards the charge.

At Z, the field due to $+2Q$ is E_1 while that due to $-Q$ is E_2,

and they are in opposite direction, thus they may be balanced to give zero resultant field, that is, the neutral point.

[Note that W cannot be a neutral point as the E-field due to the greater charge $2Q$ must be greater since it is closer.]

56. B

Since P and Q repel, they must carry like charges.

Since R and S repel, they must carry like charges.

Since Q and R attract, they must carry unlike charges.

× (1) P and R must carry unlike charges, thus they cannot be both negatively charged.

× (2) Q and S must carry unlike charges, thus they cannot be both positively charged.

✓ (3) P and S must carry unlike charges, thus P may be positively charged and S may be negatively charged.

57. C

Potential difference between the thundercloud and the ground (assume that they form 2 parallel plates)

$V = E\,d = (3\times10^6)\times(500) = 1.5\times10^9$ V

Energy released :

$U = Q\,V = (20)(1.5\times10^9) = 3\times10^{10}$ J

Order of magnitude of the energy released $= 10^{10}$ J

58. D

Before touching, electrostatic force between the two spheres :

$$F = \frac{(2Q)(6Q)}{4\pi\varepsilon_o r^2} = 12\frac{Q^2}{4\pi\varepsilon_o r^2}$$

After touching, the net charges are : $(6Q)+(-2Q) = +4Q$

This charge is then shared between X and Y, each has $+2Q$.

After touching, electrostatic force between the two spheres :

$$F' = \frac{(2Q)(2Q)}{4\pi\varepsilon_o r^2} = 4\frac{Q^2}{4\pi\varepsilon_o r^2} = \frac{1}{3}F$$

The electrostatic forces between X and Y are repulsive as they carry like charges.

59. C

When the positively charged rod is brought near X, X is negatively charged and Y is positively charged.

When X is touched by the finger, X is still negatively charged but Y becomes uncharged.

When Y is removed, X remains negatively charged and Y remains uncharged.

When the charged rod is removed, X remains negatively charged and Y remains uncharged.

60. D

Since the electron carries negative charge, the direction of electric field should be from P to Q.

By $F = q\,E$

$\therefore\ (8.0\times10^{-18}) = (1.6\times10^{-19})\,E$

$\therefore\ E = 50\ \text{N C}^{-1}$

61. D

Electrostatic force : $F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_o r^2}$

× A. To give zero resultant force on Q_3, the sign of Q_1 and Q_2 should be opposite.

× B. Distance of Q_1 from Q_3 is two times that of Q_2 from Q_3,
thus the magnitude of the charge of Q_1 should be 4 times as that of Q_2, not 2 times.

× C. To give zero resultant force on Q_1, the sign of Q_2 and Q_3 should be opposite.

✓ D. Forces between Q_1 and Q_3 is repulsive with magnitude : $F_1 = \dfrac{(4)(4)}{4\pi\varepsilon_o(2r)^2}$

Forces between Q_2 and Q_3 is attractive with magnitude : $F_2 = \dfrac{(1)(4)}{4\pi\varepsilon_o(r)^2}$

As $F_1 = F_2$, the resultant force on Q_3 is zero.

62. B

Due to the induced charges, a neutral ball and a positive charged ball would attract each other.

Due to induced charges, a neutral ball and a negative charged ball would attract each other.

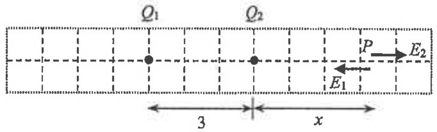
The deduction should be :

① one ball carries positive charge

② one ball carries negative charges

③ one ball is uncharged (neutral).

63. D



Assume the neutral point P is at a distance of x at the right side of Q_2.

Since Q_1 is negative, the electric field E_1 due to Q_1 is towards the left.

Since Q_2 is positive, the electric field E_2 due to Q_2 is towards the right.

To be the neutral point, the two electric fields must be equal and opposite.

$\therefore\ E_1 = E_2 \quad \therefore\ \dfrac{4Q}{4\pi\varepsilon_o\cdot(3+x)^2} = \dfrac{Q}{4\pi\varepsilon_o\cdot(x)^2} \quad \therefore\ x = 3$

$\therefore$ The neutral point is at Z.

64. D

There are two points that the magnitude of the electric field due to the two charges are equal.

For the same electric field (both magnitude and direction), the point must be at the right side of $+Q$.

Let the point from O be x.

$\therefore\ E_1 = E_2 \quad \therefore\ \dfrac{4Q}{4\pi\varepsilon_o\cdot x^2} = \dfrac{Q}{4\pi\varepsilon_o\cdot(x-15)^2} \quad \therefore\ x = 30$ cm

65. B

× (1) Since the electrostatic forces between the two spheres are repulsive, both spheres carry like charges. However, both spheres may carry positive charges OR both may carry negative charges.

× (2) The amount of charges on the two spheres may NOT be the same.

✓ (3) The electrostatic force F acting on the higher sphere is upwards that balance its downwards weight mg.

$$\therefore\ m g = \frac{Q_1 Q_2}{4 \pi \varepsilon_o d^2}$$

Thus, the separation d depends on m.

66. D

By $E = \dfrac{Q}{4 \pi \varepsilon_o r^2}$

Thus, E must be positive and tends to zero as r tends to infinity, therefore, option A and B must be incorrect.

Since the charge Q is placed at $-d$, the electric field must exist starting from $-d$, thus option D is correct.

The following list of formulae may be found useful :

Coulomb's law	$F = \dfrac{Q_1 Q_2}{4 \pi \varepsilon_o r^2}$
Electric field strength due to a point charge	$E = \dfrac{Q}{4 \pi \varepsilon_o r^2}$
Electric field between parallel plates (numerically)	$E = \dfrac{V}{d}$

Use the following data wherever necessary :

Acceleration due to gravity	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to the Earth)
Charge of electron	$e = 1.6 \times 10^{-19}\ \mathrm{C}$	
Electron rest mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Permittivity of free space	$\varepsilon_o = 8.85 \times 10^{-12}\ \mathrm{C^2\ N^{-1}\ m^{-2}}$	

Part A : HKCE examination questions

1. **< HKCE 1985 Paper I - 9 >**

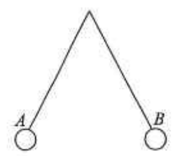
(a) A girl, after combing her hair on a dry day, holds the comb near small pieces of paper. What will be observed if the comb is made of

(i) plastic, and

(ii) aluminium ?

Explain briefly in each case. (4 marks)

(b) Two similar charged metal-coated balls, A and B, are suspended from two insulating threads as shown in the figure.

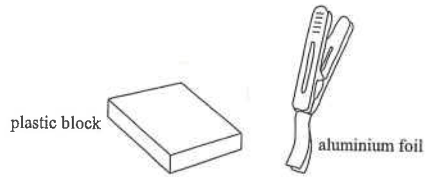


(i) Draw on the diagram all the forces acting on the two balls. (3 marks)

(ii) If the ball A is earthed by touching, what would happen to the two balls ? Explain briefly. (4 marks)

2. < HKCE 1987 Paper I - 9 >

The below figure shows two aluminium foils held by plastic clips and a negatively charged plastic block. They are used for charging the aluminium foils by induction.



(a) Describe the steps taken in charging the aluminium foils. (3 marks)

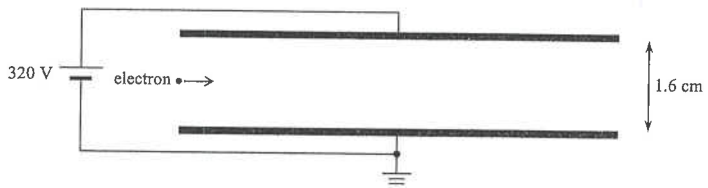
(b) What type of charge is induced on the aluminium foils ? (1 mark)

(c) Explain briefly why the clips should be an insulator but not a conductor in this experiment. (2 marks)

Part B : HKAL examination questions

3. < HKAL 2006 Paper I - 4 >

In a vacuum, a beam of electrons with an initial horizontal velocity enters midway into a region of electric field between two horizontal square metal plates as shown in the figure below. A p.d. of 320 V is applied across the plates and the separation between them is 1.6 cm.

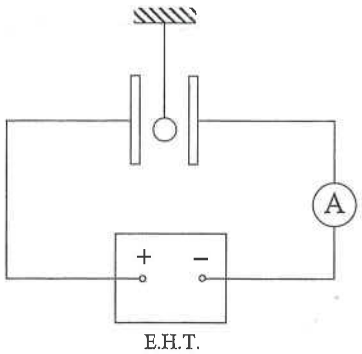


(a) Find the electric field strength between the plates. (2 marks)

(b) The electron beam reaches one of the plates. Sketch in the above figure the path of the electron beam between the two plates. (Neglect the weight of the electron.) (2 marks)

4. < HKAL 2011 Paper I - 7 >

A small conducting ball is placed midway between two parallel metal plates connected to an E.H.T. via an ammeter as shown in the Figure.



(a) State how to make the ball acquire positive charges. (1 mark)

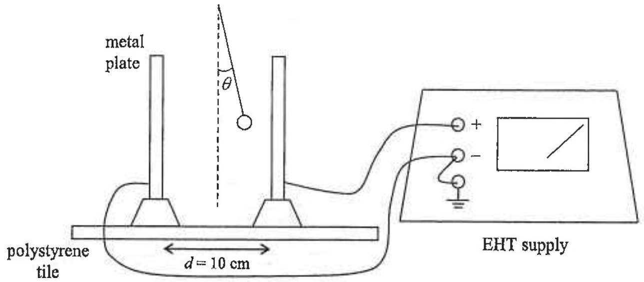
(b) After the ball acquires positive charges, explain why it can shuttle continuously between the two plates. (2 marks)

(c) State and explain how the average current registered by the ammeter is affected if the separation of the two metal plates is decreased. (3 marks)

Part C : HKDSE examination questions

5. < HKDSE Practice Paper IB - 8 >

As shown in the Figure, two large vertical parallel metal plates, each in a slotted base, are placed on a polystyrene tile. The plates are connected to the positive and negative terminals of an EHT supply respectively. The plates' separation d = 10 cm.



A small charged ball is suspended by a nylon thread and is placed midway between the plates. The thread makes an angle θ to the vertical when the ball is in equilibrium.

(a) By using a free-body diagram, draw and name all the forces acting on the charged ball. Also indicate in your diagram the direction of the electric field between the plates. (3 marks)

(b) (i) Express tan θ in terms of the electric force F acting on the ball and the weight W of the ball. (1 mark)

(ii) Given that the mass of the ball is 0.07 g. When the voltage between the plates is 4000 V, θ = 2°. Estimate the magnitude of the charge carried by the ball. Assume that the electric field between the plates is uniform. (3 marks)

(c) Using the setup in the Figure, suggest a simple method to test whether the electric field between the plates is uniform. (3 marks)

6. < HKDSE 2013 Paper IB - 11 >

Figure (a) shows two identical small metal spheres X and Y suspended by insulating threads of the same length. Each sphere has a mass of 1.0×10^{-5} kg and each carries a positive charge of 3.1 nC (1 nC = 10^{-9} C). The separation d of the spheres is 10 cm. The size of spheres is negligible compared with their separation, therefore they can be treated as point charges.

Take $\dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}.

Figure (a)

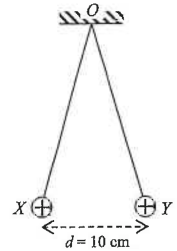


Diagram NOT drawn to scale

(a) Find the angle between the threads. (3 marks)

(b) Point P is vertically below the fixed point O and it is 10 cm from each sphere as shown in Figure (b).

(i) Indicate the direction of the resultant electric field at P due to these two charged spheres. (1 mark)

Figure (b)

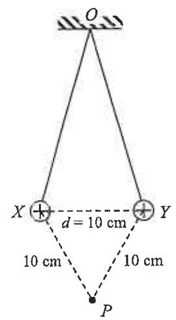


Diagram NOT drawn to scale

(ii) A neutral metal sphere of finite size is now placed at P. State whether the separation d would increase, decrease or remain unchanged due to the presence of this sphere. (1 mark)

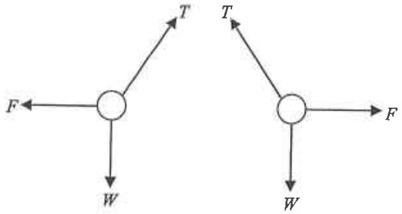
Separation d ....

Question Solution

1. (a) (i) Small pieces of paper are attracted by the comb and are found on the comb [1]
Since the plastic comb is an insulator, charges produced by rubbing remain on the comb [1]

(ii) Small pieces of paper are not affected and stay at the original places [1]
Since aluminium is a conductor, charges produced by rubbing will be conducted away. [1]

(b) (i)



< weight of the two balls marked correctly > [1]
< tension of the strings marked correctly > [1]
< electrostatic force between the two balls marked correctly > [1]

(ii) Both ball A and ball B fall, [1]
touch and then separate again [1]
Since charges in ball A is conducted away, it is attracted by ball B [1]
When it makes contact with ball B, it shares similar charges and repels away. [1]

2. (a) Place the aluminium foils near the plastic block. [1]
Touch the foil momentarily with a finger. [1]
Then remove the block. [1]

(b) positive charge [1]

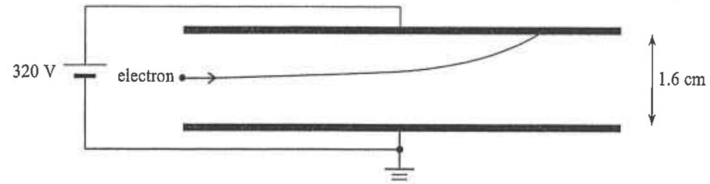
(c) If the clip is a conductor, the induced charge would escape [1]
through the clip and the hand. [1]

3. (a) $E = \dfrac{V}{d}$

$= \dfrac{320}{0.016}$ [1]

$= 2 \times 10^4$ V m^{-1} (**OR** 20 000 N C^{-1}) [1]

3. (b)



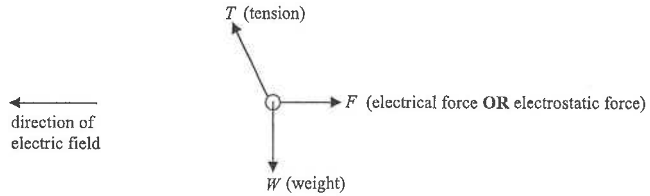
< The path bends upwards > [1]
< The path is a curve > [1]

4. (a) Let the ball touch the left plate to share some positive charges. [1]

(b) The ball is repelled by left plate and attracted to the right plate. [1]
The ball then acquires negative charges when touching the right plate and the process repeats. [1]
Hence, the ball shuttles between the two plates.

(c) As the plate separation d decreases, the electric field between the plate increases ($E = V / d$). [1]
Therefore, electric force on the ball increases. [1]
The acceleration of the ball increases and thus the average current increases. [1]

5. (a)



< Weight and tension correctly drawn with correct name > [1]
< The electrical force correctly drawn with correct name > [1]
< Direction of electric field correct > [1]

(b) (i) $\tan\theta = \dfrac{F}{W}$ [1]

(ii) For parallel plates : $E = \dfrac{V}{d} = \dfrac{4000}{0.1} = 40000$ V m^{-1} [1]

$\tan\theta = \dfrac{F}{W} = \dfrac{qE}{mg}$

$\tan 2° = \dfrac{q \cdot (40000)}{(0.07\times10^{-3})(9.81)}$ [1]

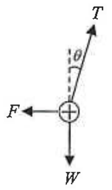
$\therefore\ q = 6.00 \times 10^{-10}$ C [1]

5. (c) Fix the plates separation and the output voltage of the EHT Supply. [1]

Move the polystyrene tile so that the ball is placed in different positions in the space between the plates. [1]

The angle θ should remain the same if the electric field between the plates is uniform. [1]

6. (a)



$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_o r^2} = (9\times10^9)\times\dfrac{(3.1\times10^{-9})^2}{(0.10)^2} = 8.65\times10^{-6}$ N [1]

$W = mg = (1.0\times10^{-5})(9.81) = 9.81\times10^{-5}$ N

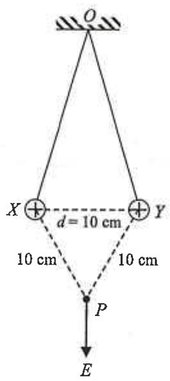
Resolve the tension T : $T\sin\theta = F$ and $T\cos\theta = W$

$\therefore \tan\theta = \dfrac{F}{W} = \dfrac{8.65\times10^{-6}}{9.81\times10^{-5}}$ [1]

$\therefore \theta = 5.04°$

Angle between the threads $= 2\theta = 10.1°$ [1]

(b) (i)



< direction of E : vertically downwards > [1]

(ii) Separation d : decreases [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普通氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe as seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恒星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

The following list of formulae may be found useful :

Resistance and resistivity	$R = \dfrac{\rho l}{A}$
Resistors in series	$R = R_1 + R_2$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$
Power in a circuit	$P = IV = I^2 R$

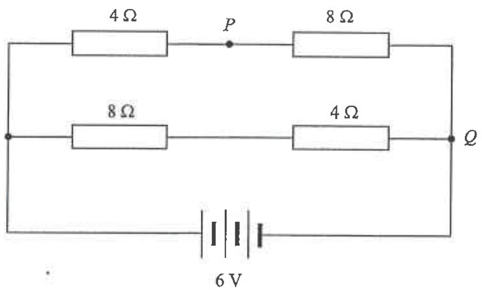
Use the following data wherever necessary :

Acceleration due to gravity	$g = 9.81 \text{ m s}^{-2}$	(close to the Earth)
Charge of an electron	$e = 1.60 \times 10^{-19} \text{ C}$	
Electron rest mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$	

Part A : HKCE examination questions

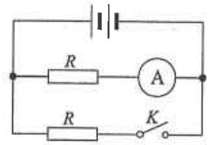
1. **< HKCE 1980 Paper II - 32 >**

In the circuit shown, the battery has an e.m.f. of 6 V with negligible internal resistance. Four resistors are connected to the battery as shown in the figure.



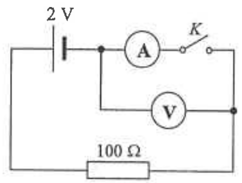
What is the potential difference between points *P* and *Q* ?
A. 1 V
B. 2 V
C. 3 V
D. 4 V

2. **< HKCE 1980 Paper II - 38 >**



Two identical resistors *R*, an ammeter, a switch *K* and a cell are connected as shown. When *K* is open, the ammeter reading is 1 A. When *K* is closed, the reading will
A. not change.
B. increase to 2 A.
C. increase to 4 A.
D. decrease to $\frac{1}{2}$ A

3. **< HKCE 1980 Paper II - 44 >**



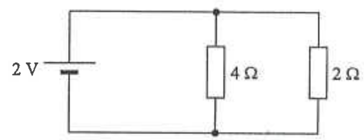
In the circuit shown, **V** is a voltmeter of high internal resistance and **A** is an ammeter of low internal resistance. What is the voltmeter reading when (a) switch *K* is open, and (b) switch *K* is closed ?

	K open	*K* closed
A.	0 V	0 V
B.	0 V	2 V
C.	1 V	1 V
D.	2 V	0 V

4. **< HKCE 1981 Paper II - 25 >**

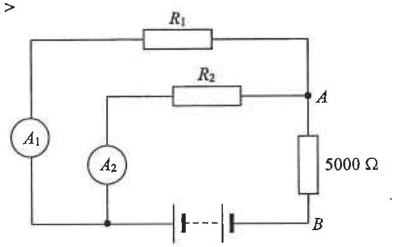
Suppose that it takes 8 minutes to boil a kettle of water. If the heating coil of the kettle is shortened to half its original length and the supply voltage remains unchanged, then to boil the same amount of water will take
A. 16 min.
B. 8 min.
C. 4 min.
D. 2 min.

5. **< HKCE 1981 Paper II - 29 >**



In the circuit shown, what is the power dissipated in the 4 Ω resistor ?
A. 0.5 W
B. 1.0 W
C. 1.5 W
D. 2.0 W

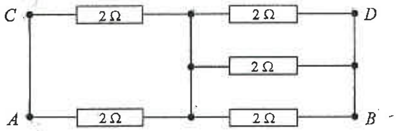
6. **< HKCE 1981 Paper II - 28 >**



In the circuit shown, ammeter A_1 reads 2 mA and ammeter A_2 reads 8 mA. What is the voltage across AB ?

A. 10 V
B. 40 V
C. 50 V
D. 100 V

7. **< HKCE 1981 Paper II - 27 >**

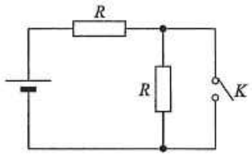


The diagram shows a network of resistors, where the resistance of each resistor is 2 Ω. What are the equivalent resistances across AB and AD respectively ?

	AB	AD
A.	1.67 Ω	1.00 Ω
B.	1.67 Ω	1.67 Ω
C.	1.67 Ω	3.67 Ω
D.	2.50 Ω	1.00 Ω

8. **< HKCE 1982 Paper II - 31 >**

In the circuit shown, the cell has negligible internal resistance. The two resistors R are identical. If the power dissipated in the circuit is P when K is open, find the power dissipated when K is closed.



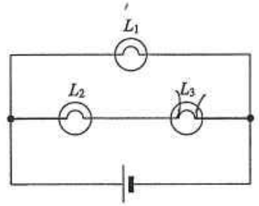
A. $\frac{1}{4}P$
B. $\frac{1}{2}P$
C. $2P$
D. $4P$

9. **< HKCE 1982 Paper II - 1 >**

Which of the following are vectors ?
(1) weight
(2) charge
(3) voltage

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

10. **< HKCE 1982 Paper II - 27 >**



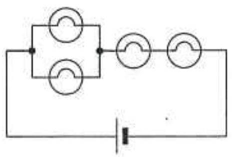
In the circuit shown, the cell has negligible internal resistance. If the lamp L_3 burns out, then

A. L_1 becomes brighter.
B. L_2 becomes brighter.
C. L_1 becomes dimmer.
D. L_1 retains the same brightness.

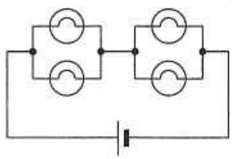
11. **< HKCE 1982 Paper II - 30 >**

Suppose you were given four similar lamps and a battery. Which of the following ways of connecting the lamps to the battery would give the maximum brightness overall ?

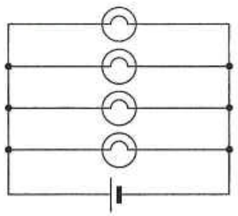
A.



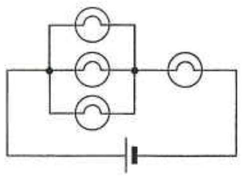
B.



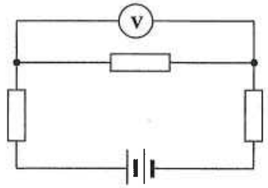
C.



D.



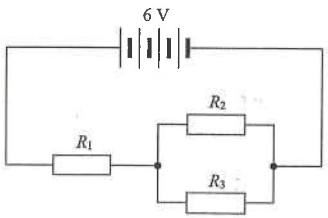
12. **< HKCE 1982 Paper II - 33 >**



In the given circuit diagram, the battery has a voltage of 6 V and negligible internal resistance. The three resistors are identical and the voltmeter has the same resistance as each resistor. What is the reading on the voltmeter ?

A. 1.0 V
B. 1.2 V
C. 1.5 V
D. 2.0 V

13. **< HKCE 1983 Paper II - 27 >**



In the circuit shown, the resistances of R_1, R_2 and R_3 are all equal to 2 Ω. The power dissipated by R_2 is

A. 2 W
B. 4 W
C. 6 W
D. 8 W

14. **< HKCE 1983 Paper II - 32 >**

The resistance of a given conducting wire may be increased by

(1) decreasing the radius of the wire.
(2) increasing the length of the wire.
(3) winding the wire in the form of a coil.

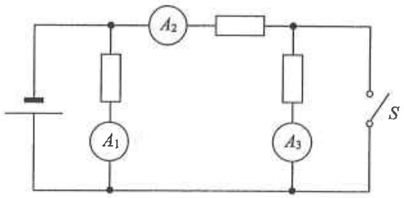
A. (1) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

15. **< HKCE 1983 Paper II - 28 >**

When connected in series in an electric circuit, the power dissipated in two resistors R_1 and R_2 is in the ratio of 1 : 4. What will be the ratio of the power dissipated in R_1 and R_2 when they are connected in parallel ?

A. 1 : 2
B. 2 : 1
C. 1 : 4
D. 4 : 1

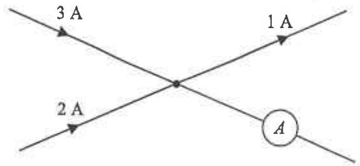
16. **< HKCE 1983 Paper II - 31 >**



In the above circuit, A_1, A_2 and A_3 are ammeters of negligible internal resistance. What will happen to the readings of the ammeters if the switch S is closed ?

	Reading of A_1	Reading of A_2	Reading of A_3
A.	decreases	increases	becomes zero
B.	increases	decreases	decreases
C.	unchanged	increases	becomes zero
D.	unchanged	decreases	increases

17. **< HKCE 1983 Paper II - 30 >**



In the circuit shown, what is the current passing through the ammeter A ?

A. 0 A
B. 1 A
C. 2 A
D. 4 A

18. **< HKCE 1984 Paper II - 12 >**

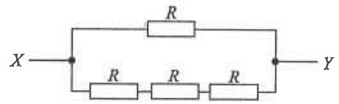
An immersion heater of resistance 50 Ω raises the temperature of 1 kg of water by 20°C in 3 minutes, the voltage supply being 200 V. What would be the energy wasted ?
(Specific heat capacity of water = 4.2 kJ kg^{-1} $°C^{-1}$)

A. 0.44 kJ
B. 2.32 kJ
C. 44 kJ
D. 60 kJ

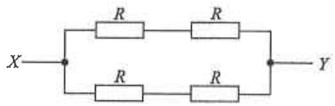
19. **< HKCE 1984 Paper II - 32 >**

The diagrams below show three possible arrangements of four identical resistors R.

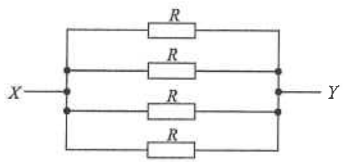
(a)



(b)



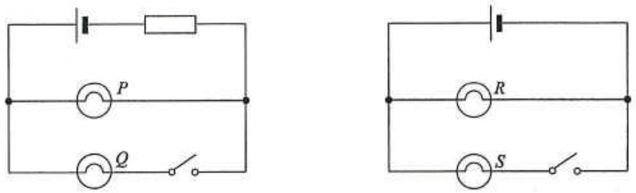
(c)



List the arrangements in order of increasing equivalent resistance, as measured between X and Y.

A. (a), (b), (c)
B. (b), (c), (a)
C. (c), (a), (b)
D. (c), (b), (a)

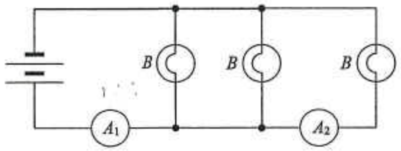
20. **< HKCE 1984 Paper II - 33 >**



Four identical bulbs P, Q, R and S are connected as shown in the two circuit diagrams above. What happens to the brightness of P and R if the switches of both circuits are closed ?

	Brightness of *P*	**Brightness of *R***
A.	decreases	remains constant
B.	remains constant	decreases
C.	increases	remains constant
D.	decreases	decreases

21. **< HKCE 1985 Paper II - 36 >**



In the circuit shown, all bulbs B are identical. If ammeter A_1 reads 1.8 A, what does ammeter A_2 read ?

A. 1.2 A
B. 0.9 A
C. 0.6 A
D. 0.3 A

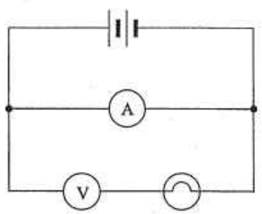
22. **< HKCE 1985 Paper II - 34 >**

An immersion heater A takes 10 minutes to boil a kettle of water while another heater B takes 40 minutes to boil the same kettle of water under the same voltage supply. If the resistance of heater A is 100 Ω, what is the resistance of heater B ?

A. 50 Ω
B. 100 Ω
C. 200 Ω
D. 400 Ω

23. **< HKCE 1985 Paper II - 35 >**

A student, who wishes to find the resistance of a light bulb when connected to a certain battery, incorrectly connects a practical voltmeter and a practical ammeter as shown. What would be the most probable outcome of his error ?



A. The voltmeter would indicate zero voltages.
B. The ammeter would burn out.
C. The light bulb would burn out.
D. Both the ammeter and the voltmeter would burn out.

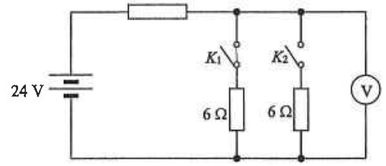
24. **< HKCE 1985 Paper II - 44 >**

Which of the following will increase the resistance of a metal wire ?
(1) increasing the length of the wire
(2) increasing the cross-sectional area of the wire
(3) increasing the temperature of the wire

A. (1) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

25. **< HKCE 1985 Paper II - 38 >**

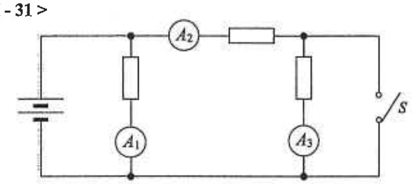
6Ω



In the circuit, when K_1 is closed the voltmeter reads 12 V. What would the reading be if both K_1 and K_2 are closed ?

A. 8 V
B. 12 V
C. 16 V
D. 18 V

26. **< HKCE 1986 Paper II - 31 >**



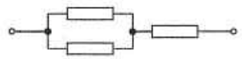
In the above circuit A_1, A_2 and A_3 are ammeters connected to a constant voltage source. What will happen to the readings of the ammeters if the switch S is closed ?

	A_1	A_2	A_3
A.	decreases	increases	becomes zero
B.	increases	decreases	decreases
C.	no change	increases	becomes zero
D.	no change	decreases	increases

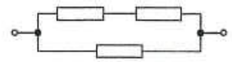
27. **< HKCE 1986 Paper II - 30 >**

Arrange the following circuits in ascending order of equivalent resistances :

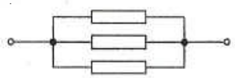
(1)



(2)

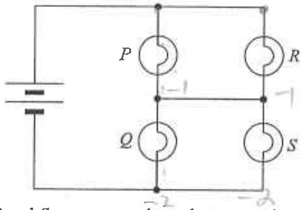


(3)



A. (3), (2), (1)
B. (1), (3), (2)
C. (2), (3), (1)
D. (2), (1), (3)

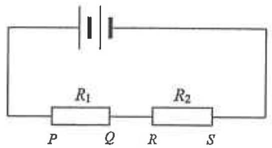
28. **< HKCE 1987 Paper II - 28 >**



Four identical lamps P, Q, R and S are connected to a battery as shown above. If lamp P is blown, which of the following would happen ?

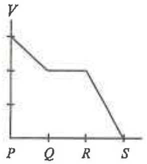
A. Lamp R becomes brighter.
B. Lamp Q becomes brighter.
C. Lamp S becomes brighter.
D. Lamps Q and S remain at the same degree of brightness.

29. **< HKCE 1987 Paper II - 32 >**

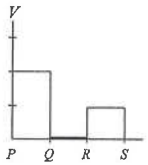


The above circuit shows two resistors R_1 and R_2 connected in series to a battery. The resistance of R_1 is greater than that of R_2. The ends of the resistors are marked P, Q, R and S. Which of the graphs best shows how the potential V varies along PS ?

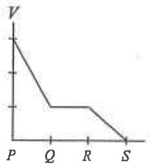
A.



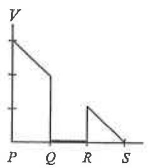
B.



C.



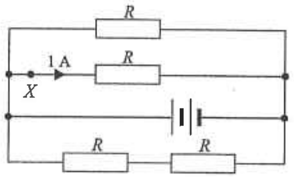
D.



30. **< HKCE 1987 Paper II - 30 >**

In the circuit shown, all resistors are the same. If the current passing through point X is 1 A, what will the current delivered from the battery be ?

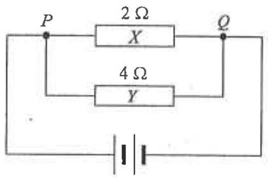
A. 1 A
B. 2 A
C. 2.5 A
D. 3 A



31. **< HKCE 1988 Paper II - 26 >**

In the circuit shown, the energy required by an electron to travel from Q to P through X is E_1 and that through Y is E_2. Which of the following is true ?

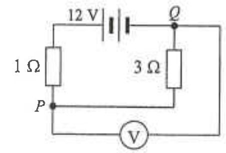
A. $E_1 = 4E_2$
B. $E_1 = 2E_2$
C. $E_1 = E_2$
D. $2E_1 = E_2$



32. **< HKCE 1988 Paper II - 27 >**

What should be the potential difference between P and Q in the circuit shown ?

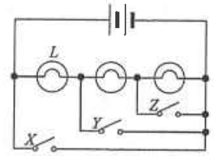
A. 3 V
B. 6 V
C. 9 V
D. 12 V



33. **< HKCE 1988 Paper II - 30 >**

In the circuit shown, which of the switches should be closed in order to get the maximum brightness in lamp L ?

A. X only
B. Y only
C. Z only
D. X and Y only



34. **< HKCE 1989 Paper II - 34 >**

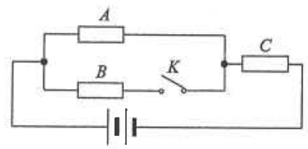
Two copper wires, A and B, of the same length have the ratio of mass of 4 : 9. Assuming the cross-sections are uniform, what is the ratio of the resistance of A to that of B ?

A. 2 : 3
B. 3 : 2
C. 4 : 9
D. 9 : 4

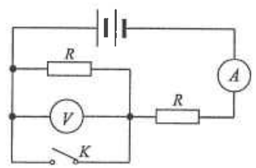
35. **< HKCE 1989 Paper II - 31 >**

In the circuit shown, resistors A, B and C are identical. When K is open, the power dissipated by A is P_1. When K is closed, the power dissipated by A becomes P_2. The ratio $P_1 : P_2$ is equal to

A. 3 : 2
B. 2 : 1
C. 9 : 4
D. 4 : 1



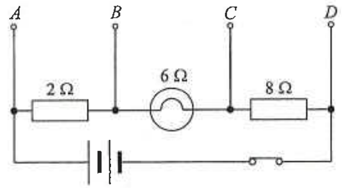
36. **< HKCE 1989 Paper II - 38 >**



In the circuit above, the two resistors are identical. When the switch K is closed, what happens to the readings of the ammeter A and the voltmeter V ?

	Reading of ammeter A	Reading of voltmeter V
A.	increases	decreases to zero
B.	decreases	decreases to zero
C.	decreases	decreases
D.	increases	decreases

37. **< HKCE 1989 Paper II - 33 >**



In the circuit shown, a 4 Ω resistor is to be connected to two of the terminals *A*, *B*, *C* and *D* to give the greatest brightness in the lamp bulb. Which connection should be made ?

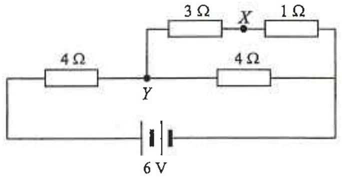
A. across *AB*
B. across *BC*
C. across *CD*
D. across *AD*

38. **< HKCE 1990 Paper II - 35 >**

An electric heater takes a time *T* to boil a kettle of water when connected to a 200 V source. What will be the time required to boil the same kettle of water when the heater is connected to a 100 V source ?
(You may assume that the resistance of the heater remains unchanged.)

A. *T* / 4
B. *T* / 2
C. 2 *T*
D. 4 *T*

39. **< HKCE 1990 Paper II - 32 >**



In the circuit shown, the potential difference between *X* and *Y* is

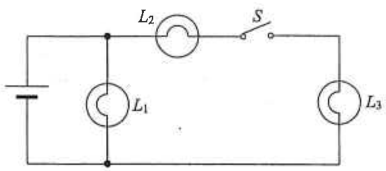
A. zero.
B. 1.5 V.
C. 3.0 V
D. 4.5 V.

40. **< HKCE 1990 Paper II - 34 >**

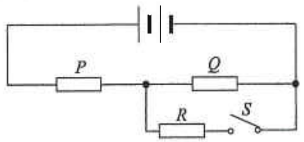
In the circuit shown, L_1, L_2 and L_3 are identical light bulbs. Which of the following statements is/are correct when the switch *S* is closed ?

(1) The brightness of L_1 decreases.
(2) L_2 and L_3 are of same brightness.
(3) L_1 is brighter than L_2.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only



41. **< HKCE 1991 Paper II - 30 >**

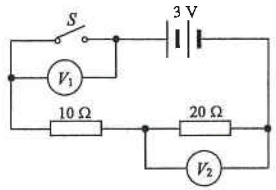


In the above circuit, *P*, *Q* and *R* are identical resistors. Which of the following is true when switch *S* is closed ?

A. The power output from the battery increases.
B. The voltage across *P* remains unchanged.
C. The current through *Q* remains unchanged.
D. The current through *P* decreases.

42. **< HKCE 1991 Paper II - 33 >**

In the circuit shown, what are the readings of voltmeters V_1 and V_2 if switch *S* is closed ?

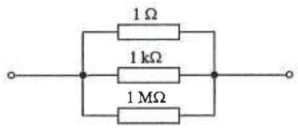


	Voltmeter V_1	Voltmeter V_2
A.	0 V	2 V
B.	0 V	3 V
C.	1 V	2 V
D.	3 V	0 V

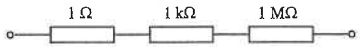
43. **< HKCE 1991 Paper II - 31 >**

The following diagrams show three networks consisting of different resistors.

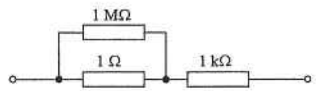
(1)



(2)



(3)



Arrange the above networks in descending order of equivalent resistances :

A. (1), (2), (3)
B. (2), (1), (3)
C. (2), (3), (1)
D. (3), (1), (2)

44. **< HKCE 1991 Paper II - 1 >**

Which of the following is/are vectors ?

(1) momentum
(2) power
(3) voltage

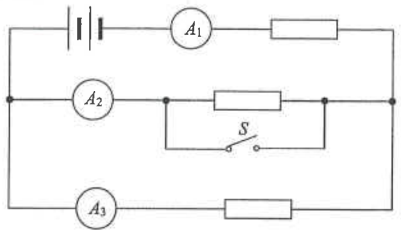
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

45. < HKCE 1992 Paper II - 29 >

The potential difference between two points X and Y in a circuit is 10 V. Which of the following must be true ?

A. 1 J of electrical potential energy is transferred in passing 10 C of charges from X to Y.
B. 5 J of electrical potential energy is transferred in passing 2 C of charges from X to Y.
C. 10 J of electrical potential energy is transferred in passing 1 C of charges from X to Y.
D. The resistance between X and Y is 10 Ω.

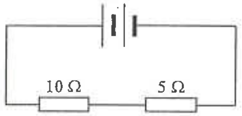
46. < HKCE 1992 Paper II - 31 >



In the circuit above, what happens to the readings of the three ammeters if switch S is closed ?

	A_1	A_2	A_3
A.	increases	increases	increases
B.	remains unchanged	becomes zero	increases
C.	increases	increases	becomes zero
D.	decreases	increases	becomes zero

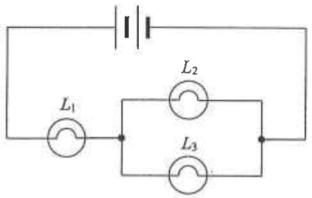
47. < HKCE 1992 Paper II - 32 >



In the circuit shown, what is the power dissipated in the 10 Ω resistor ?

A. 0.8 W
B. 1.6 W
C. 2.4 W
D. 3.6 W

48. < HKCE 1993 Paper II - 32 >

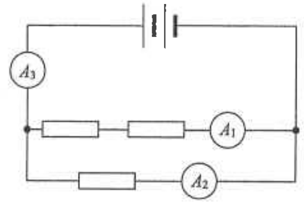


In the circuit, L_1, L_2 and L_3 are identical light bulbs. Which of the following statements is/are true ?

(1) L_2 and L_3 are of the same brightness.
(2) L_1 is brighter than L_2.
(3) The power dissipated in L_1 is equal to the sum of powers dissipated in L_2 and L_3.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

49. < HKCE 1993 Paper II - 29 >



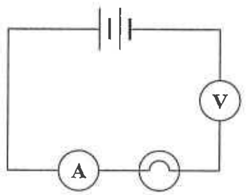
In the circuit shown above, all resistors are identical and the ammeters are of negligible resistance. If the readings of ammeter A_1 is 2 A, find the readings of ammeters A_2 and A_3.

	A_2	A_3
A.	2 A	2 A
B.	2 A	4 A
C.	4 A	2 A
D.	4 A	6 A

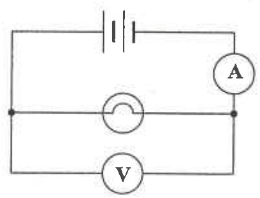
50. < HKCE 1993 Paper II - 30 >

Which of the following circuits can be used to measure the resistance of the light bulb ?

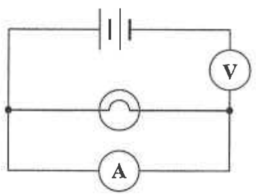
A.



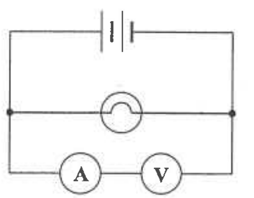
B.



C.



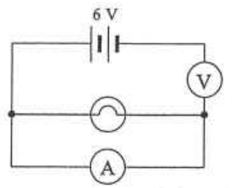
D.



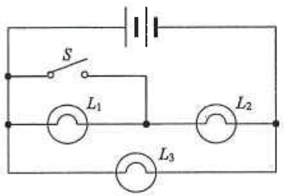
51. < HKCE 1994 Paper II - 26 >

A student uses an ammeter and a voltmeter to find the resistance of a light bulb. He incorrectly connects the circuit as shown. Which of the following is the most probable outcome ?

A. The ammeter burns out.
B. The light bulb burns out.
C. The reading of the voltmeter is zero.
D. The reading of the ammeter is zero.



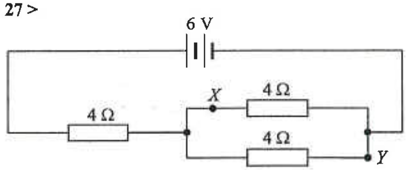
52. **< HKCE 1994 Paper II - 28 >**



In the above circuit, all the light bulbs are identical. What happens to the brightness of the bulbs L_1, L_2 and L_3 if switch S is closed ?

	L_1	L_2	L_3
A.	decreases	increases	remains unchanged
B.	increases	remains unchanged	increases
C.	decreases	remains unchanged	remains unchanged
D.	remains unchanged	decreases	increases

53. **< HKCE 1994 Paper II - 27 >**



Find the p.d. between X and Y in the above circuit.

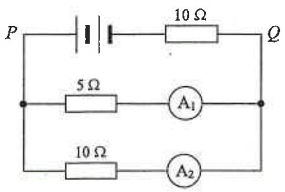
A. 0 V
B. 1 V
C. 2 V
D. 3 V

54. **< HKCE 1994 Paper II - 1 >**

Which of the following is a correct unit for the corresponding physical quantity ?

	Physical quantity	Unit
A.	Work	watt
B.	Electromotive force	newton
C.	Momentum	newton second
D.	Heat capacity	joule per kilogram

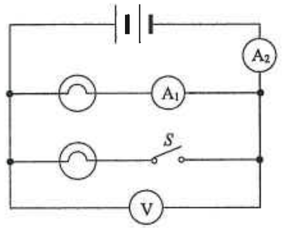
55. **< HKCE 1995 Paper II - 27 >**



In the above circuit, the reading of ammeter A_1 is 0.6 A. Find the p.d. between points P and Q.

A. 3 V
B. 6 V
C. 9 V
D. 12 V

56. **< HKCE 1995 Paper II - 33 >**



In the circuit above, the ammeters have negligible resistance. Which of the following statements are true if switch S is closed ?

(1) The reading of ammeter A_1 decreases.
(2) The reading of ammeter A_2 increases.
(3) The reading of the voltmeter remains unchanged.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

57. **< HKCE 1995 Paper II - 1 >**

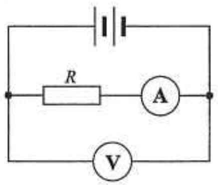
Which of the following pairs of physical quantities has the same units ?

A. Charge and current
B. Work and voltage
C. Kinetic energy and heat
D. Force and momentum

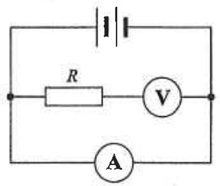
58. **< HKCE 1996 Paper II - 30 >**

It is known that the resistance of a resistor R is about 5 kΩ. Which of the following circuits is most suitable for measuring the resistance of R ? The ammeter and voltmeter used are common moving coil meters.

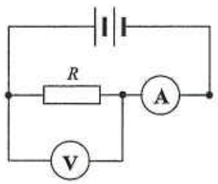
A.



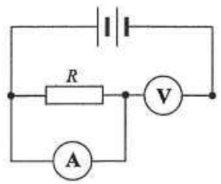
B.



C.



D.

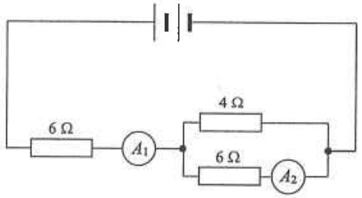


59. **< HKCE 1996 Paper II - 1 >**

Which of the following expressions does not represent energy ?

A. Force × displacement
B. $\frac{1}{2}$ × mass × (speed)^2
C. (Current)^2 × resistance
D. Current × voltage × time

60. < HKCE 1996 Paper II - 27 >



In the circuit shown, the reading of ammeter A_2 is 0.3 A. Find the reading of ammeter A_1.

A. 0.75 A
B. 0.6 A
C. 0.5 A
D. 0.45 A

61. < HKCE 1996 Paper II - 32 >

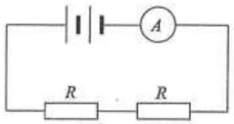


Figure (a)

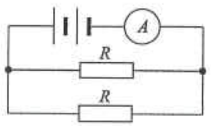


Figure (b)

In Figure (a), the ammeter reading and the total power dissipated in the two identical resistors are I and P respectively. The resistors are rearranged as shown in Figure (b). Find the ammeter reading and the total power dissipated in the two resistors.

	Ammeter reading	Total power dissipated
A.	$2I$	$2P$
B.	$2I$	$4P$
C.	$4I$	$2P$
D.	$4I$	$4P$

62. < HKCE 1997 Paper II - 1 >

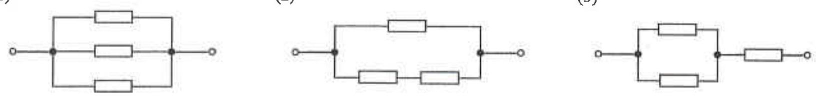
Which of the following expressions represents a physical quantity which is different from the others ?

A. Work / Time
B. $(\text{Voltage})^2$ / Resistance
C. Force × Velocity
D. Mass × Specific latent heat of fusion

63. < HKCE 1997 Paper II - 29 >

All the resistors in the below networks are identical.

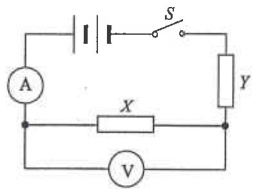
(1) (2) (3)



Arrange the networks in ascending order of equivalent resistances :

A. (1), (2), (3)
B. (1), (3), (2)
C. (2), (1), (3)
D. (3), (1), (2)

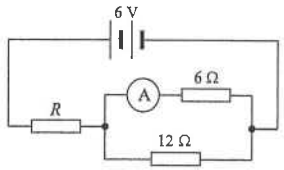
64. < HKCE 1997 Paper II - 31 >



In the circuit shown, X and Y are identical heaters. The ammeter has negligible resistance while the voltmeter has very high resistance. When switch S is closed, the ammeter records a reading but the voltmeter reading is zero. Which of the following provides a possible explanation ?

A. The heater X burns out.
B. The heater Y burns out.
C. The heater X is short-circuited.
D. The heater Y is short-circuited.

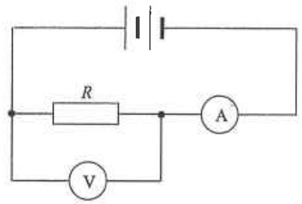
65. < HKCE 1998 Paper II - 30 >



In the above circuit, the reading of the ammeter is 0.4 A. Find the resistance of the resistor R.

A. 3 Ω
B. 5 Ω
C. 6 Ω
D. 9 Ω

66. < HKCE 1999 Paper II - 27 >



A student uses the above circuit to find the resistance of a resistor R

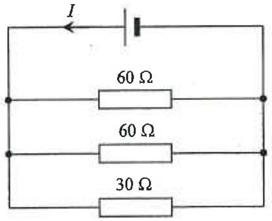
(i.e. resistance $= \dfrac{\text{voltmeter reading}}{\text{ammeter reading}}$).

Which of the following statements is/are correct ?

(1) The ammeter reading records the actual current passing through R.
(2) The voltmeter reading records the actual voltage across R.
(3) The value of the resistance of R obtained is smaller than its actual value.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

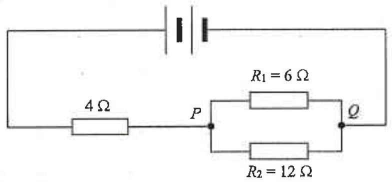
67. **< HKCE 1999 Paper II - 28 >**



In the above circuit, the current delivered by the cell is I. What is the current passing through the 30 Ω resistor ?

A. $\frac{1}{2}I$
B. $\frac{1}{3}I$
C. $\frac{1}{4}I$
D. $\frac{1}{5}I$

68. **< HKCE 2000 Paper II - 30 >**

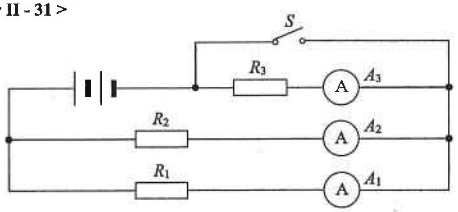


Three resistors are connected to a battery as shown above. Which of the following statements is/are correct ?

(1) The current passing through R_1 is equal to that passing through R_2.
(2) The voltage across R_1 is equal to that across R_2.
(3) The energy dissipated by one coulomb of charge passing through the 4 Ω-resistor is equal to that dissipated by one coulomb of charge passing through PQ.

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

69. **< HKCE 2000 Paper II - 31 >**

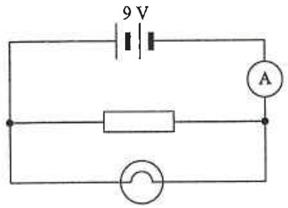


If switch S in the above circuit is closed, which of the following statements is/are correct ?

(1) The readings of ammeters A_1 and A_2 are both increased.
(2) The ratio of the readings of ammeters A_1 and A_2 is increased.
(3) The reading of ammeter A_3 remains unchanged.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

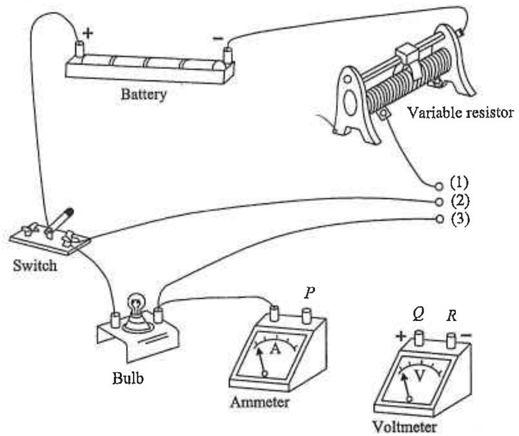
70. **< HKCE 2000 Paper II - 34 >**



A resistor and a bulb are connected in parallel to a 9 V battery as shown above. The reading of the ammeter is 5 A. If the power dissipated by the resistor is 18 W, find the power dissipated by the bulb.

A. 9 W
B. 18 W
C. 22.5 W
D. 27 W

71. **< HKCE 2000 Paper II - 36 >**



The above figure shows an experimental set-up for measuring the resistance of a bulb. To which of the terminals P, Q and R of the ammeter and voltmeter should each of the wires be connected ?

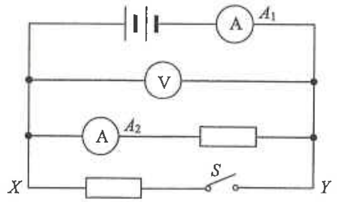
	Wire (1)	Wire (2)	Wire (3)
A.	P	Q	R
B.	P	R	Q
C.	Q	P	R
D.	R	P	Q

72. **< HKCE 2001 Paper II - 27 >**

Which of the following relations is **incorrect** ?

A. 1 ohm (Ω) = 1 volt per ampere (V A^{-1})
B. 1 watt (W) = 1 joule per second (J s^{-1})
C. 1 coulomb (C) = 1 ampere per second (A s^{-1})
D. 1 volt (V) = 1 joule per coulomb (J C^{-1})

73. **< HKCE 2001 Paper II - 30 >**



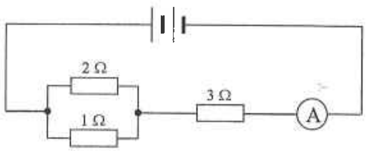
In the above circuit, the two resistors are identical. If switch S is closed, which of the following predictions is **incorrect** ?

A. The reading of the ammeter A_1 increases.
B. The reading of the ammeter A_2 remains unchanged.
C. The voltage between points X and Y increases.
D. The power delivered by the battery increases.

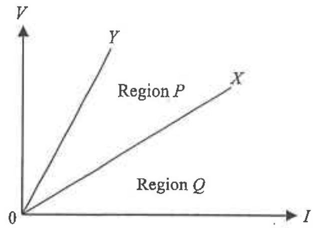
74. **< HKCE 2001 Paper II - 29 >**

If the ammeter in the circuit reads 3 A, find the voltage of the battery.

A. 11 V
B. 12 V
C. 13.5 V
D. 15 V



75. **< HKCE 2002 Paper II - 33 >**



The figure above shows the voltage-current ($V - I$) graphs of two resistors X and Y. Which of the following deductions is/are correct ?

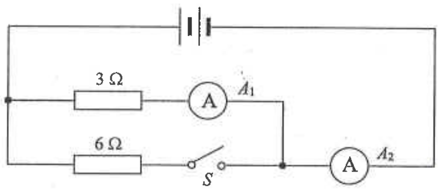
(1) The resistance of X is higher than that of Y.
(2) If X and Y are connected in series, the V-I graph of the combined resistor will lie in region P.
(3) If X and Y are connected in parallel, the V-I graph of the combined resistor will lie in region Q.

A. (2) only
B. (3) only
C. (1) & (2) only
D. (1) & (3) only

76. **< HKCE 2002 Paper II - 30 >**

In the circuit shown, both ammeters A_1 and A_2 read 1 A when the switch S is open. Find the readings of the two ammeters when S is closed.

	A_1	A_2
A.	0.5 A	1.5 A
B.	0.67 A	1 A
C.	1 A	1.5 A
D.	1 A	3 A



77. **< HKCE 2003 Paper II - 33 >**

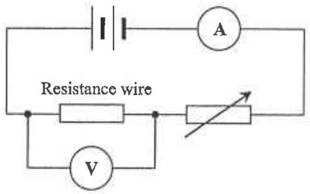


Figure (a)

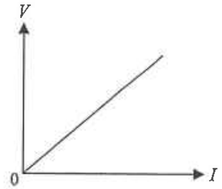
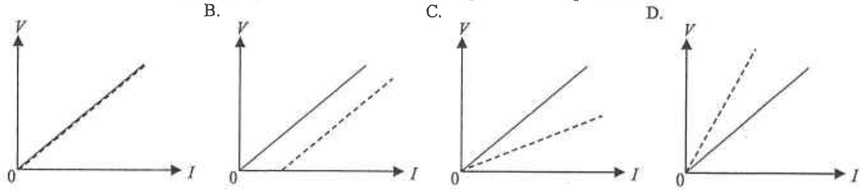


Figure (b)

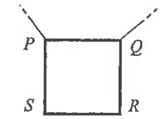
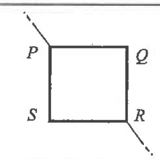
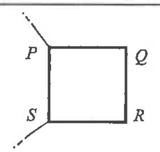
Figure (a) shows a circuit used to investigate how the voltage V across a resistance wire varies with the current I through the wire. The result is shown in Figure (b). If the experiment is repeated using a thinner wire of the same material and of equal length, which of the following graphs (denoted by the dashed line) represents the expected result ?

A. B. C. D.



78. **< HKCE 2003 Paper II - 32 >**

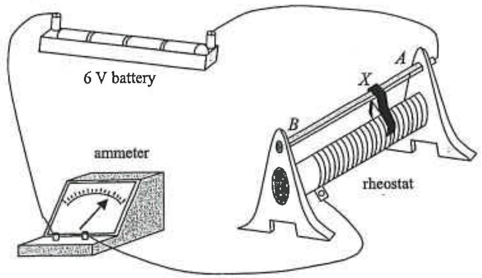
A square loop $PQRS$ is made of uniform resistance wire. Let X, Y and Z be the equivalent resistance of the loop when connected as shown below :

Method of connection	Equivalent resistance
	X
	Y
	Z

Which of the following relations is correct ?

A. $X = Y = Z$
B. $X = Z > Y$
C. $X = Z < Y$
D. $X < Y < Z$

79. < HKCE 2004 Paper II - 31 >

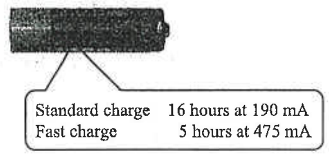


An ammeter and a rheostat of range 0 – 40 Ω are connected to a 6 V battery. The sliding contact is located at a position X where $AX = \frac{1}{4}AB$ as shown above. Find the ammeter reading.

A. 0.15 A
B. 0.2 A
C. 0.45 A
D. 0.6 A

80. < HKCE 2004 Paper II - 28 >

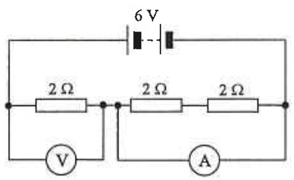
The photograph shows a rechargeable cell. If the cell is charged for 16 hours using the standard charge mode, estimate the total amount of charge flowed through the charging circuit.



A. 182.4 C
B. 3040 C
C. 10 944 C
D. 27 360 C

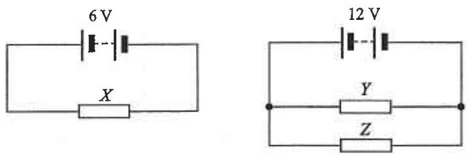
81. < HKCE 2004 Paper II - 29 >

An ammeter with negligible resistance and a high-resistance voltmeter are connected into a circuit as shown. Find the ammeter and voltmeter readings.



	Ammeter reading / A	Voltmeter reading / V
A.	0	2
B.	1	2
C.	3	2
D.	3	6

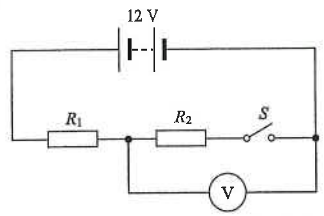
82. < HKCE 2004 Paper II - 32 >



In the above circuits, X, Y and Z are identical resistors. The power dissipated in X is 20 W. Find the total power dissipated in Y and Z.

A. 10 W
B. 20 W
C. 80 W
D. 160 W

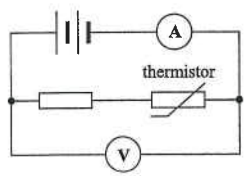
83. < HKCE 2005 Paper II - 19 >



In the above circuit, what is the reading of the voltmeter when switch S is closed ?

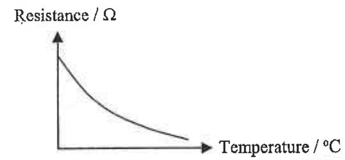
A. zero
B. 6 V
C. 12 V
D. It cannot be determined since insufficient information is given.

Questions 84 and 85 :



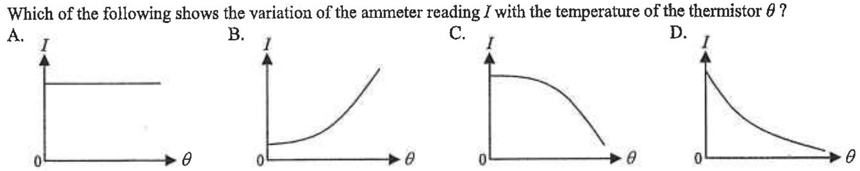
A teacher sets up the circuit as shown in the above Figure and provides the following information to her students.

Thermistors are devices whose resistance varies with temperature. The variation of the resistance of the thermistor used with temperature is shown in the figure below.



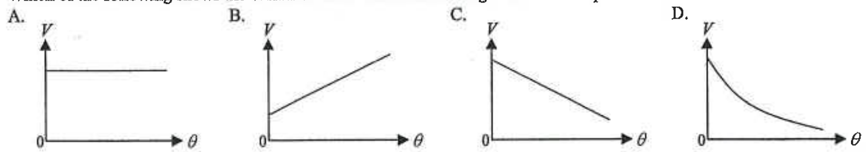
84. < HKCE 2005 Paper II - 40 >

Which of the following shows the variation of the ammeter reading I with the temperature of the thermistor θ ?

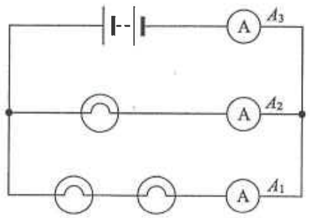


85. < HKCE 2005 Paper II - 41 >

Which of the following shows the variation of the voltmeter reading V with the temperature of the thermistor θ ?



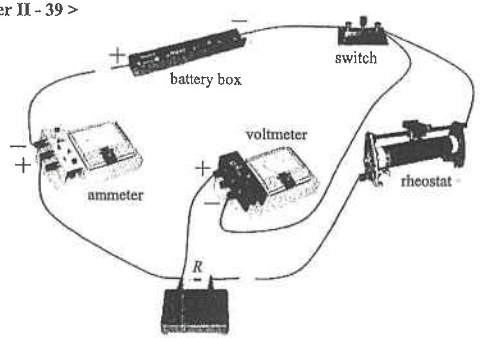
86. **< HKCE 2005 Paper II - 18 >**



In the above circuit, the bulbs are identical. If the reading of ammeter A_1 is 1 A, find the readings of ammeters A_2 and A_3.

	Reading of A_2	Reading of A_3
A.	0.5 A	1 A
B.	0.5 A	1.5 A
C.	2 A	2 A
D.	2 A	3 A

87. **< HKCE 2005 Paper II - 39 >**



A student wants to measure the resistance of a resistor R and sets up a circuit as shown above. Which of the following describe(s) the mistake(s) made by the student in setting up the circuit ?

(1) The polarity of the ammeter is reversed.
(2) The polarity of the voltmeter is reversed.
(3) The voltmeter is connected across both R and the rheostat.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

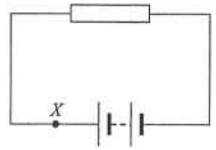
88. **< HKCE 2006 Paper II - 35 >**

Lithium cell :	3.6 V
Capacity :	800 mA h
Time (stand-by mode) :	about 3 days

The figure shows a label on a lithium cell of a mobile phone. The capacity 800 mA h indicates the quantity of electric charges that the cell will discharge in 3 days when the mobile phone is in stand-by mode. Estimate the average power of the cell assuming the voltage remains constant during the discharge.

A. 16 mW
B. 40 mW
C. 120 mW
D. 960 mW

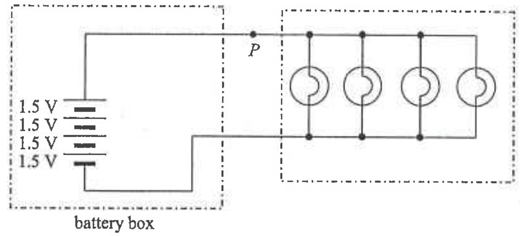
89. **< HKCE 2006 Paper II - 23 >**



If the current in the circuit shown is 0.8 A, what is the number of electrons passing through the point X in 1 minute ?

A. 8.3×10^{16}
B. 1.6×10^{17}
C. 5.0×10^{18}
D. 3.0×10^{20}

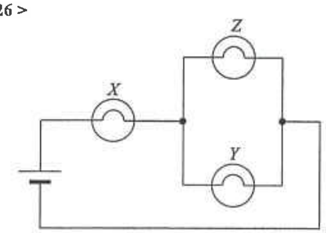
90. **< HKCE 2006 Paper II - 24 >**



The diagram shows the circuit of a camping light which uses four 1.5 V cells and four identical light bulbs. The current passing through each light bulb is 1 A. What is the current passing through the point P and what is the power of each light bulb ?

	Current passing through the point P	Power of each bulb
A.	4 A	6 W
B.	4 A	1.5 W
C.	1 A	6 W
D.	1 A	1.5 W

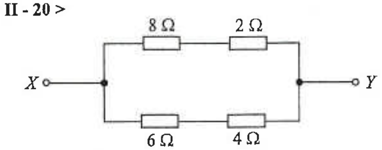
91. **< HKCE 2006 Paper II - 26 >**



Three identical light bulbs are connected to a cell as shown in the diagram. After some time, the filament of bulb Z breaks. What will happen to the brightness of the remaining light bulbs ?

	Brightness of X	Brightness of Y
A.	increases	increases
B.	increases	decreases
C.	decreases	increases
D.	decreases	decreases

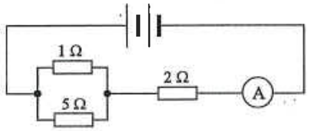
92. < HKCE 2007 Paper II - 20 >



In the circuit shown, a voltage of 10 V is applied across XY. What is the current passing through the 8 Ω resistor ?

A. 0.5 A
B. 0.8 A
C. 1 A
D. 2 A

93. < HKCE 2007 Paper II - 21 >



If the ammeter in the above circuit reads 3 A, what is the voltage of the battery ?

A. 8.5 V
B. 9.6 V
C. 21 V
D. 24 V

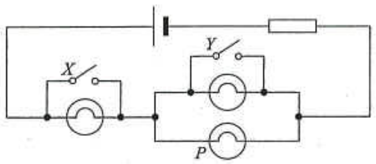
94. < HKCE 2007 Paper II - 22 >

The voltage and the capacity of the cell of a portable music player are 3.6 V and 700 mA h respectively. The continuous playing time of the player is 15 hours. The capacity 700 mA h indicates the quantity of electric charges that the cell will discharge in 15 hours of playing. Assume that the voltage remains constant during discharge, what is the estimated power of the player when it is playing ?

A. 0.047 W
B. 0.168 W
C. 0.194 W
D. 0.252 W

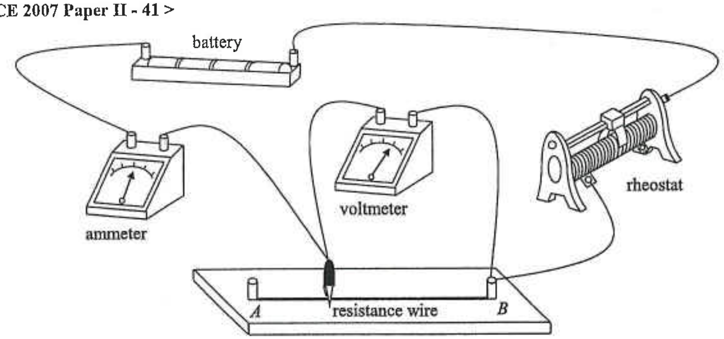
95. < HKCE 2007 Paper II - 23 >

In the following circuit, three identical light bulbs are connected to a cell. Under what conditions will light bulb P have the maximum brightness?



	Switch X	Switch Y
A.	open	closed
B.	open	open
C.	closed	closed
D.	closed	open

96. < HKCE 2007 Paper II - 41 >



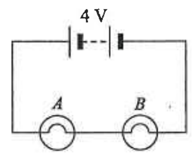
A student sets up the above circuit to study the effect of the length of a resistance wire on its resistance. As the crocodile clip is moved from A to B along the resistance wire, which of the following statements is/are correct ?

(1) The reading of the ammeter increases.
(2) The reading of the voltmeter increases.
(3) The voltmeter reading is directly proportional to the reading of the ammeter.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

97. < HKCE 2008 Paper II - 20 >

The figure shows two light bulbs A and B, which are connected in series. The voltages across A and B are 3 V and 1 V respectively. Which of the following statements is/are correct ?



(1) The resistance of A is greater than that of B.
(2) The current flowing through A is greater than that through B.
(3) A is dimmer than B.

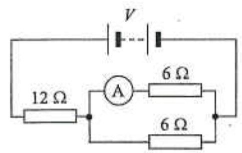
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

98. < HKCE 2008 Paper II - 23 >

A cell fully discharges at a constant current 225 mA in 10 hours. If its average voltage is 1.2 V, what is the estimated total energy stored in the cell ?

A. 2.7 J
B. 6750 J
C. 8100 J
D. 9720 J

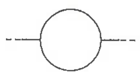
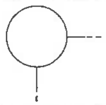
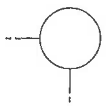
99. < HKCE 2008 Paper II - 21 >



In the above circuit, the reading of the ammeter is 0.3 A. What is the voltage V of the battery ?

A. 4.8 V
B. 5.4 V
C. 9.0 V
D. 14.4 V

100. < HKCE 2008 Paper II - 18 >

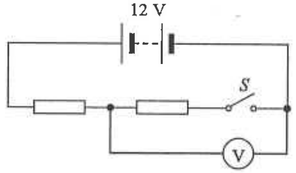
Method of connection	Equivalent resistance
	X
	Y
	Z

A circular loop is made of uniform resistance wire. Let X, Y and Z be the equivalent resistance of the loop when connected as shown above. Which of the following is correct ?

A. $X = Y = Z$
B. $X > Y = Z$
C. $X < Y = Z$
D. $X < Y < Z$

101. < HKCE 2009 Paper II - 19 >

Two identical resistors are connected in series in the circuit shown. What are the readings of the voltmeter when S is open and when S is closed respectively ?

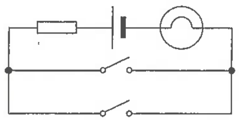


	S is open	S is closed
A.	zero	6 V
B.	zero	12 V
C.	12 V	6 V
D.	12 V	12 V

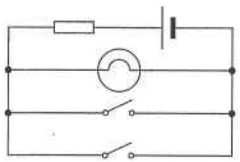
102. < HKCE 2010 Paper II - 17 >

A car has two doors and an indicator lamp is installed to act as a car door warning signal. When either or both doors are open, the lamp lights up. A student designs four different circuits for this application. A switch is installed in each door. The switch is open when the car door opens. Which of the following circuits is correct ?

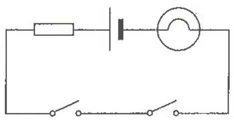
A.



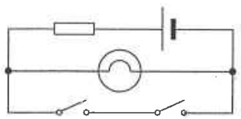
B.



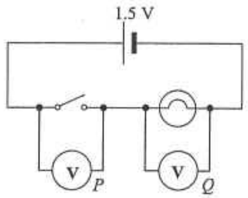
C.



D.



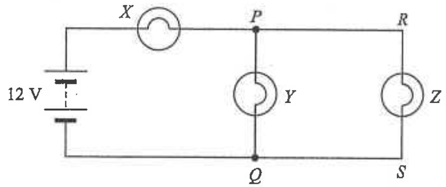
103. < HKCE 2010 Paper II - 18 >



In the circuit above, voltmeters P and Q of very high resistance are connected across the switch and the light bulb respectively. What are the voltmeter readings when the switch is open ?

	reading of P / V	reading of Q / V
A.	0	0
B.	0	1.5
C.	1.5	0
D.	1.5	1.5

104. < HKCE 2010 Paper II - 21 >

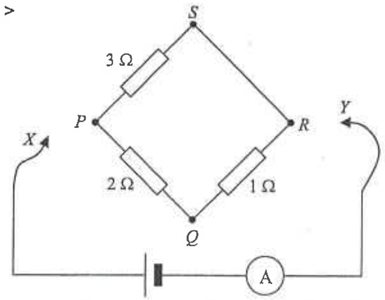


Three identical bulbs X, Y and Z are connected to a 12 V battery in the circuit above. Which of the following statements are correct ?

(1) The voltage across PQ is greater than 6 V.
(2) The voltage across QS is zero.
(3) If Y burns out and becomes open circuit, Z becomes brighter.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

105. < HKCE 2010 Paper II - 41 >

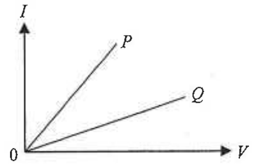


In the circuit shown, wires X and Y are to be connected to two points in the resistor network $PQRS$. Across which two points should X and Y be connected to so that the ammeter reading will be a minimum ?

A. P and Q
B. Q and R
C. R and S
D. S and P

106. **< HKCE 2011 Paper II - 18 >**

The figure below shows the current-voltage (I-V) graphs of two resistors P and Q.



Which of the following statements about the two resistors are correct ?

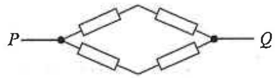
(1) Both of them obey Ohm's law.
(2) The resistance of P is greater than that of Q.
(3) If they are connected in parallel to a battery, the current passing through P will be greater than that passing through Q.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

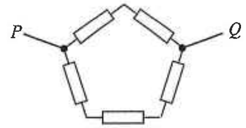
107. **< HKCE 2011 Paper II - 19 >**

Which of the following resistor networks gives the largest equivalent resistance across PQ if all the resistors have the same resistance ?

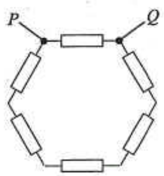
A.



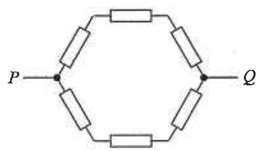
B.



C.



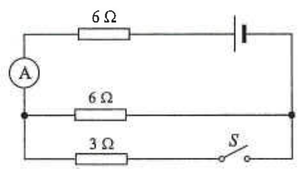
D.



108. **< HKCE 2011 Paper II - 20 >**

In the circuit shown, the ammeter reading is 1.0 A when S is open. What is the ammeter reading when S is closed ?

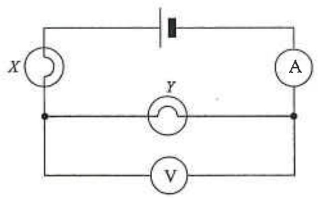
A. 1.5 A
B. 2.0 A
C. 2.5 A
D. 3.0 A



109. **< HKCE 2011 Paper II - 40 >**

In the circuit shown, both bulbs X and Y light up normally. Both the ammeter reading and the voltmeter reading are non-zero. Which of the following will cause the ammeter reading to drop to zero while the voltmeter reading is still non-zero ? Assume meters are ideal.

A. Bulb X becomes short circuit.
B. Bulb Y becomes short circuit.
C. Bulb X is burnt out and becomes open circuit.
D Bulb Y is burnt out and becomes open circuit.

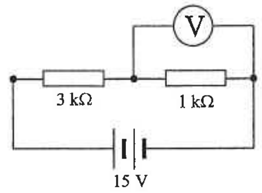


Part B : HKAL examination questions

110. **< HKAL 1980 Paper I - 21 >**

The voltmeter reads 3 V in the circuit shown. The e.m.f. of the battery is 15 V. If the internal resistance of the battery is negligible. What is the internal resistance of the voltmeter ?

A. 0.75 kΩ
B. 1.50 kΩ
C. 3.00 kΩ
D. 3.75 kΩ

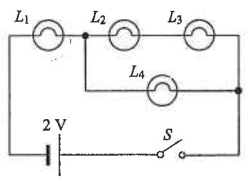


111. **< HKAL 1980 Paper I - 47 >**

When the switch S is closed in the circuit shown, only L_1 lights up. Which of the following possibilities would account for this ?

(1) There is a short circuit across L_4.
(2) The filament of L_2 is burnt out.
(3) The filaments of both L_2 and L_4 are burnt out.

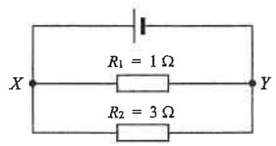
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only



112. **< HKAL 1982 Paper I - 22 >**

In the circuit shown, an electron travelling from Y to X through R_1 loses energy E_1, and an electron travelling from Y to X through R_2 loses energy E_2. What is the relation between E_1 and E_2 ?

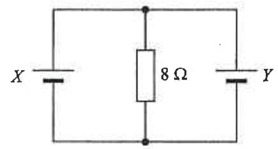
A. $4E_1 = E_2$
B. $3E_1 = E_2$
C. $E_1 = E_2$
D. $E_1 = 3E_2$



113. **< HKAL 1983 Paper I - 20 >**

In the circuit shown, X and Y are two identical cells, of e.m.f. 10 V and internal resistance 4 Ω. What is the current given out by each cell ?

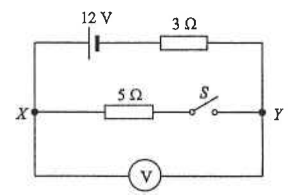
A. zero
B. 0.42 A
C. 0.50 A
D. 0.83 A



114. **< HKAL 1984 Paper I - 21 >**

An ideal voltmeter is connected between points X and Y in the circuit shown. Find the readings of the voltmeter when the switch is open and closed respectively.

	switch open	switch closed
A.	1.5 V	2.5 V
B.	2.5 V	8.0 V
C.	12 V	4.5 V
D.	12 V	7.5 V

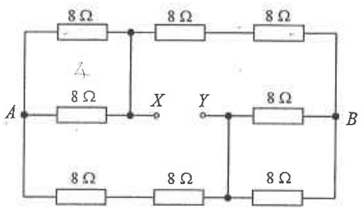


115. < HKAL 1985 Paper I - 44 >

The e.m.f. of a battery is equal to
(1) the electrical power it given out divided by the current it delivers.
(2) the electrical energy it transfers to unit coulomb of charge passing through the battery.
(3) its terminal voltage when the battery is on open circuit.

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

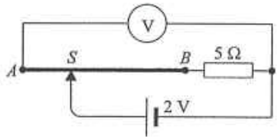
116. < HKAL 1986 Paper I - 34 >



In the circuit shown, if a battery of e.m.f. 20 V with negligible internal resistance is connected across *XY*, what is the current given out by this battery ?

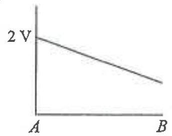
A. 1.0 A.
B. 2.0 A.
C. 2.5 A.
D. 4.0 A.

117. < HKAL 1987 Paper I - 31 >

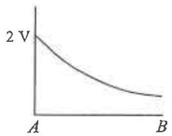


In the above figure, *AB* is a resistance wire of uniform cross-section, and *S* is a sliding contact. The 2 V battery has negligible internal resistance, and the connected voltmeter is ideal. Which of the following graphs shows the correct variation of voltage measured by the voltmeter when the contact *S* is moved from *A* to *B* ?

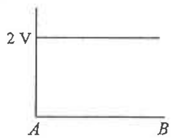
A.



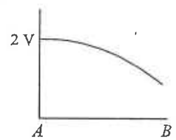
B.



C.

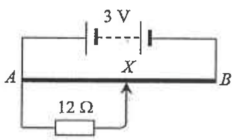


D.



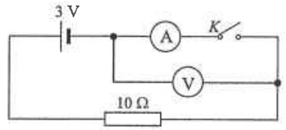
118. < HKAL 1989 Paper I - 31 >

In the circuit shown, *AB* is a metre-wire of resistance 12 Ω. When *X* is moved to the mid-point of *AB*, the p.d. across *AX* will be



A. 0.9 V.
B. 1.2 V.
C. 1.5 V.
D. 1.8 V.

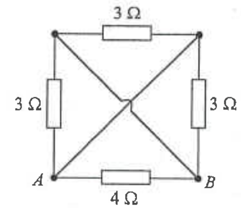
119. < HKAL 1989 Paper I - 28 >



In the circuit shown, *V* is a voltmeter of ~~high internal resistance~~ and *A* is an ammeter of low internal resistance. What is the voltmeter reading when (a) switch *K* is open, (b) switch *K* is closed ?

	K open	*K* closed
A.	0 V	0 V
B.	0 V	2 V
C.	3 V	2 V
D.	3 V	0 V

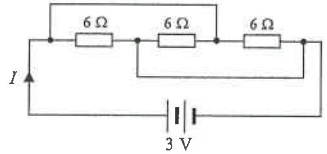
120. < HKAL 1989 Paper I - 29 >



In the circuit shown, four resistors are connected to form a network. The equivalent resistance between *A* and *B* is

A. 0.8 Ω.
B. 1.2 Ω.
C. 1.5 Ω.
D. 2.0 Ω.

121. < HKAL 1990 Paper I - 33 >



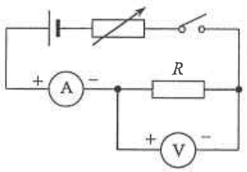
In the circuit shown, the battery has negligible internal resistance. The current *I* delivered by the battery is

A. 0.5 A.
B. 0.9 A.
C. 1.2 A.
D. 1.5 A.

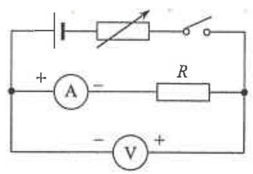
122. < HKAL 1990 Paper I - 34 >

Which of the following circuits is best used for the measurement of a high resistance *R* ?

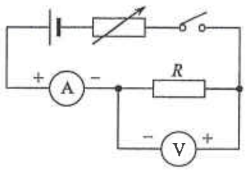
A.



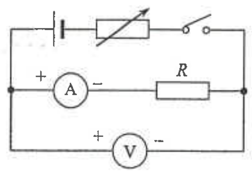
B.



C.

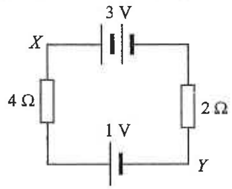


D.



123. < HKAL 1995 Paper IIA - 23 >

Two cells of negligible internal resistance are connected with two resistors as shown. What is the potential difference between X and Y ?



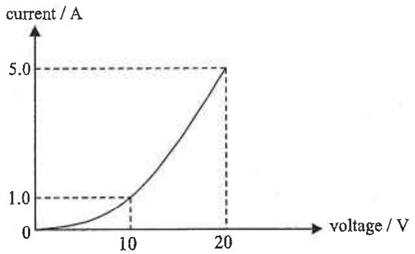
A. 1.33 V
B. 1.67 V
C. 2.00 V
D. 2.33 V

124. < HKAL 1997 Paper IIA - 25 >

Two cylindrical wires, X and Y, are made from the same metal and have the same volume. The length of X is three times that of Y. If currents of 1 A and 2 A pass through X and Y respectively, the ratio of the power dissipation in X to that in Y is

A. 1 : 4
B. 9 : 2
C. 3 : 4
D. 9 : 4

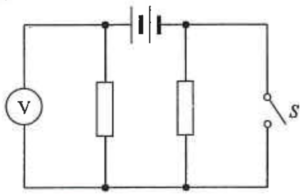
125. < HKAL 1998 Paper IIA - 19 >



The variation of current with the voltage applied across a device is as shown in the figure. What is the change in resistance of the device when the voltage increases from 10 V to 20 V ?

A. It increases by 2.5 Ω.
B. It decreases by 15 Ω.
C. It increases by 6 Ω.
D. It decreases by 6 Ω.

126. < HKAL 1998 Paper IIA - 39 >



In the above circuit, the two resistors are identical. The battery has an e.m.f. of 4 V and it has negligible internal resistance. The voltmeter is ideal. What are the voltmeter readings when S is open and when S is closed ?

	S open	S closed
A.	2 V	4 V
B.	2 V	2 V
C.	0 V	4 V
D.	4 V	0 V

127. < HKAL 1999 Paper IIA - 17 >

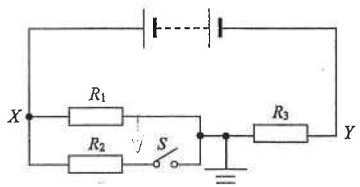
Three resistors of resistance R_1, R_2 and R_3 are connected in parallel. It is known that $R_1 > R_2 > R_3$. The equivalent resistance of this combination is R. Which of the following statements is/are correct ?

(1) Energy dissipated in moving 1 C of charge through the resistor of resistance R_1 is greater than that through R_2.
(2) R is smaller than R_1.
(3) If the resistor with resistance R_3 is removed, the resulting equivalent resistance is increased.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

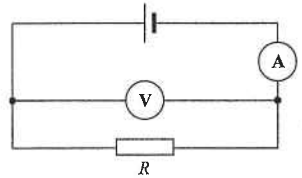
128. < HKAL 1999 Paper IIA - 19 >

In the circuit shown, the battery has negligible internal resistance. The three resistors have same resistance. If switch S is closed, what would happen to the electric potential at points X and at Y ?



	Potential at X	Potential at Y
A.	increase	increase
B.	increase	decrease
C.	decrease	increase
D.	decrease	decrease

129. < HKAL 1999 Paper IIA - 16 >

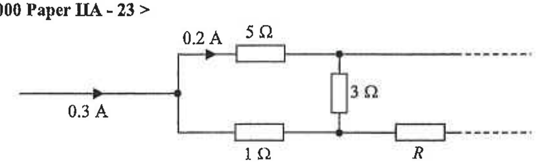


The above circuit can be used to find the resistance of the resistor R. The voltmeter and the ammeter are not ideal. Which of the following statements is/are correct ?

(1) The reading of the ammeter is in fact larger than the actual current passing through R.
(2) The ratio of voltmeter reading to ammeter reading is in fact smaller than the resistance of R.
(3) The circuit is suitable for measuring high resistance.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

130. < HKAL 2000 Paper IIA - 23 >

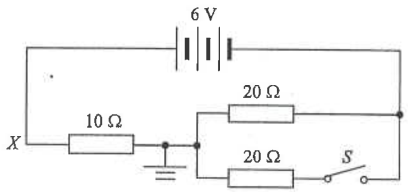


The figure shows part of the circuit in a network of resistors. According to the marked values, find the magnitude and direction of the current passing through the resistor R.

A. 0.2 A from right to left
B. 0.2 A from left to right
C. 0.4 A from right to left
D. 0.4 A from left to right

131. < HKAL 2003 Paper IIA - 25 >

In the circuit shown, a battery of e.m.f. 6 V and negligible internal resistance is connected to three resistors. What are the electric potential at X before and after switch S is closed ?

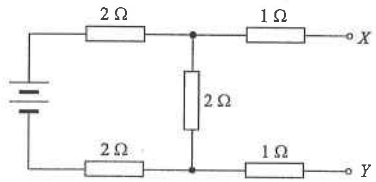


	Before	**After**
A.	+ 6 V	+ 3 V
B.	+ 3 V	+ 3 V
C.	+ 2 V	+ 2 V
D.	+ 2 V	+ 3 V

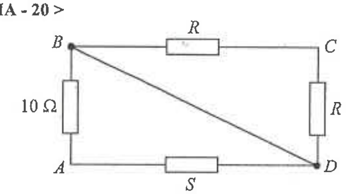
132. < HKAL 2003 Paper IIA - 27 >

In the circuit shown, the battery has constant e.m.f. and negligible internal resistance. An ideal voltmeter connected across terminals X and Y reads 2 V. If an ideal ammeter is connected across X and Y, the ammeter should read

A. 0.3 A
B. 0.5 A
C. 0.6 A
D. 1.0 A



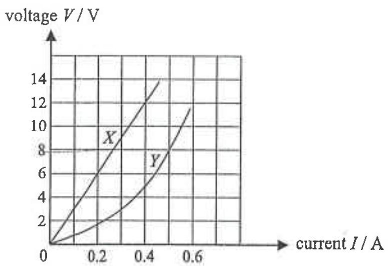
133. < HKAL 2003 Paper IIA - 20 >



In the network of resistors shown above, the resistance of S is infinitely large and the two resistors R are identical. If the equivalent resistance across CD is 25 Ω, what is the equivalent resistance across AC ?

A. 25 Ω
B. 35 Ω
C. 50 Ω
D. infinitely large

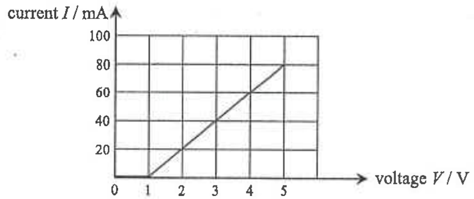
134. < HKAL 2007 Paper IIA - 16 >



The above figure shows the V–I characteristic curves of resistance wire X and filament bulb Y. If they are connected in series to a 12 V d.c. supply of negligible internal resistance, what is the voltage across the resistance wire X ?

A. 9 V
B. 8 V
C. 7 V
D. 6 V

135. < HKAL 2008 Paper IIA - 15 >



The above graph shows the I-V relationship of an electric device. Which of the following statements is/are correct ?

(1) When the applied voltage is 0.5 V, the resistance of the device is infinite.
(2) When the applied voltage is between 1 V and 5 V, the resistance of the device is constant.
(3) When the applied voltage is between 1 V and 5 V, the current is directly proportional to the voltage.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

136. < HKAL 2009 Paper IIA - 28 >

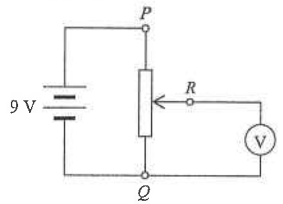


Figure (a)

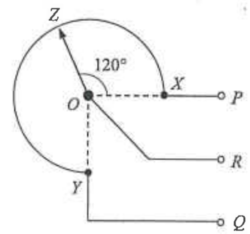


Figure (b)

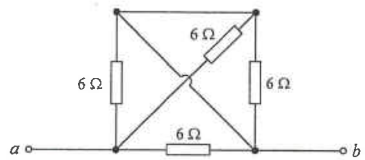
Figure (a) shows a rotary-type potential divider PQR connected to an 9 V battery of negligible internal resistance. The internal structure of the potential divider is shown in Figure (b). XYZ is a uniform resistance wire in the form of a circuit arc with centre O and $\angle XOY = 90°$. OZ is a sliding contact and $\angle XOZ = 120°$. Find the reading of the ideal voltmeter.

A. 2.5 V
B. 4.0 V
C. 5.0 V
D. 6.8 V

137. < HKAL 2010 Paper IIA - 23 >

In the network shown, the resistance of each resistor is 6 Ω. Find the equivalent resistance of the network across a and b.

A. 1.2 Ω
B. 1.5 Ω
C. 2.0 Ω
D. 2.4 Ω



138. < HKAL 2010 Paper IIA - 25 >

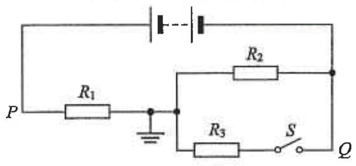
Which of the following statements concerning an ammeter are correct ?

(1) An ammeter should be connected in series to a circuit.
(2) An ammeter should have a low resistance.
(3) An ammeter of high resistance significantly changes the current in the circuit to which it is connected.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

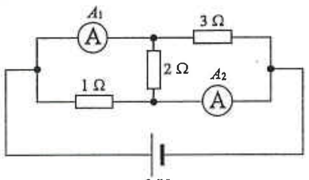
139. < **HKAL 2013 Paper IIA - 24** >

In the circuit shown, the battery has negligible internal resistance. The three resistors have the same resistance. Which statement is **NOT** correct when switch S is closed ?



A. The potential difference across P and Q remains unchanged.
B. The electric potential at P increases.
C. The electric potential at Q decreases.
D. The current flowing through resistor R_2 decreases.

140. < **HKAL 2013 Paper IIA - 25** >



In the above circuit, the cell has an e.m.f. of 3 V and negligible internal resistance. Ammeters A_1 and A_2 have zero resistance. What are the readings of the two ammeters ?

	ammeter A_1	ammeter A_2
A.	1.0 A	1.5 A
B.	1.5 A	3.0 A
C.	1.5 A	4.5 A
D.	2.5 A	4.5 A

Part C : Supplemental exercise

141. Two light bulbs P and Q are connected in parallel to a power supply. The resistance of P is greater than that of Q. Which of the following statements is/are correct ?

(1) The voltage across P is greater than that across Q.
(2) The current through P is smaller than that of Q.
(3) P is brighter than Q.

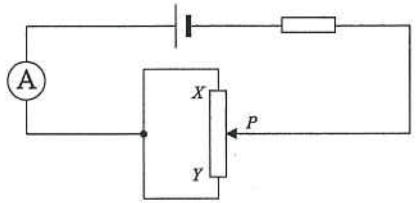
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

142. Two light bulbs P and Q are connected in series to a power supply. The resistance of P is greater than that of Q. Which of the following statements is/are correct ?

(1) The voltage across P is greater than that across Q.
(2) The current through P is smaller than that of Q.
(3) P is brighter than Q.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

143.



In the above circuit, XY is a uniform resistance wire. What is the change of the reading of the ammeter A when the sliding contact P is moved from X to Y ?

A. gradually increases
B. gradually decreases
C. increases and then decreases
D. decreases and then increases

144. Which of the following statements concerning two identical resistors connected in parallel compared with one resistor is/are correct ?

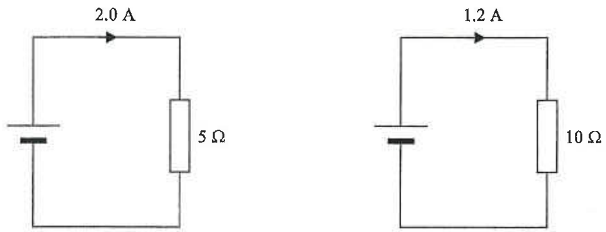
(1) Two resistors consume more power than one resistor.
(2) Two resistors draw more current than one resistor.
(3) The equivalent resistance of two resistors is greater than that of one resistor.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

145. Which of the following is a correct statement of Ohm's Law ?

A. The resistance of a conductor is always constant.
B. The voltage across a conductor is always proportional to the current flowing through it.
C. The resistance of a conductor increases with the temperature.
D. The resistance of a conductor is constant only if the temperature of the conductor is constant.

146.

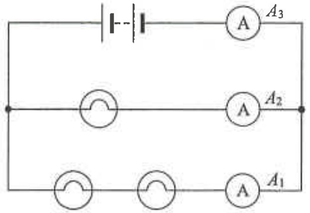


A cell has a constant e.m.f. and internal resistance. If a resistor of resistance 5 Ω is connected in series with the cell, the current is 2.0 A. If the resistor is replaced by another resistor of resistance 10 Ω, the current in the circuit becomes 1.2 A. What is the value of the internal resistance ?

A. 1.5 Ω
B. 2.0 Ω
C. 2.5 Ω
D. 3.0 Ω

Part D : HKDSE examination questions

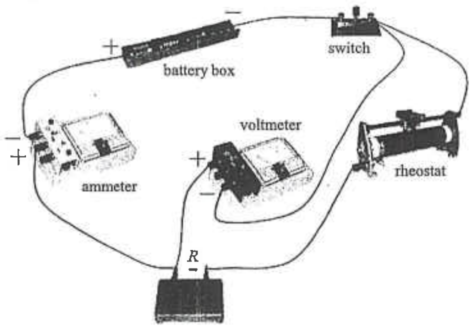
147. **< HKDSE Sample Paper IA - 27 >**



In the above circuit, the bulbs are identical. If the reading of ammeter A_1 is 1 A, find the readings of ammeters A_2 and A_3.

	Reading of A_2	Reading of A_3
A.	2.0 A	2.0 A
B.	2.0 A	3.0 A
C.	0.5 A	1.0 A
D.	0.5 A	1.5 A

148. **< HKDSE Sample Paper IA - 30 >**



A student wants to measure the resistance of a resistor R and sets up a circuit shown. The student made which of these mistakes in setting up the circuit ?

(1) The polarity of the ammeter was reversed.
(2) The polarity of the voltmeter was reversed.
(3) The voltmeter was connected across both R and the rheostat.

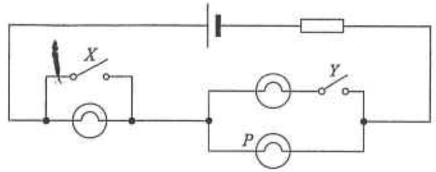
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

149. **< HKDSE Practice Paper IA - 26 >**

Two metal rods, X and Y, of uniform cross-sectional area are made of the same material and have the same volume. The length and resistance of X are L and R respectively. What is the resistance of Y if it has a length of $2L$?

A. $\frac{1}{4}R$
B. $\frac{1}{2}R$
C. $2R$
D. $4R$

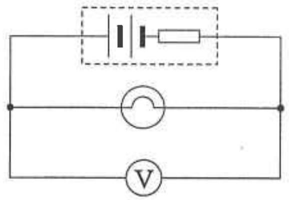
150. **< HKDSE Practice Paper IA - 29 >**



In the circuit shown, three identical light bulbs are connected to a cell. Under what conditions will light bulb P have the maximum brightness ?

	Switch X	Switch Y
A.	closed	open
B.	closed	closed
C.	open	open
D.	open	closed

151. **< HKDSE Practice Paper IA - 27 >**



The figure shows a battery of e.m.f. 3.0 V and internal resistance 2.0 Ω is connected to a light bulb of resistance 10.0 Ω. A voltmeter of internal resistance 10 kΩ is connected in parallel with the light bulb. What is the reading of the voltmeter ?

A. 2.4 V
B. 2.5 V
C. 2.9 V
D. 3.0 V

152. **< HKDSE Practice Paper IA - 28 >**

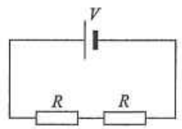


Figure (a)

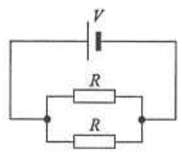
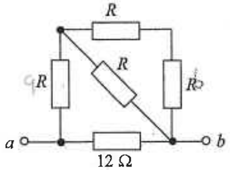


Figure (b)

In Figure (a), two identical resistors are connected in series to a cell of e.m.f. V and negligible internal resistance. The power dissipated by each resistor is P. If the two resistors are now connected in parallel as shown in Figure (b), what is the power dissipated by each resistor ?

A. $2P$
B. $4P$
C. $8P$
D. $16P$

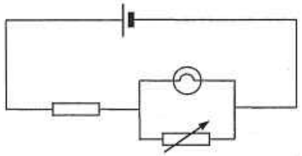
153. < HKDSE 2012 Paper IA - 26 >



In the above network, the resistance across terminals a and b is 6 Ω. If the 12 Ω resistor is replaced by a 6 Ω resistor, the resistance across terminals a and b

A. becomes 2 Ω.
B. becomes 4 Ω.
C. becomes 6 Ω.
D. cannot be found as the value of R is unknown.

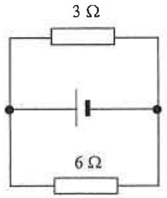
154. < HKDSE 2012 Paper IA - 27 >



What will happen if the variable resistor is set to zero in the circuit ?

A. The light bulb will burn out.
B. The light bulb will not light up.
C. The brightness of the light bulb will increase.
D. The brightness of the light bulb will remain unchanged.

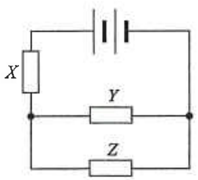
155. < HKDSE 2012 Paper IA - 28 >



In the above circuit, the cell has e.m.f. 12 V and internal resistance 2 Ω. What is the current in the 6 Ω resistor ?

A. 0.5 A
B. 1.0 A
C. 1.5 A
D. 2.0 A

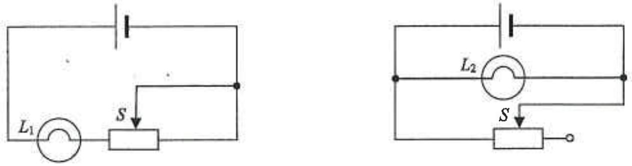
156. < HKDSE 2013 Paper IA - 30 >



Resistors X, Y and Z in the above circuit are identical while the battery of negligible internal resistance supplies a total power of 24 W. What is the power dissipated in resistor Z ?

A. 3 W
B. 4 W
C. 6 W
D. 8 W

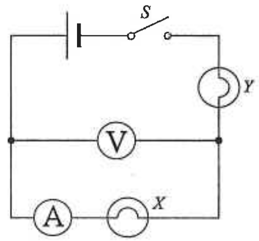
157. < HKDSE 2013 Paper IA - 31 >



In each of the above circuits, the cell has constant e.m.f. and negligible internal resistance. When the sliding contact S of each rheostat shifts from the mid-position to the right, how would the brightness of each bulb change ?

	bulb L_1	bulb L_2
A.	becomes dimmer	remains unchanged
B	becomes dimmer	becomes brighter
C	remains unchanged	becomes dimmer
D	becomes brighter	remains unchanged

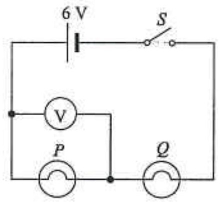
158. < HKDSE 2013 Paper IA - 32 >



In the above circuit, the cell has negligible internal resistance. When switch S is closed, both bulbs are not lit. The voltmeter has a reading but the ammeter reads zero. If only one fault has been developed in the circuit, which of the following is possible ?

A. Bulb X has been shorted accidentally.
B. Bulb Y has been shorted accidentally.
C. Bulb X is burnt out and becomes open circuit.
D. Bulb Y is burnt out and becomes open circuit.

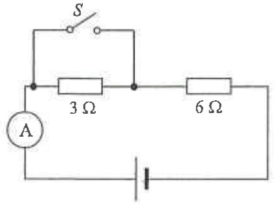
159. < HKDSE 2014 Paper IA - 25 >



The figure shows two light bulbs P and Q connected to a cell of e.m.f. 6 V and negligible internal resistance. The voltmeter reads 6 V when the switch S is closed. Which of the following is possible ?

A. Both P and Q are short-circuited.
B. Both P and Q are burnt out and become open circuit.
C. P is short-circuited or Q is burnt out and becomes open circuit.
D. P is burnt out and becomes open circuit or Q is short-circuited.

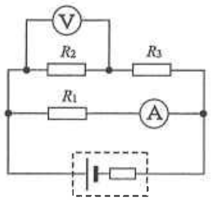
160. < HKDSE 2014 Paper IA - 24 >



In the above circuit, the cell has constant e.m.f. and a fixed internal resistance. When S is closed, the ammeter reads 3.0 A. When S is open, which of the following is a possible reading of the ammeter ?

A. 1.6 A
B. 2.0 A
C. 2.4 A
D. 3.2 A

161. < HKDSE 2015 Paper IA - 26 >



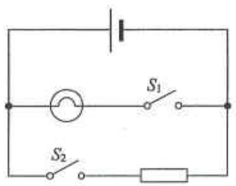
In the above circuit, the cell has a finite internal resistance and both meters are ideal. In which situation below will the readings of the ammeter and the voltmeter suddenly increase ?

A. R_1 is faulty and becomes a short circuit.
B. R_2 is faulty and becomes a short circuit.
C. R_3 is faulty and becomes a short circuit.
D. R_2 is faulty and becomes an open circuit.

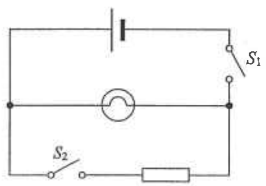
162. < HKDSE 2015 Paper IA - 25 >

For safety purposes, the driver seat of a car is equipped with a seat belt warning light. When the driver seat is occupied, the switch S_1 under his seat will close. If the seat belt is not yet fastened, switch S_2 will remain open and the warning light will light up. If the seat belt is fastened, the switch S_2 will close and the warning light will shut off. Which circuit below is the best design ?

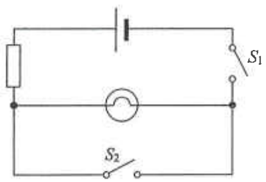
A.



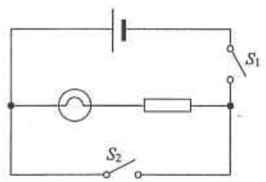
B.



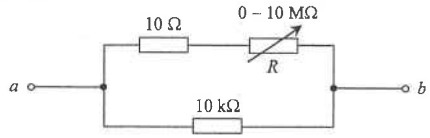
C.



D.



163. < HKDSE 2016 Paper IA - 25 >



In the above circuit, the variable resistor R can be adjusted over its full range from 0 to 10 MΩ. What is the approximate range of resistance between a and b ?

A. 0 Ω to 10 kΩ
B. 10 Ω to 10 kΩ
C. 10 Ω to 10 MΩ
D. 10 kΩ to 10 MΩ

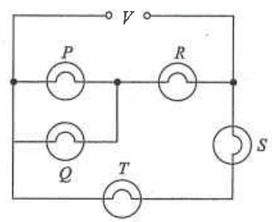
164. < HKDSE 2016 Paper IA - 26 >

Two filament light bulbs X and Y are connected in parallel to a dry cell. X is brighter than Y. Which statements are correct ?

(1) In 1 s, the number of charges flowing through X is greater than that flowing through Y.
(2) In 1 s, the electrical energy dissipated by X is greater than that dissipated by Y.
(3) For every unit charge passing, the electrical energy dissipated by X is equal to that dissipated by Y.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

165. < HKDSE 2016 Paper IA - 27 >

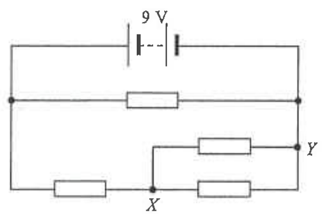


In the above circuit, all the bulbs are identical. If the voltage V gradually increases, which bulb(s) will burn out first ?

A. P and Q
B. R
C. S
D. T

166. < HKDSE 2017 Paper IA - 24 >

In the circuit, all resistors are identical. The internal resistance of the battery can be neglected. What is the potential difference between X and Y ?



A. 1.5 V
B. 3.0 V
C. 4.5 V
D. 6.0 V

167. <HKDSE 2019 Paper IA-24>

168. <HKDSE 2019 Paper IA-25>

169. <HKDSE 2020 Paper IA-22>

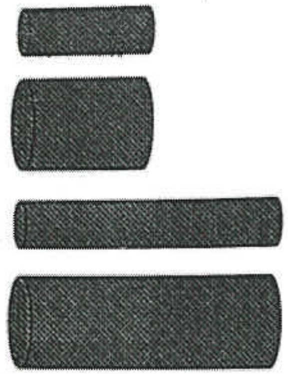
The cylindrical resistors below are made from the same metal. Which one would produce the most power when the same voltage is applied in turns across the two ends of each resistor ?

A.

B.

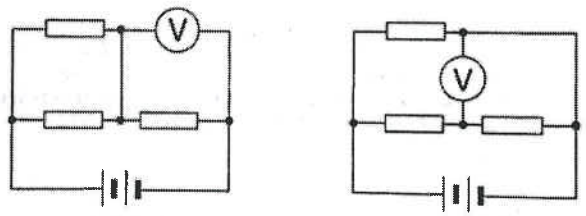
C.

D.



170. <HKDSE 2020 Paper IA-23>

Three identical resistors, a battery of negligible internal resistance and an ideal voltmeter are connected to form Circuits (a) and (b) respectively.



Circuit (a) Circuit (b)

Given that the voltmeter reading is 8 V in Circuit (a), what is the voltmeter reading in Circuit (b) ?

A. 4 V
B. 6 V
C. 8 V
D. 12 V

M.C. Answers

1. D	11. C	21. C	31. C	41. A	51. D
2. A	12. B	22. D	32. C	42. A	52. A
3. D	13. A	23. B	33. B	43. C	53. C
4. C	14. B	24. B	34. D	44. A	54. C
5. B	15. D	25. A	35. C	45. C	55. A
6. C	16. C	26. C	36. A	46. C	56. C
7. B	17. D	27. A	37. C	47. B	57. C
8. C	18. D	28. A	38. D	48. C	58. A
9. A	19. C	29. C	39. B	49. D	59. C
10. D	20. A	30. C	40. D	50. B	60. A
61. D	71. A	81. D	91. C	101. C	111. A
62. D	72. C	82. D	92. C	102. D	112. C
63. A	73. C	83. D	93. A	103. C	113. C
64. C	74. A	84. B	94. B	104. C	114. D
65. C	75. B	85. A	95. D	105. D	115. D
66. D	76. C	86. D	96. A	106. B	116. B
67. A	77. D	87. C	97. A	107. D	117. C
68. C	78. C	88. B	98. D	108. A	118. B
69. A	79. B	89. D	99. C	109. D	119. D
70. D	80. C	90. A	100. B	110. C	120. A
121. D	131. D	141. B	151. B	161. D	
122. D	132. C	142. C	152. B	162. C	
123. D	133. B	143. D	153. B	163. B	
124. D	134. A	144. C	154. B	164. D	
125. D	135. A	145. D	155. B	165. B	
126. A	136. C	146. C	156. B	166. B	
127. D	137. C	147. B	157. A	167. C	
128. D	138. D	148. C	158. C	168. B	
129. C	139. C	149. D	159. D	169. B	
130. A	140. D	150. A	160. C	170. B	

M.C. Solution

1. D

Voltage given to the upper two resistors $= 6$ V

Since voltage is proportional to the resistance for two resistors in series,

voltage across the upper 8-Ω resistor $= 6 \times \dfrac{8}{4+8} = 4$ V

potential difference between points P and $Q = 4$ V

2. A

When K is closed, the voltage across the upper resistor R remains unchanged.

Thus same current flows through the ammeter A, reading of ammeter will not change.

3. D

***K* open :**

all voltage of the cell would be across the voltmeter since its resistance is very large

$\therefore\ V = 2$ V

***K* closed :**

all voltage of the cell would be across the 100 Ω resistor but no voltage across the ammeter

$\therefore\ V = 0$ V

4. C

As the length is halved, the resistance of the heating coil is also halved

since $R \propto \ell \quad \therefore\ R \to \frac{1}{2}R$

Power : $P = \dfrac{V^2}{R} \quad \therefore\ P \propto \dfrac{1}{R} \quad \therefore\ P \to 2P$

Since $E = Pt$, as same energy is required for boiling,

$\therefore\ P \to 2P \Rightarrow t \to \frac{1}{2}t$

$\therefore$ Time taken $= 8 \times \frac{1}{2} = 4$ min.

5. B

Since the two resistors are connected in parallel, each of them has a voltage of 2 V.

$P = \dfrac{V^2}{R} = \dfrac{(2)^2}{(4)} = 1$ W

6. C

Current through the 5000 Ω resistor $= 2 + 8 = 10$ mA

$V_{AB} = IR = (10 \times 10^{-3}) \times (5000) = 50$ V

7. B

The two resistors at the left hand side are in parallel, equivalent resistance is $\frac{R}{2}$.

The three resistors at the right hand side are in parallel, equivalent resistance is $\frac{R}{3}$.

$\therefore\ R = \frac{2}{2} + \frac{2}{3} = 1.67\,\Omega$

As D and B are at the same potential, equivalence resistances across AB and AD are the same.

8. C

Let the voltage of the cell be V

When K is open, the equivalent resistance of the two resistors is $2R$.

$\therefore\ P = \frac{V^2}{2R}$

When K is closed, one of the resistors is shorted and the resistance of the circuit is R

$\therefore\ P' = \frac{V^2}{R}$ $\quad \therefore\ P' = 2P$

9. A

✓ (1) Weight is a type of force which is a vector that has both magnitude and direction

× (2) Charge is a scalar which has no direction (+ or − only indicates two types of charge)

× (3) Voltage is a scalar which has no direction

10. D

Since the voltage across L_1 remains unchanged although L_3 burns out

$\therefore$ the current through L_1 and the power given out by L_1 remain unchanged

$\therefore$ brightness of L_1 remains unchanged.

(Note that L_2 will go out when L_3 burns out)

11. C

Since power : $P = \frac{V^2}{R}$ $\quad \therefore\ R$ decreases $\Rightarrow$ power given out by the cell increases $\Rightarrow$ total brightness increases

As more lamps in parallel $\Rightarrow$ equivalent resistance R decreases $\quad \therefore$ C gives the maximum brightness overall.

12. B

As the voltmeter has same resistance R,

the equivalent resistance of the voltmeter and the resistor in parallel is $\frac{R}{2}$ or $0.5R$

$\therefore$ Voltage across the voltmeter $= 6 \times \frac{0.5R}{R + 0.5R + R} = 1.2\text{ V}$

13. A

Equivalent resistance $= 2 + \frac{2}{2} = 3\,\Omega$

Current flows through $R_1 = \frac{V}{R} = \frac{6}{3} = 2\text{ A}$

Current flows through $R_2 = \frac{2}{2} = 1\text{ A}$ (as R_2 and R_3 are equal.)

Power dissipated by $R_2 = I^2 R = (1)^2 (2) = 2\text{ W}$

14. B

✓ (1) Radius decreases $\Rightarrow$ cross-sectional area decreases $\Rightarrow$ R increases

✓ (2) Length increases $\Rightarrow$ R increases

× (3) Resistance of wire is independent of its shape.

15. D

When connecting in series, same current flows through 2 resistors

$\therefore\ P = I^2 R \propto R$ $\qquad \therefore\ \frac{R_1}{R_2} = \frac{P_1}{P_2} = \frac{1}{4}$

When connecting in parallel, same voltage flows through 2 resistors

$\therefore\ P = \frac{V^2}{R} \propto \frac{1}{R}$ $\qquad \therefore\ \frac{P_1}{P_2} = \frac{R_2}{R_1} = 4$

16. C

Reading of A_1 : same voltage across and same resistance $\Rightarrow$ same current $\therefore$ reading remains unchanged

Reading of A_2 : S closed $\Rightarrow$ voltage across the resistor with A_2 increases $\Rightarrow$ reading of A_2 increases

Reading of A_3 : S closed $\Rightarrow$ no current flows through A_3 as it is shorted $\therefore$ reading becomes zero

17. D

Total current flows into a junction point = total current flows out of the junction point

$\therefore\ 3 + 2 = 1 + I$

$\therefore\ I = 4\text{ A}$

18. D

Energy given out by the heater $= \frac{V^2}{R} \cdot t = \frac{(200)^2}{(50)} \times (3 \times 60) = 144\text{ kJ}$

Energy absorbed by the water $= m\,c\,\Delta T = (1) \times (4.2) \times (20) = 84\text{ kJ}$

Energy wasted $= 144 - 84 = 60\text{ kJ}$

19. C

(a) $R_a = \dfrac{R \times 3R}{R+3R} = \dfrac{3}{4}R$

(b) $R_b = \dfrac{2R \times 2R}{2R+2R} = R$

(c) $R_c = \dfrac{R}{4}$

$\therefore\ R_c < R_a < R_b$

20. A

Brightness of P :

equivalent resistance of the circuit decreases

$\Rightarrow$ current from cell increases

$\Rightarrow$ voltage across resistor increases

$\Rightarrow$ voltage across P decreases

Brightness of R :

same voltage across R after the switch is closed

$\Rightarrow$ same brightness

21. C

Since A_1 indicates the current flowing through the three bulbs,

but A_2 indicates the current flowing through one of the light bulb.

$\therefore\ A_2 = \dfrac{1.8}{3} = 0.6\text{ A}$

22. D

$E = Pt = \dfrac{V^2}{R} \cdot t$ $\therefore\ t \propto R$ as same energy E is required for same heating process

$\therefore\ \dfrac{t_B}{t_A} = \dfrac{R_B}{R_A}$ $\therefore\ \dfrac{(40)}{(10)} = \dfrac{R_B}{(100)}$ $\therefore\ R_B = 400\ \Omega$

23. B

× A. Resistance of V >> resistance of bulb $\therefore$ voltage across voltmeter = voltage across the cell

✓ B. Resistance of A is very small $\therefore$ very large current flows to ammeter $\therefore$ ammeter burns out

× C. Very small current through the bulb $\therefore$ the light bulb would not burn out but go out

× D. Only the ammeter will burn out ; there is only very small current through the voltmeter

24. B

✓ (1) Length increases $\Rightarrow$ resistance increases

× (2) Cross-sectional area increases $\Rightarrow$ resistance decreases

✓ (3) T increases $\Rightarrow$ resistance increases

25. A

When K_1 is closed, voltmeter reads 12 V $\Rightarrow$ unknown resistance = 6 Ω.

Both switches are closed $\Rightarrow$ equivalent resistance of parallel circuit = 3 Ω

$\therefore\ V = 24 \times \dfrac{3}{3+6} = 8\text{ V}$

26. C

Reading of A_1 : same voltage across the resistor with A_1 and same resistance $\Rightarrow$ same current

Reading of A_2 : S closed $\Rightarrow$ voltage across the resistor with A_2 increases $\Rightarrow$ reading of A_2 increases

Reading of A_3 : S closed $\Rightarrow$ shorted circuit $\therefore$ no current flows through A_3

27. A

Assume the resistance of each resistor is 1 Ω.

(1) $R_1 = \dfrac{1}{2} + 1 = \dfrac{3}{2}\Omega$ (2) $R_2 = \dfrac{1 \times 2}{1+2} = \dfrac{2}{3}\Omega$ (3) $R_3 = \dfrac{1}{3}\Omega$

$\therefore\ R_3 < R_2 < R_1$

28. A

P is blown $\Rightarrow$ equivalent resistance of the whole circuit increases

$\Rightarrow$ current given out by the battery decreases

$\Rightarrow$ voltage across Q and S decreases $\therefore$ Q and S both become less bright ($\therefore$ B, C and D are wrong.)

$\Rightarrow$ voltage across R increases ($\therefore$ A is correct.)

29. C

There is a drop in potential when current flows through a resistor.

$\therefore$ Q and R are at the same potential.

As $R_1 > R_2$

$\therefore$ p.d. across PQ > p.d. across RS

30. C

Current passing through 1st row = current passing through 2nd row = 1 A

Current passing through 3rd row $= 1 \times \dfrac{R}{2R} = 0.5\text{ A}$

Current delivered from the battery = 1 + 1 + 0.5 = 2.5 A

31. C

For parallel circuit, voltage across X = voltage across Y.

Same voltage and same charge $\Rightarrow$ same energy required, by $E = QV$

$\therefore\ E_1 = E_2$

32. C

Potential difference between P and Q = voltage across the 3 Ω resistor

$\therefore\ V_{PQ} = \dfrac{3}{3+1} \times 12 = 9\ \text{V}$

33. B

If X is closed, all the lamps will be short-circuited and go out.

If Y is closed, current will only flow through L but not the other two lamps, L would then give out maximum brightness.

34. D

Since $R \propto \dfrac{1}{A}$

For the same length : area A ∝ volume ∝ mass m

$\therefore\ R \propto \dfrac{1}{A} \propto \dfrac{1}{m}$

$\therefore\ \dfrac{R_A}{R_B} = \dfrac{m_B}{m_A} = \dfrac{9}{4}$

35. C

When K is open, power dissipated by A :

$$P_1 = \frac{(V/2)^2}{R} = \frac{1}{4}\cdot\frac{V^2}{R}$$

When K is closed, power dissipated by A :

$$P_2 = \frac{(V/3)^2}{R} = \frac{1}{9}\cdot\frac{V^2}{R}$$

$\therefore\ \dfrac{P_1}{P_2} = \dfrac{\frac{1}{4}}{\frac{1}{9}} = \dfrac{9}{4}$

36. A

Reading of ammeter A :

K is closed ⇒ equivalent resistance of circuit decreases ⇒ current through ammeter increases

Reading of voltmeter V :

K is closed ⇒ the part with K is shorted ⇒ no voltage across K ⇒ no voltage across V

37. C

Connect the additional resistor parallel to the resistor(s) of the largest R (excluding the bulb)

⇒ equivalent resistance of that part of circuit decreases

⇒ current given out from the battery increases ⇒ greatest brightness of the light bulb

∴ The additional resistor should be connected across CD.

(If connected across the bulb, the equivalent resistance with the bulb ↓ and voltage across the bulb ↓)

38. D

$E = Pt = \dfrac{V^2}{R}\cdot t$

As same energy E is required for boiling :

$\therefore\ t \propto \dfrac{1}{V^2}$

$\therefore\ \dfrac{t_2}{t_1} = \dfrac{V_1^2}{V_2^2}$ $\qquad \therefore\ \dfrac{t_2}{T} = \dfrac{(200)^2}{(100)^2}$

$\therefore\ t_2 = 4T$

39. B

equivalent resistance of the circuit $= 4 + \dfrac{(3+1)\times 4}{(3+1)+4} = 6\ \Omega$

current through $XY = \dfrac{6}{6} \times \dfrac{1}{2} = 0.5\ \text{A}$

p.d. between X and Y = voltage across the 3 Ω resistor = 3 × 0.5 = 1.5 V

40. D

×	(1)	same voltage across L_1 ⇒ no change in current through L_1 ∴ same brightness
✓	(2)	L_2 and L_3 are in series ⇒ same current flowing through ⇒ equal brightness
✓	(3)	voltage across $L_1 = 2 \times$ voltage across L_2 ⇒ $P_1 > P_2$ (by $P = V^2/R$) ⇒ L_1 is brighter

41. A

S is closed

⇒ equivalent resistance ↓

⇒ current given out by the battery ↑ (∴ D is incorrect but A is correct by $P = VI$)

⇒ voltage across P ↑ (∴ B is incorrect.)

⇒ voltage across Q ↓

⇒ current across Q ↓ (by $V = IR$) (∴ C is incorrect.)

42. A

Voltmeter V_1 : S is closed ⇒ short circuit across the voltmeter ⇒ $V_1 = 0$ V.

Voltmeter V_2 : $V_2 = \dfrac{20}{10+20} \times 3 = 2\ \text{V}$

43. C

(1) Equivalent resistance ≈ 1 Ω

(2) Equivalent resistance ≈ 1 MΩ (10^6 Ω)

(3) Equivalent resistance ≈ 1 kΩ

∴ Equivalent resistance in descending order : (2), (3), (1)

44. A

✓ (1) momentum is a vector which has direction

× (2) power is energy per time, power is a scalar

× (3) voltage is energy per charge, voltage is a scalar

45. C

By $E = QV$

$\therefore$ (10 J) = (1 C) × (10 V)

C is correct while A and B are incorrect.

Voltage has no direct relationship with resistance $\therefore$ D is incorrect.

46. C

If S is closed, the second row resistor and the third row resistor are shorted,

current flows through A_2, S, the 1st row resistor and A_1 only $\therefore$ A_3 becomes zero

As equivalent resistance decreases $\therefore$ current given out by battery increases $\therefore$ A_1 increases and A_2 increases

($A_1 = A_2$ after the switch S is closed)

47. B

Current of the circuit : $I = \frac{V}{R} = \frac{6}{10+5} = 0.4$ A

Power dissipated in the 10 Ω resistor : $P = I^2 R = (0.4)^2 (10) = 1.6$ W

48. C

✓ (1) As they are in parallel, thus same voltage across L_2 and L_3 to give same brightness

✓ (2) Current through L_1 is the sum of current through L_2 and L_3, thus L_1 is brighter.

× (3) Consider L_2 and L_3 as one equivalent bulb L, same current flowing L_1 and L,
but equivalent resistance of $L < L_1 \Rightarrow P_2 + P_3 < P_1$ (by $P = I^2 R$)

49. D

The 1st row has an equivalent resistance of $2R$ while the 2nd row has a resistance of R

As $V = IR$, the reading of A_2 must be two times the reading of A_1

$\therefore$ reading of $A_2 = 2 \times 2 = 4$ A

$\therefore$ $A_3 = A_1 + A_2 = 2 + 4 = 6$ A

50. B

× A. The voltmeter should not be connected in series to the light bulb.

✓ B. Voltmeter is connected in parallel correctly while ammeter is in series correctly.

× C. Ammeter should not be in parallel and voltmeter should not be in series.

× D. Voltmeter should not be in series with the ammeter.

51. D

× A. Large resistance voltmeter in series ⇒ current is very small ⇒ ammeter would not burn out

× B. Very small current ⇒ light bulb would not burn out

× C. Large resistance voltmeter ⇒ share all the voltage of the circuit ⇒ reading of voltmeter is 6 V

✓ D. Very small current ⇒ reading of ammeter is zero

52. A

S is closed ⇒ no current through L_1 as it is shorted ⇒ brightness of L_1 decreases to zero

Without L_1, all the voltage of the battery is given to L_2, thus brightness of L_2 increases.

Same voltage across L_3 as L_3 is connected in parallel to the battery ⇒ brightness of L_3 is no change

53. C

Equivalent resistance of the circuit : $R = 4 + \frac{4}{2} = 6\ \Omega$

Current flows from the battery : $I = \frac{V}{R} = \frac{6}{6} = 1$ A

Current flow through point $X = 0.5$ A

P.d. between X and $Y = 0.5 \times 4 = 2$ V

54. C

× A. Work → unit : J (watt : unit of power)

× B. Electromotive force → unit : V (Newton : unit of force)

✓ C. Momentum → unit : N s or kg m s^{-1}

× D. Heat capacity → unit : J °C^{-1} (joule per kilogram : specific latent heat)

55. A

p.d. between P and Q = p.d. across 5 Ω resistor

= (0.6)(5) = 3 V

56. C

× (1) Same voltage across the light bulb with A_1 ⇒ I_1 : no change

✓ (2) S closed ⇒ equivalent resistance decreases ⇒ more current given out by battery ⇒ I_2 increases

✓ (3) Same voltage across voltmeter after S is closed since the voltmeter measures the voltage of the battery

57. C

×	A.	Charge : C = A s	Current : A
×	B.	Work : J	voltage : V
✓	C.	Kinetic energy : J	Heat : J
×	D.	Force : N	Momentum : N s

58. A

Since the resistance is 5 kΩ, it is a large resistance.

Circuit in A is used to measure a large resistance.

Current measured by ammeter = current flowing through R

Voltage across R >> voltage across ammeter ⇒ voltage measured by voltmeter ≈ voltage across R

59. C

✓ A. Force × displacement = Work

✓ B. ½ × mass × (speed)^2 = K.E.

× C. (Current)^2 × resistance = Power

✓ D. Current × voltage × time = Power × time = Energy

60. A

Voltage across the lower 6 Ω resistor : $V = IR = (0.3)(6) = 1.8$ V

Current through the 4 Ω resistor : $I = \dfrac{1.8}{4} = 0.45$ A

Reading of A_1 = total current through the two resistors = 0.3 + 0.45 = 0.75 A

61. D

Equivalent resistance of (a) = $2R$ Equivalent resistance of (b) = $\dfrac{R}{2}$

Ammeter reading : $I = \dfrac{V}{R} \propto \dfrac{1}{R} \Rightarrow I' = \dfrac{2R}{R/2} \cdot I = 4I$

Total power dissipated : $P = \dfrac{V^2}{R} \propto \dfrac{1}{R} \Rightarrow P' = \dfrac{2R}{R/2} \cdot P = 4P$

62. D

✓ A. $\dfrac{W}{t} = P$

✓ B. $\dfrac{V^2}{R} = P$

✓ C. $Fv = P$

× D. $m \cdot \ell_v = E$

63. A

Let the resistance of each resistor be R.

(1) $R_1 = \dfrac{1}{3}R$ (2) $R_2 = \dfrac{(2R)(R)}{2R+R} = \dfrac{2}{3}R$ (3) $R_3 = \dfrac{R}{2} + R = \dfrac{3}{2}R$

∴ Equivalent resistance in ascending order : $R_1 < R_2 < R_3$

64. C

× A. If X burns out, ammeter becomes zero.

× B. If Y burns out, ammeter becomes zero.

✓ C. As X is shorted, current by-passes X and flows to Y. Thus, voltmeter gives zero reading.

× D. If Y is shorted, current would flow through X and voltmeter would give a non-zero reading.

65. C

Voltage across 6 Ω = (0.4) × (6) = 2.4 V

Current through the 12 Ω resistor = $\dfrac{2.4}{12}$ = 0.2 A

Current through the resistor R = 0.4 + 0.2 = 0.6 A

Voltage across the resistor R = 6 − 2.4 = 3.6 V

Resistor : $R = \dfrac{V}{I} = \dfrac{3.6}{0.6} = 6\ \Omega$

66. D

× (1) Ammeter reads the total current through the resistor R and the voltmeter.

✓ (2) Since the voltmeter is connected in parallel with R ∴ voltmeter gives the actual voltage across R

✓ (3) By $R = \dfrac{V}{I}$, $I\uparrow \Rightarrow R\downarrow$.

67. A

Equivalent resistance of two 60 Ω resistors = $\dfrac{60}{2}$ = 30 Ω = the resistance at the 3rd row (30 Ω resistor)

∴ Current through 30 Ω resistor = $\dfrac{I}{2}$

68. C

× (1) For same voltage : $I = \dfrac{V}{R} \propto \dfrac{1}{R}$ ∴ current through R_1 is doubled that through R_2

✓ (2) R_1 and R_2 are in parallel ⇒ same voltage across each of them

✓ (3) Equivalent resistance of $PQ = \dfrac{6\times12}{6+12} = 4\ \Omega$ ∴ Voltage across PQ and 4 Ω resistor are the same.

∴ Energy dissipated by each coulomb of charge are the same. (By $E = QV$)

69. A

✓ (1) S closed ⇒ equivalent resistance of circuit ↓ ⇒ current ↑

× (2) For same voltage, $I = \dfrac{V}{R} \propto \dfrac{1}{R}$. Ratio of R kept unchanged ⇒ ratio of I is unchanged

× (3) S closed ⇒ R_3 is shorted ⇒ no current through A_3 ∴ reading of A_3 becomes zero

70. D

Power given out by the battery = VI = (9) (5) = 45 W

Power dissipated by the bulb = 45 − 18 = 27 W

71. A

Ammeter : in series with the bulb and rheostat $\Rightarrow$ wire (1) connected to P

Voltmeter : in parallel with bulb $\Rightarrow$ wires (2) and (3) connected to Q and R

Current flows into voltmeter via (+) terminal $\Rightarrow$ wire (2) connected to Q

72. C

✓	A	Resistance = Voltage / current	$\therefore \Omega = \text{V A}^{-1}$
✓	B	Power = Energy / time	$\therefore \text{W} = \text{J s}^{-1}$
×	C	Charge = Current × time	$\therefore \text{C} = \text{A s}$
✓	D	Voltage = Energy / charge	$\therefore \text{V} = \text{J C}^{-1}$

73. C

✓ A As equivalent resistance of the circuit ↓, current given out by battery ↑ ∴ reading of A_1 ↑

✓ B Since still same voltage across A_2 and the resistor in series ∴ same current through A_2

× C Voltage between X and Y is equal to the voltage across the battery which is unchanged

✓ D As current given out by battery ↑ ∴ power delivered by battery ↑

74. A

Equivalent resistance of the circuit $= \dfrac{2\times1}{2+1}+3=3.67\ \Omega$

Voltage of the battery $= IR = (3)\times(3.67) = 11$ V

75. B

× (1) Slope of V-I graph $= R$. As Y has a greater slope than X ∴ resistance of Y is higher than that of X

× (2) The equivalent resistance of X and Y in series must be greater ∴ the slope must be greater than Y.

✓ (3) The equivalent resistance of X and Y in parallel must be smaller ∴ the slope must be smaller than X

76. C

When switch S is open, $I_1 = 1$ A since same voltage of the battery is across the 3 Ω-resistor

Voltage across the 3 Ω-resistor = voltage of the battery = (1)(3) = 3 V

Voltage across the 6 Ω-resistor = 3 V

Current through the 6 Ω-resistor $= \dfrac{3\text{ V}}{6\ \Omega} = 0.5$ A

Current through the ammeter $A_2 = 1 + 0.5 = 1.5$ A

77. D

For a thinner wire, the resistance should be greater.

Since the slope of the V-I graph represents the resistance of the wire,

thus the slope should be greater as shown in D.

78. C

Suppose each length of the square has a resistance of 1 Ω.

$X = \dfrac{1\times3}{1+3} = 0.75\ \Omega$ $\quad Y = \dfrac{2\times2}{2+2} = 1\ \Omega$ $\quad Z = \dfrac{1\times3}{1+3} = 0.75\ \Omega$

$\therefore X = Z < Y$

79. B

The current flows through the resistance coil between XB only.

Resistance of coil between $XB = 40 \times \dfrac{3}{4} = 30\ \Omega$

Current : $I = \dfrac{V}{R} = \dfrac{6}{30} = 0.2$ A

80. C

$Q = It$

$= (190 \times 10^{-3}) \times (16 \times 60 \times 60)$

$= 10944$ C

81. D

Since the ammeter has no resistance, the two resistors at the right are shorted and no current flows through them.

The current will flow through the resistor at the left and then through the ammeter.

Ammeter reading $= \dfrac{6}{2} = 3$ A

Voltmeter reading = 6 V

82. D

Let the resistance of X be R.

By $P = \dfrac{V^2}{R}$ $\quad \therefore (20) = \dfrac{(6)^2}{R}$ $\quad \therefore R = 1.8\ \Omega$

Equivalent resistance of Y and $Z = \dfrac{1.8}{2} = 0.9\ \Omega$

Total power dissipated in Y and $Z = \dfrac{V^2}{R} = \dfrac{(12)^2}{(0.9)} = 160$ W

83. D

Since the voltage of the battery 12 V is shared between R_1 and R_2,

the resistances of R_1 and R_2 have to be given in order to calculate the reading of the voltmeter.

84. B

When temperature θ is increased, resistance of the thermistor is decreased, thus the current should increase as shown in B.

85. A

Since the voltmeter measures the voltage across the battery, the reading should be constant.

86. D

Reading of A_2 is two times that of A_1 since the resistance is halved. Thus, reading of A_2 = 2 A

Reading of A_3 is the sum of A_1 and A_2 $\therefore$ reading of $A_3 = 1 + 2 = 3$ A

87. C

✓ (1) The polarity of the ammeter is wrongly connected in reverse direction.
Current should flow into the (+) terminal and out of the (–) terminal.

× (2) The voltmeter is correctly connected.

✓ (3) The voltmeter should be connected across the resistor R only.

88. B

① Capacity : Q = 800 mA h = $(800 \times 10^{-3}$ A$) \times (3600$ s$)$ = 2880 C

② $E = QV = (2880) \times (3.6) = 10368$ J

③ $P = \dfrac{E}{t} = \dfrac{10368}{3 \times 24 \times 3600} = 0.04$ W = 40 mW

89. D

① $Q = It = (0.8) \times (1 \times 60) = 48$ C

② number of electrons $= \dfrac{48}{1.6 \times 10^{-19}} = 3.0 \times 10^{20}$

90. A

Current passing through point $P = 4 \times 1 = 4$ A

Voltage across each light bulb $= 4 \times 1.5 = 6$ V

Current through each light bulb = 1 A

Power of each light bulb $= VI = (6) \times (1) = 6$ W

91. C

If filament of bulb Z breaks, equivalent resistance of the whole circuit increases. Current delivered by the cell decreases.

Voltage across bulb X decreases, thus brightness of X decreases.

Voltage across bulb Y increases, thus brightness of Y increases.

92. C

Voltage across the 8 Ω and 2 Ω resistors = 10 V

Equivalent resistance of the 8 Ω and 2 Ω resistors $= 8 + 2 = 10$ Ω

Current through the two resistors : $I = \dfrac{V}{R} = \dfrac{10}{10} = 1$ A

93. A

Equivalent resistance of the whole circuit $= \dfrac{1 \times 5}{1 + 5} + 2 = 2.833$ Ω

Voltage of the battery : $V = IR = (3) \times (2.833) = 8.5$ V

94. B

By $Q = It$ $\therefore$ (700 mA h) $= I$(15 h) $\therefore I = 0.04667$ A

By $P = VI$ $\therefore P = (3.6)(0.04667) = 0.168$ W

95. D

If switch X is closed, the left light bulb is shorted,
and the equivalent resistance of the circuit would decrease, thus current given by the cell is increased.

If switch Y is closed, the light bulb P would be shorted and would not light, thus Y must be opened.

96. A

✓ (1) From A to B, the resistance of the circuit decrease, thus the current in the circuit increases.

× (2) As current increases, the voltage across the rheostat increases, thus the voltage across the wire decreases.

× (3) Since the resistance of the wire is not constant,
the voltage across the wire will not be proportion to the current through the wire.

97. A

✓ (1) Since the two light bulbs are in series, same current flows through each of them.
Thus, the voltage is proportional to the resistance.
Since voltage across A is greater, thus the resistance of A is greater than B.

× (2) Current must be the same for two light bulbs in series.

× (3) By $P = VI$, since A has greater voltage and same current, power of A is greater, thus A is brighter.

98. D

$Q = It = (0.225)(10 \times 3600) = 8100$ C
$E = QV = (8100)(1.2) = 9720$ J

OR

$P = VI = (1.2)(225 \times 10^{-3}) = 0.27$ W
$E = Pt = (0.27)(10 \times 3600) = 9720$ J

99. C

Current through the upper 6 Ω-resistor = 0.3 A

Current through the lower 6 Ω-resistor = 0.3 A

Current through the 12 Ω-resistor $= 0.3 + 0.3 = 0.6$ A

Thus current delivered from the cell = 0.6 A

Total equivalent resistance of the circuit $= 12 + \dfrac{6}{2} = 15$ Ω

Voltage of the battery $V = IR = (0.6)(15) = 9.0$ V

100. B

Assume the circumference of the circle consists of 4 equal arcs, each arc has a resistance of R.

X : The equivalent resistance is two resistors, each of $2R$ in parallel, i.e. equal to R.

Y : The equivalent resistance is two resistors, one of $3R$ and the other of R, in parallel, i.e. equal to $3R / 4$.

Z : The equivalent resistance is two resistors, one of R and the other of $3R$, in parallel, i.e. equal to $3R / 4$.

$\therefore X > Y = Z$

101. C

When S is open, the left resistor and the voltmeter are in series.

As the resistance of the voltmeter is infinite, all the voltage would be given to the voltmeter, reading is 12 V.

When S is closed, the two resistors are in series, and each resistor shares half of the voltage of the battery.

The voltmeter measures the voltage of the right resistor, thus the reading is $12 \times \frac{1}{2} = 6$ V.

102. D

× A. When both switches are open, the lamp would not light up.

× B. When either switch is open, the lamp would not light up.

× C. When only one switch is open and one is closed, the lamp would not light up.

✓ D. When either or both switches are open, the lamp lights up.

103. C

When the switch is open, no current is given out by the cell.

As no current flows through the light bulb, voltage across the light bulb is zero, thus reading of voltmeter Q is 0 V.

All the voltage of the cell is then given to the switch, thus the reading of voltmeter P is 1.5 V.

104. C

× (1) Let the resistance of each bulb be R.
The equivalent resistance of Y and Z is $R/2$, which is less than that of X.
Thus the voltage across PQ should be less than 6 V.

✓ (2) As Q and S are shorted, there is no voltage across these two points.

✓ (3) If Y burns out, voltage across Z would increase to 6 V, thus Z becomes brighter.

105. D

Equivalent resistance between PQ = 1.33 Ω

Equivalent resistance between QR = 0.83 Ω

Equivalent resistance between RS = 0 Ω

Equivalent resistance between SP = 1.5 Ω

As the equivalent resistance across S and P is the maximum, minimum current would be given out by the cell, thus the ammeter reading is the minimum.

106. B

✓ (1) Since both of them are straight line passing through the origin, $I \propto V$, thus they obey Ohm's Law.

× (2) Resistance is equal to the reciprocal of slope, i.e. $R = 1 / \text{slope}$.
As the slope of P is greater, resistance of P is smaller.

✓ (3) In parallel, $I \propto 1/R$, since resistance of P is smaller, current passing through P is greater.

107. D

Assume each resistor has a resistance of 2 Ω.

$R_A = \frac{2+2}{2} = 2\ \Omega$ $\qquad R_B = \frac{4\times 6}{4+6} = 2.4\ \Omega$

$R_C = \frac{2\times 10}{2+10} = 1.67\ \Omega$ $\qquad R_D = \frac{2+2+2}{2} = 3\ \Omega$

Network D has the largest equivalent resistance.

108. A

Voltage of the cell = (1) (6 + 6) = 12 V

When S is closed, total equivalent resistance of the whole circuit $= 6 + \frac{6\times 3}{6+3} = 8\ \Omega$

Current given out by the cell $= \frac{12}{8} = 1.5$ A

109. D

× A. If X is short circuit, current still flows through X, Y and the ammeter.

× B. If Y is short circuit, current still flows through X, Y and the ammeter.

× C. If X is open circuit, no current can flow through X, thus both ammeter and voltmeter have zero reading.

✓ D. If Y is open circuit, since ideal voltmeter has infinite resistance, no current flows from the cell.
Reading of ammeter is zero.
However, the voltmeter will read the voltage of the cell and is non-zero.

110. C

As 1 kΩ resistor and voltmeter are in parallel, $V_{\text{voltmeter}} = V_{1\Omega} = 3$ V.

For series circuit, $V \propto R$ $\quad \therefore \frac{15-3}{3} = \frac{3}{R}$ $\quad \therefore R = 0.75\,\text{k}\Omega$

$\frac{1}{R} = \frac{1}{R_{1\Omega}} + \frac{1}{R_V}$ $\quad \therefore \frac{1}{(0.75)} = \frac{1}{(1)} + \frac{1}{R_V}$ $\quad \therefore R_V = 3$ kΩ

111. A

✓ (1) Short circuit across L_4 ⇒ current does not flow through L_2 and L_3 ⇒ L_1 lights only

× (2) Filament of L_2 burnt out ⇒ current can flow through L_4 ⇒ L_4 can also light

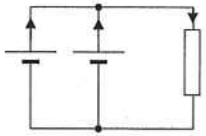
× (3) Both filament burnt out ⇒ no current flow through L_1 ⇒ L_1 does not light

112. C

By $E = qV$

$\therefore\ V_{R_1} = V_{R_2} \Rightarrow E_1 = E_2$ (q is the charge of one electron)

113. C



Equivalent e.m.f. of the two cells = 10 V

Equivalent internal resistance of the two cells $= \frac{4}{2} = 2\ \Omega$

Current through the resistor : $I = \frac{V}{R} = \frac{10}{2+8} = 1\ \text{A}$

Current given out by each cell $= 1 \times \frac{1}{2} = 0.5\ \text{A}$

114. D

① When S is open, the voltmeter is connected in series with the 12 V battery,
thus there is no current flow as the resistance of the voltmeter is infinite.
There is no voltage shared by the 3 Ω resistor.
Thus all the voltage of 12 V is given to the voltmeter to give the reading of 12 V.

② When S is closed, the 3 Ω and 5 Ω resistors are in series.

Voltage shared by the 5 Ω resistor $= 12 \times \frac{5}{3+5} = 7.5\ \text{V}$

115. D

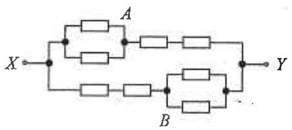
✓ (1) $\varepsilon = \frac{P}{I}$

✓ (2) $\varepsilon = \frac{E}{q}$

✓ (3) Open circuit ⇒ no current ⇒ no voltage drop across the internal resistance ⇒ $\varepsilon = V$

116. B

The circuit diagram can be redrawn as shown :



$\because$ Equivalent resistance $= \dfrac{\frac{8}{2}+8+8}{2} = 10\ \Omega$

$\therefore\ I = \frac{V}{R} = \frac{20}{10} = 2\ \text{A}$

117. C

Since resistance of voltmeter is infinite, there is no current flows through AS, thus no voltage across AS.

Voltmeter thus measures the voltage across the battery which is always equal to 2 V.

Thus, the graph should be a horizontal line.

118. B

X is the mid-point of $AB \Rightarrow R_{AX} = R_{XB} = 6\ \Omega$

Equivalent resistance across $AX = \frac{6 \times 12}{6+12} = 4\ \Omega$

$\frac{V_{AX}}{\varepsilon} = \frac{R_{AX}}{R_{AB}}$

$\frac{V_{AX}}{(3)} = \frac{4}{4+6}$ $\therefore\ V_{AX} = 1.2\ \text{V}$

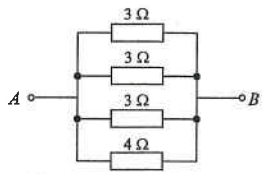
119. D

K open : Voltmeter is in series with the 10 Ω-resistor, thus no current given out by the cell
As no voltage across the 10 Ω-resistor, all the voltage of the cell is given to the voltmeter
$\therefore$ reading = 3 V

K closed : Voltmeter is in parallel with the ammeter, all the voltage of the cell is given to the 10 Ω-resistor
There is no voltage across the ammeter
$\therefore$ reading = 0 V

120. A

The circuit diagram can be redrawn as shown.



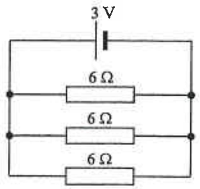
Let R be the equivalent resistance.

$\frac{1}{R} = \frac{1}{(3)} + \frac{1}{(3)} + \frac{1}{(3)} + \frac{1}{(4)}$

$\therefore\ R = 0.8\ \Omega$

121. D

The circuit diagram can be redrawn as shown.



The three resistors are in parallel.

Equivalent resistance :

$R = \frac{(6)}{3} = 2\ \Omega$

$\therefore\ I = \frac{V}{R} = \frac{(3)}{(2)} = 1.5\ \text{A}$

122. D

To measure a high resistance R, voltmeter should be connected in parallel across the resistor and the ammeter.

The ammeter can read the actual current flowing through the resistor.

Since the resistance of the ammeter is small compared with the resistor, the voltage across the ammeter is negligible.

Thus, the voltmeter reading is close to the actual voltage across the resistor.

Circuit A is used to measure a low resistance R.

Note that current flowing through the ammeter and voltmeter must be from (+) terminal to the (+) terminal of the meters.

123. D

The cell 3 V is discharging and gives out current while the 1 V cell is under charging.

Net e.m.f. $= 3 - 1 = 2$ V

$\therefore\ I = \dfrac{2}{2+4} = 0.333$ A

$V_{4\Omega} = 0.333 \times 4 = 1.33$ V

p.d. across X and Y $= 1.33 + 1 = 2.33$ V

124. D

$P = I^2R = I^2 \cdot \dfrac{\rho\ell}{A} \propto I^2 \cdot \dfrac{\ell \cdot \ell}{A \cdot \ell} \propto \dfrac{I^2 \cdot \ell^2}{V} \propto I^2 \cdot \ell^2$ where volume of wire : $V = A \cdot \ell$

$\therefore\ \dfrac{P_X}{P_Y} = \left(\dfrac{I_X}{I_Y}\right)^2 \left(\dfrac{\ell_X}{\ell_Y}\right)^2 = \left(\dfrac{1}{2}\right)^2 (3)^2 = \dfrac{9}{4}$

125. D

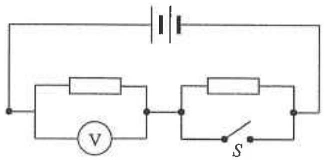
Note that the device does not obey Ohm's law, resistance is found by $R = \dfrac{V}{I}$

$\Delta R = \dfrac{20}{5} - \dfrac{10}{1} = -6\ \Omega$

The resistance decreases by 6 Ω.

126. A

The circuit diagram can be redrawn as :



S open : Voltage of the battery is shared among 2 resistors. Then, voltmeter measures voltage across 1 resistor only, which is equal to half of the e.m.f., that is, 2 V.

S closed : The right resistor is shorted, all the voltage of the battery is given to the left resistor. Thus, voltmeter measures the e.m.f. of the battery, that is, 4 V.

127. D

× (1) Resistors in parallel have same voltage ⇒ same energy dissipated by the 1 C charge (by $E = QV$)

✓ (2) For parallel circuit, equivalent resistance < resistance of every individual resistor, $\therefore R < R_1$

✓ (3) Less resistors in parallel ⇒ $R\uparrow$

128. D

S is closed ⇒ equivalent resistance of R_1 and $R_2\downarrow$ ⇒ p.d. across $R_1\downarrow$ but p.d. across $R_3\uparrow$

Potential at the earthed point is 0 V.

Potential at X: decrease (as p.d. across $R_1\downarrow$)

Potential at Y: decrease (as p.d. across $R_3\uparrow$)

129. C

✓ (1) Reading of ammeter gives the sum of current flowing through R and voltmeter.

✓ (2) By $R = \dfrac{V}{I}$, larger measured I ⇒ smaller measured R

× (3) High resistance of resistor R ⇒ large current across voltmeter ⇒ incorrect ammeter reading

130. A

$I_{1\Omega} = 0.3 - 0.2 = 0.1$ A (from left to right)

$V_{5\Omega} = (0.2)(5) = 1$ V $\qquad V_{1\Omega} = (0.1)(1) = 0.1$ V

∴ The lower intersection point is at a higher potential since the potential drops only 0.1 V which is less than 1 V.

$I_{3\Omega} = \dfrac{1-0.1}{3} = 0.3$ A (from bottom to top)

$\therefore\ I_R = 0.3 - 0.1 = 0.2$ A (from right to left)

131. D

The potential of earthed point is 0 V.

Before switch S is closed, potential difference across the 10 Ω resistor = 2 V.

Thus potential at $P = +2$ V.

After switch S is closed, potential difference across the 10 Ω resistor = 3 V.

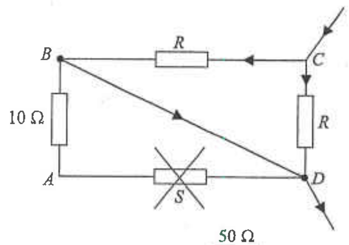
Thus potential at $P = +3$ V.

132. C

When the voltmeter with infinite resistance is connected, there is no current flowing through the two 1 Ω resistors. Since voltage across the middle 2 Ω resistor is 2 V, the battery has e.m.f. of 6 V.

When the ammeter with zero resistance is connected, the equivalent resistance of the whole circuit is 5 Ω. Current delivered from the battery is 1.2 A. Current flows from X to Y is 0.6 A.

133. B

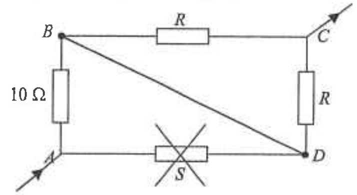


Across CD, no current flows through the 10 Ω resistor and S.

The two resistors R and R are in parallel.

$\therefore\ \dfrac{R}{2} = 25 \qquad \therefore\ R = 50\ \Omega$

Across AC, no current flows through S.



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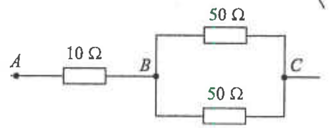
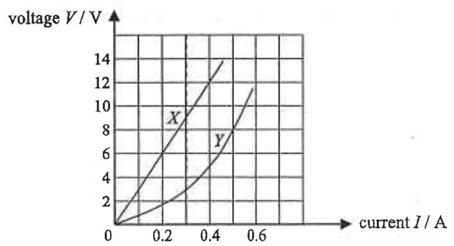


Equivalent resistance $= 10 + \dfrac{50}{2} = 35\ \Omega$

134. A



Since the current through the two light bulbs are the same, draw a vertical line such that $V_X + V_Y = 12$.

The current is 0.3 A and $V_X = 9$ V, $V_Y = 3$ V.

135. A

✓ (1) By $R = \dfrac{V}{I} = \dfrac{0.5}{0} = \infty\ \Omega$

× (2) When $V = 2$ V : $R = \dfrac{2}{20\times10^{-3}} = 100\ \Omega$.

When $V = 3$ V : $R = \dfrac{3}{40\times10^{-3}} = 75\ \Omega$.

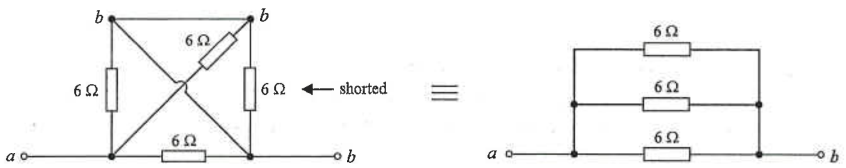
The resistance is not constant.

× (3) As the line does not pass through the origin, the current is not directly proportional to the voltage.

136. C

$$V = 9\times\frac{270-120}{270} = 5\text{ V}$$

137. C



Equivalent resistance : $R = \dfrac{6}{3} = 2\ \Omega$

138. D

✓ (1) As an ammeter is used to measure current, it should be connected in series for current to flow through it.

✓ (2) An ideal ammeter has zero resistance, a practical ammeter should have low resistance.

✓ (3) For high resistance ammeter, it would increase the equivalent resistance of the circuit, thus it would seriously affect the current of the circuit.

139. C

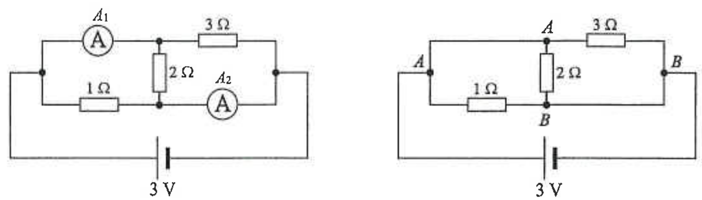
✓ A. The p.d. between PQ is equal to the p.d. across the battery, which is equal to the e.m.f. of the battery, thus it is unchanged.

✓ B. After switch S is closed, equivalent resistance of the whole circuit decreases, thus more current flows out from the battery, and the p.d. across R_1 increases. As the right hand side of R_1 is earthed at zero potential, the potential at P increases.

× C. The p.d. across R_2 decreases after the switch is closed. As the left hand side of R_2 is at zero potential, potential at Q should increase.

✓ D. As the p.d. across R_2 decreases, the current flowing through R_2 decreases.

140. D



As each resistor is connected between point A and point B, they are in parallel,

The voltage across each resistor is equal to the e.m.f. of the cell, that is, each has a voltage of 3 V.

Current through the 1 Ω resistor $= \dfrac{3}{1} = 3$ A

Current through the 2 Ω resistor $= \dfrac{3}{2} = 1.5$ A

Current through the 3 Ω resistor $= \dfrac{3}{3} = 1$ A

Ammeter $A_1 = 1.5 + 1 = 2.5$ A

Ammeter $A_2 = 3 + 1.5 = 4.5$ A

141. B

× (1) As they are connected in parallel, their voltages must be the same.

✓ (2) As the resistance of P is greater, the current through it is smaller.

× (3) By $P = VI$, as current I through P is smaller, power of P is smaller, thus P should be dimmer.

142. C

✓ (1) As the resistance of P is greater, the voltage across P is greater by $V = IR$.

× (2) As they are connected in series, their currents must be the same.

✓ (3) By $P = VI$, as voltage to P is greater, power of P is greater, thus P is brighter.

143. D

When P is at X, current flows directly from X to P without passing through the resistance wire XY, current is maximum.
When P is at the mid point of XY, current flows from X and Y to P through the resistance wire XY, current is minimum.
When P is at Y, current flows directly from Y to P without passing through the resistance wire XY, current is maximum.
As a whole, current decreases and then increases when P is moved from X to Y.

144. C

✓ (1) Two resistors consume two times the power compared with that of one resistor.
✓ (2) Two resistors draw two times the current compared with that of one resistor.
✗ (3) The equivalent resistance of two resistors in parallel is halved of that of one resistor.

145. D

Ohm's law states that the voltage across a conductor is directly proportional to the current
provided the temperature is constant,
which is equivalent to say that the resistance of a conductor is constant provided the temperature is constant.

146. C

$\varepsilon = (2.0)(5 + r)$

$\varepsilon = (1.2)(10 + r)$

Combine the two equations :

$(2.0)(5 + r) = (1.2)(10 + r) \quad \therefore r = 2.5\ \Omega$

147. B

Reading of A_2 is two times that of A_1 since the resistance is halved. Thus, reading of $A_2 = 2$ A
Reading of A_3 is the sum of A_1 and A_2. Thus, reading of $A_3 = 1 + 2 = 3$ A

148. C

✓ (1) The polarity of the ammeter is wrongly connected in reverse direction.
Current should flow into the (+) terminal and out of the (–) terminal.
✗ (2) The voltmeter is correctly connected.
✓ (3) The voltmeter should be connected across the resistor R only.

149. D

$$R = \frac{\rho L}{A} \propto \frac{L}{A} \propto \frac{L}{A} \times \frac{L}{L} \propto \frac{L^2}{V} \propto L^2$$

$\therefore L \to 2L \Rightarrow R \to 4R$

OR

Since the volume is the same, $L \to 2L \Rightarrow A \to \frac{1}{2}A$

$$R = \frac{\rho L}{A} \propto \frac{L}{A} \quad \therefore R \to \frac{2}{1/2}R = 4R$$

150. A

X should be closed so that current would not pass through the light bulb below the switch X.
Y should be opened so that current would not pass through the light bulb beside the switch Y.
If no current flows to other light bulbs, the current or voltage of P would be maximum, thus the brightness is maximum.

151. B

Since the resistance of the voltmeter is very large, negligible current is drawn by the voltmeter.

Current given out by the battery $= \frac{3.0}{2+10} = 0.25$ A

Voltage given to the light bulb $= 0.25 \times 10 = 2.5$ V **OR** Voltage given to the light bulb $= 3.0 \times \frac{10}{2+10} = 2.5$ V

152. B

Voltage across each resistor in Figure (a) $= \frac{1}{2}V$

Voltage across each resistor in Figure (b) $= V$

By $P = \frac{V^2}{R} \quad \therefore P \propto V^2 \quad \therefore V \to 2V \Rightarrow P \to 4P$

153. B

Assume the equivalent resistance of the four resistors R is R'.

By $\frac{1}{6} = \frac{1}{12} + \frac{1}{R'}$

$\therefore R' = 12\ \Omega$

If the 12 Ω resistor is replaced by a 6 Ω resistor,

equivalent resistance $= \frac{6 \times 12}{6 + 12} = 4\ \Omega$

154. B

If the variable resistor is set to zero, the light bulb is shorted,
all the current will flow through the zero resistance path,
thus no current will flow through the light bulb, the light bulb will not light up.

155. B

Equivalent resistance of the 3 Ω and 6 Ω resistors which are in parallel $= \frac{6 \times 3}{6 + 3} = 2\ \Omega$

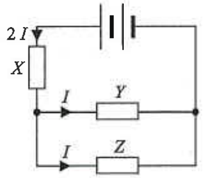
Total equivalent resistance of the whole circuit $= 2 + 2 = 4\ \Omega$

Current given out by the cell $= \frac{12}{4} = 3$ A

Terminal voltage of the cell $= \varepsilon - Ir = 12 - 3 \times 2 = 6$ V

Current flowing through the 6 Ω resistor $= \frac{6}{6} = 1$ A

156. B



Let the current passing through Z be I.

Current passing through Y should also be I.

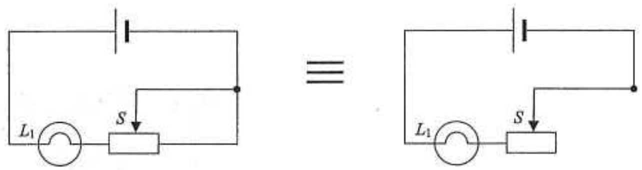
Thus the current passing through X is $2\,I$.

Total power dissipated by X, Y and Z = $(2\,I)^2R + I^2R + I^2R = 24$

$\therefore\ I^2R = 4$

Power dissipated in resistor $Z = I^2R = 4$ W

157. A



L_1 : The above two circuits are equivalent. Current would not flow to the right part of the rheostat.
When the slider shifts to the right, the resistance of the rheostat increases, current decreases, thus L_1 becomes dimmer.

L_2 : As the light bulb and the rheostat are connected in parallel to the cell, the voltage across L_2 is constant.
Thus the brightness of L_2 is not affected by the rheostat, and therefore brightness of L_2 remains unchanged.

158. C

× A. If X is shorted, the ammeter A should have reading but voltmeter V reads zero and Y is lit.

× B. If Y is shorted, both the ammeter A and the voltmeter V have readings, and X is lit.

✓ C. If X is burnt out, no current flows through ammeter A, X and Y, thus X and Y are not lit.
However, the voltmeter V reads the voltage of the cell, thus the reading of V is not zero.

× D. If Y is burnt out, X and Y are not lit, but both the voltmeter V and ammeter A have no readings.

159. D

If the voltmeter reads 6 V when switch S is closed, then one of the following may happen :

① P is burnt out and becomes open circuit.
The voltage of the cell would then share between Q and the voltmeter.
As the resistance of the voltmeter is much larger than Q,
all the voltage of the cell would be given to the voltmeter and the voltmeter reads 6 V.

② Q is short-circuited. The voltage across Q becomes 0 V.
All the voltage of the cell would be given to P and the voltmeter reads 6 V.

160. C

Let the e.m.f. of the cell be ε and the internal resistance of the cell be r.

When S is closed, the 3 Ω resistor is shorted, thus, the total resistance of the circuit is $(6 + r)$ Ω.

$\therefore\ \varepsilon = 3 \times (6 + r)$

When S is open, the total resistance of the circuit becomes $(3 + 6 + r)$ Ω. Let the current be I.

$\therefore\ \varepsilon = I \times (9 + r)$

Combine the two equations :

$\therefore\ 3 \times (6 + r) = I \times (9 + r)$

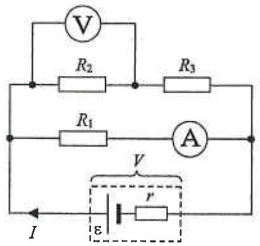
× A. If I = 1.6 A, then $3 \times (6 + r) = 1.6 \times (9 + r)$ $\therefore\ r$ is negative $\therefore$ it is impossible

× B. If I = 2.0 A, then $3 \times (6 + r) = 2.0 \times (9 + r)$ $\therefore\ r = 0\ \Omega$ $\therefore$ it is impossible

✓ C. If I = 2.4 A, then $3 \times (6 + r) = 2.4 \times (9 + r)$ $\therefore\ r = 6\ \Omega$ $\therefore$ **possible**

× D. As the total resistance increases, the current must decrease and less than 3 A $\therefore$ it is impossible

161. D



× A. If R_1 becomes a short circuit (that is, $R_1 = 0$),
current would not flow through R_2 and R_3.
Voltmeter reading would become zero.

× B. If R_2 becomes a short circuit (that is, $R_2 = 0$),
the voltmeter reading would become zero.

× C. If R_3 becomes a short circuit (that is, $R_3 = 0$),
the total resistance of the circuit decreases.
Current given out by the cell increases.
As terminal voltage : $V = \varepsilon - Ir$ $\therefore\ I\uparrow \Rightarrow V\downarrow$
Reading of ammeter would decrease.

✓ D. If R_2 becomes an open circuit (that is, $R_2 = \infty$), the total resistance of the circuit increases.
Current given out by the cell decreases.
As terminal voltage : $V = \varepsilon - Ir$ $\therefore\ I\downarrow \Rightarrow V\uparrow$
As voltage across R_1 increases since it is equal to the terminal voltage, current through R_1 increases.
Reading of ammeter thus increases and reading of voltmeter also increases.

162. C

The light bulb will light up only when S_1 is closed (seat is occupied) and S_2 is open (seat belt not yet fastened).

Option C is correct. If both switches are closed (seat is occupied and seat belt fastened),

the light bulb is shorted by S_2, current would pass through the resistor, S_2 and S_1 and the light bulb is shut off.

Option D is not a good design since the cell would be shorted and damaged when both switches are closed.

163. B

① When the variable resistor is adjusted to 0 Ω, the equivalent resistance is 10 Ω and 10 kΩ in parallel.
Since 10 Ω is much smaller than 10 kΩ, the equivalent resistance is about 10 Ω.

② When the variable resistor is adjusted to 10 MΩ, the equivalent resistance is 10 MΩ and 10 kΩ in parallel.
Since 10 kΩ is much smaller than 10 MΩ, the equivalent resistance is about 10 kΩ.

164. D

✓ (1) Since X is brighter than Y, the power of X is greater than that of Y.
As $P = VI$, the two bulbs in parallel have same voltage, thus the current flowing through X is greater.
Current is the amount of charge flowing in 1 s, thus, number of charges through X in 1 s is greater.

✓ (2) Power is the energy given out in 1 s.
As the power of X is greater, the electrical energy dissipated by X is greater.

✓ (3) Voltage (p.d.) is the conversion of electrical energy to other energy per unit charge.
As they are in parallel, they must have same voltage,
thus the electrical energy dissipated by X is equal to that of Y.

165. B

Assume each light bulb has a resistance of 2 Ω and the voltage of the supply is 6 V.

The equivalent resistance of P and Q is 1 Ω. They are in series with R and share the voltage of 6 V in proportional.

Thus, voltage across P and Q are both 2 V and voltage across R is 4 V.

As T and S are in series and connected across the supply voltage of 6 V, each of them shares 3 V.

The highest voltage across the light bulb is R, thus, R will burn out first.

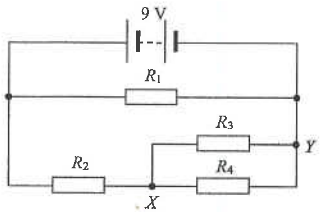
166. B

In the circuit, all the resistors all identical.
Assume the resistance of each resistor is 2 Ω.
The voltage across R_1 is 9 V and is irrelevant.
Resistors R_3 and R_4 are in parallel,

their equivalent resistance $= \frac{2}{2} = 1\ \Omega$

Resistor R_2 and this equivalent resistance are in series.

Voltage across $XY = 9 \times \frac{1}{2+1} = 3$ V

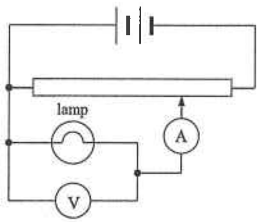


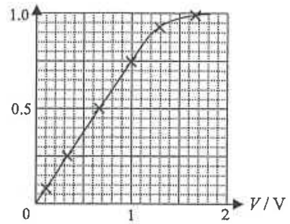
The following list of formulae may be found useful :

Resistance and resistivity	$R = \frac{\rho l}{A}$
Resistors in series	$R = R_1 + R_2$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
Power in a circuit	$P = IV = I^2 R$
Energy transfer during heating or cooling	$E = mc\Delta T$
Energy transfer during change of state	$E = l\Delta m$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper I - 8 >**





A student performed an experiment to investigate Ohm's Law using the circuit as shown above. The results are shown in the graph above.

(a) What is the range of voltages for which Ohm's Law is obeyed ? (1 mark)

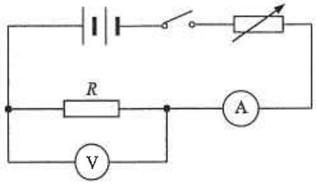
(b) Suggest a reason why Ohm's Law is not obeyed outside this range. (2 marks)

(c) Find the resistance of the lamp when the voltage is

(i) 0.5 V ; and

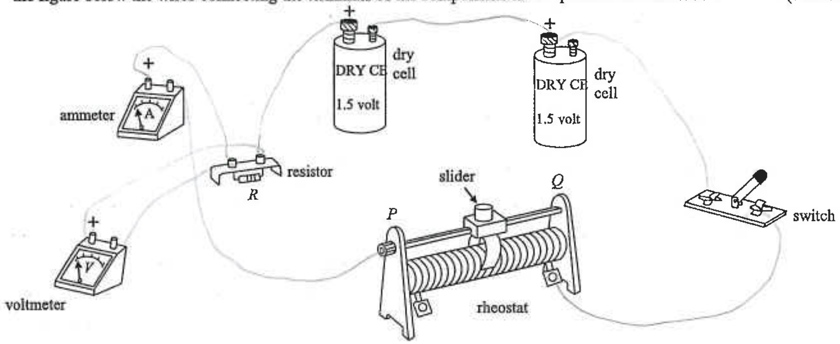
(ii) 1.5 V. (2 marks)

2. **< HKCE 1984 Paper I - 7 >**



The figure above shows a circuit diagram to measure an unknown resistance R.

(a) The figure below shows the components used in the circuit. You are then given 8 pieces of conducting wires. Draw in the figure below the wires connecting the terminals of the components to complete the circuit above. (7 marks)

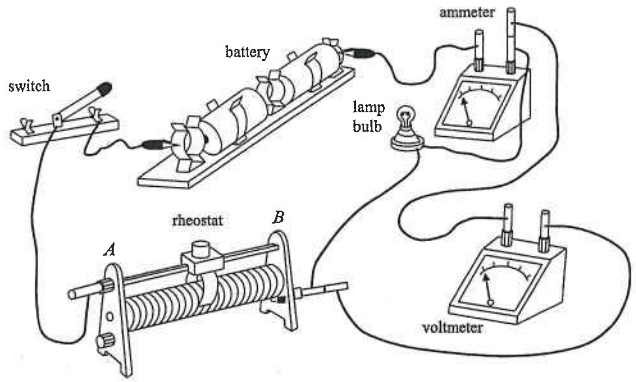


(b) State where you should set the slider of the rheostat at the beginning of the experiment. State the reason for your choice. (3 marks)

(c) If the resistor were connected in reverse direction, how would the readings of the ammeter and voltmeter be affected ? (2 marks)

(d) Using the same components provided, draw a circuit diagram you would use to measure a resistance comparable to that of the voltmeter. (3 marks)

3. **< HKCE 1987 Paper I - 7 >**

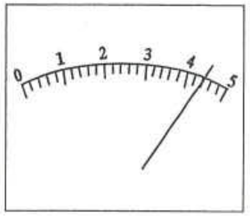


The figure above shows an experiment set-up to measure the resistance of a light bulb.

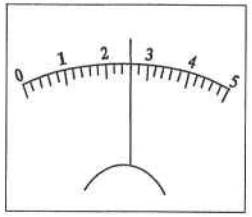
(a) Draw a circuit diagram for the experiment. Indicate on your drawn diagram the positive terminals of the ammeter and voltmeter with "+" signs. (5 marks)

(b) If the slider in the rheostat moves from A to B, how does the reading of the ammeter change ? (2 marks)

3. (c)



(0 – 500 mA)



(0 – 5 V)

The figure above shows the voltmeter and the ammeter used in the experiment. What is

(i) the ammeter reading, and

(ii) the voltmeter reading

as indicated in the diagram ? Hence calculate the resistance of the light bulb at this moment. (4 marks)

(d) (i) When the current increases, how does

(1) the temperature, and

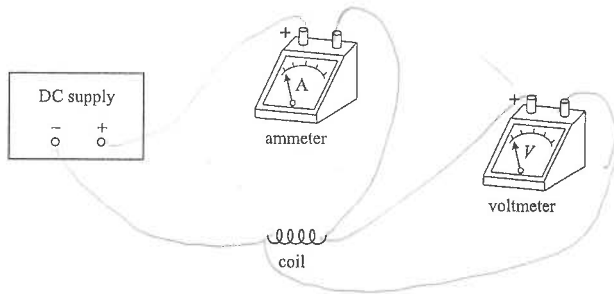
(2) the resistance

of the light bulb change ? (2 marks)

(ii) Make a rough sketch of the voltage across the light bulb against the current. (2 marks)

4. **< HKCE 1989 Paper I - 8 >**

The figure shows the apparatus of an experiment to study how the resistance of a metallic coil changes with temperature. The temperature is controlled by changing the output voltage of the DC supply.



(a) Draw the wires connecting the terminals of the apparatus to complete the circuit for the experiment. (4 marks)

(b) Describe how to measure the temperature of the coil. (3 marks)

(c) When the voltmeter reads 12 V, the ammeter reads 2 A. Calculate the resistance of the coil at this reading. (3 marks)

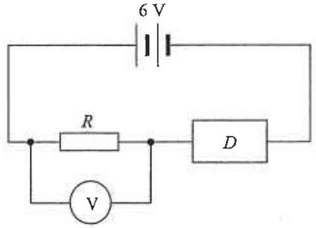
(d) How would the resistance of the metallic coil change with temperature ? (2 marks)

(e) For a particular output voltage, if the resistance coil were shortened, how would the ammeter and the voltmeter reading change ?

(The internal resistance of the DC supply and the ammeter are negligible.) (3 marks)

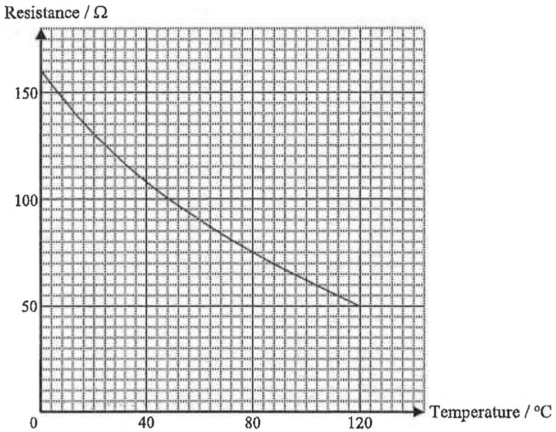
5. < HKCE 1991 Paper I - 6 >

Figure 1



An electronic device D is connected to a resistor R and a 6 V power supply as shown in Figure 1 above. The resistance of R is 470 Ω. A voltmeter of high resistance is connected across R. Figure 2 shows the variation of the resistance of the device D with temperature.

Figure 2



(a) The reading of the voltmeter is 4.7 V. At this instant, find (5 marks)

(i) the current flowing through R,

(ii) the resistance of the device D,

(iii) the temperature of the device D.

(b) How would the voltmeter reading change if the temperature of the device D increases ? Explain briefly. (3 marks)

6. < HKCE 2001 Paper I - 10 >

Figure 1

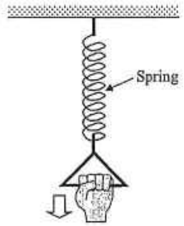
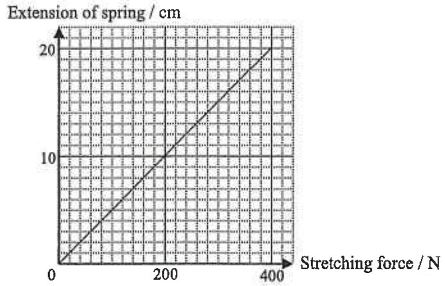


Figure 2

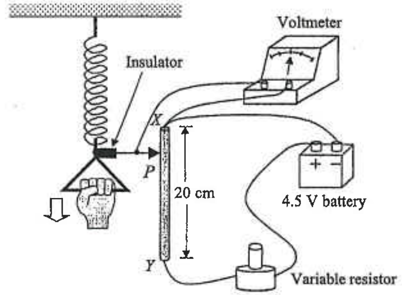


A spring is hanging freely from the ceiling and John stretches the spring with his hand as shown in Figure 1. It is known that the extension of the spring is directly proportional to the stretching force (see Figure 2).

(a) Using Figure 2, find the stretching force if the extension of the spring is 5 cm. (1 mark)

(b)

Figure 3



John wants to use a voltmeter to measure the force he applies to stretch the above spring. He sets up a device as shown in Figure 3. XY is a uniform resistance wire of length 20 cm and P is a metallic sliding contact. XY is fixed vertically and P can slide smoothly along XY as the spring is stretched. The voltage of the battery is 4.5 V and the resistance of XY is 20 Ω. The resistance of the variable resistor is set to 40 Ω. P touches end X of the wire when the stretching force is zero.

(i) Draw a circuit diagram for the circuit in Figure 3. (4 marks)

(ii) Show that the voltmeter reads 1.5 V when P touches end Y of the wire. (2 marks)

6. (b) (iii) If the voltmeter reading is 1.2 V, find

(1) the distance of P from end X,

(2) the stretching force. (4 marks)

(iv) John finds that the device is not sensitive enough (i.e. the voltmeter reading shows no observable change when he slightly alters his stretching force). In order to increase the sensitivity, he suggests reducing the resistance of the variable resistor. Explain whether John's suggestion is appropriate. (3 marks)

7. < HKCE 2005 Paper I - 9 >

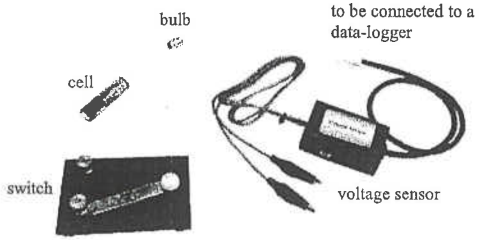


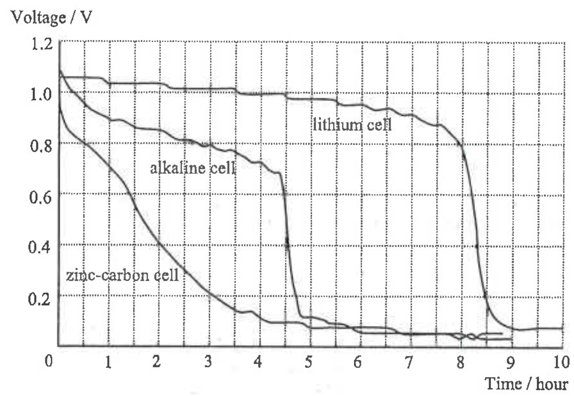
Figure 1

Iris uses the apparatus shown in Figure 1 to study the lifetime of AA-size cells for lighting up a bulb. She connects a cell and a switch to the bulb and uses a voltage sensor to measure the voltage across the bulb.

(a) Draw a circuit diagram to illustrate how the apparatus is connected. Use the symbol (V) to denote the voltage sensor. (3 marks)

7. (b) Iris conducts the experiment for a zinc-carbon cell, an alkaline cell and a lithium cell separately. Figure 2 shows the variation of the voltage across the bulb with time for the cells. The bulb will light up as long as the voltage across it is above 0.6 V.

Figure 2



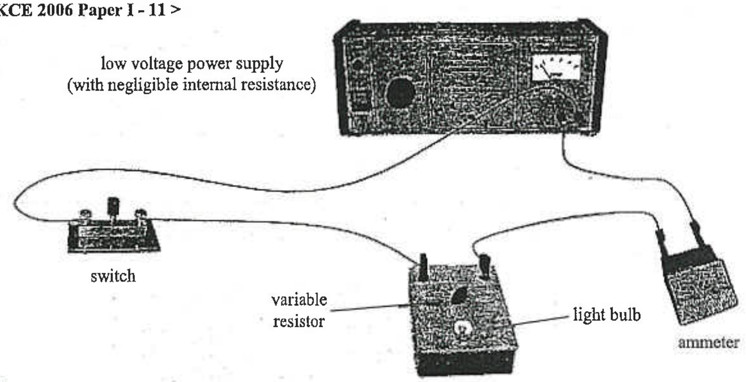
(i) A salesman claims that the lifetime of a lithium cell for lighting up the bulb is five times that of an alkaline cell. Determine whether the claim is correct or not. (2 marks)

(ii) The prices of the three types of cells are shown in the Table below.

Type of cells	Price per cell
zinc-carbon	\$ 1.5
alkaline	\$ 3.8
lithium	\$25.0

Which type of cells is the best buy, in terms of the cost per hour for lighting up the bulb ? Show your calculations. (3 marks)

8. < HKCE 2006 Paper I - 11 >



A teacher gives Jane a sealed box in which a light bulb is connected to a variable resistor. The teacher asks Jane to find out how the bulb and the variable resistor are connected together inside the sealed box. Jane then sets up a circuit as shown in the above Figure. She reduces the resistance R of the variable resistor and records the changes as shown in the below Table.

Data :	Voltage of the power supply = 3 V	
	Initial value of R = 15 Ω	Initial ammeter reading = 2.6 A
	Final value of R = 5 Ω	Final ammeter reading = 3.0 A
Observation :	Brightness of the bulb remains unchanged	

(a) (i) Jane correctly concludes that the variable resistor and the bulb are connected in parallel inside the box. Give a reason to support Jane's conclusion. (1 mark)

(ii) Draw a circuit diagram to illustrate how the apparatus shown in the above Figure are connected, including the components inside the box. Use the symbol —o + o— − to denote the low voltage power supply. (2 marks)

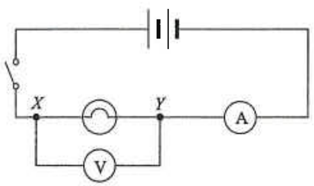
(iii) Using the data in the above Table, find the resistance of the bulb. (3 marks)

(b) Jane's classmate Mary conducts the same experiment by replacing the low voltage power supply with two 1.5 V dry cells which are connected in series. If the internal resistance of the dry cells is not negligible, explain why the brightness of the bulb decreases when R is reduced. (3 marks)

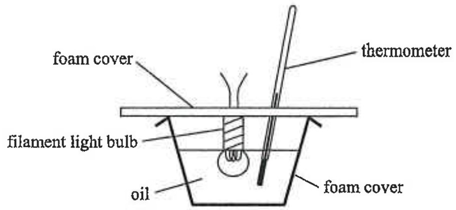
8. (c) The teacher asks Mary, "What happens if the variable resistor is set to zero ?"
"The light bulb will burn out," Mary answered.

Explain whether Mary's answer is correct. (2 marks)

9. < HKCE 2007 Paper I - 7 >



A teacher conducts an experiment to study the energy conversion of a filament light bulb. A simple circuit is connected as shown in the above figure and the bulb is immersed into 0.09 kg of oil inside a foam cup as shown below. The bulb is lighted up for 300 s, and the temperature of the oil is increased from 20°C to 42°C.



In the experiment, the ammeter and voltmeter readings are 1.4 A and 12 V respectively. The specific heat capacity of the oil is 2100 J kg^{-1} °C^{-1}.

(a) Calculate the energy absorbed by the oil. (2 marks)

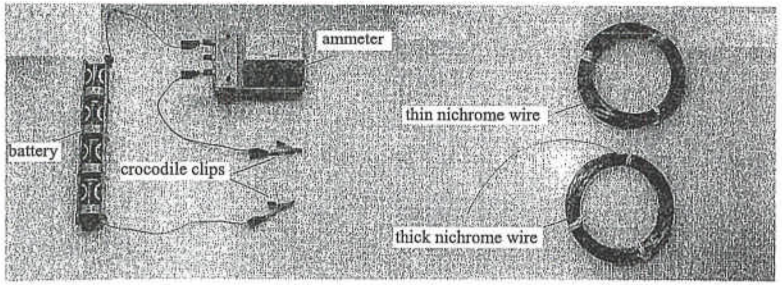
(b) Describe the energy conversion when a current passes through the filament light bulb. (1 mark)

(c) (i) Estimate the amount of energy that is converted into light energy in the experiment, and state ONE assumption made in your calculation. (4 marks)

(ii) Hence, determine the percentage of electrical energy consumed by the filament light bulb that is converted into light energy. (2 marks)

10. < HKCE 2009 Paper I - 6 >

Using the apparatus shown in the figure below, describe the procedures of an experiment to study how the resistance of a nichrome wire depends on its thickness. (4 marks)

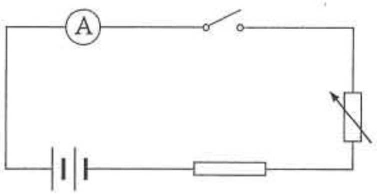


11. < HKCE 2011 Paper I - 5 >

Jane wants to find the resistance of a resistance wire by measuring the voltage across and current through the resistance wire.

(a) As shown in Figure (a), Jane has connected the resistance wire in series with a battery, an ammeter, a switch and a variable resistor. Add a voltmeter (Ⓥ) in Figure (a) to complete the circuit. (1 mark)

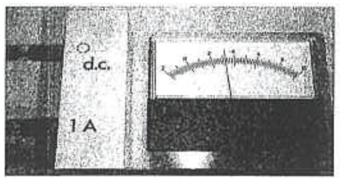
Figure (a)



(b) After the teacher has checked the circuit, Jane performs the experiment.

(i) The ammeter reading in a certain trial is shown in Figure (b). In this setting, the maximum current that can be measured by the ammeter is 1 A. What is the reading shown ? (1 mark)

Figure (b)

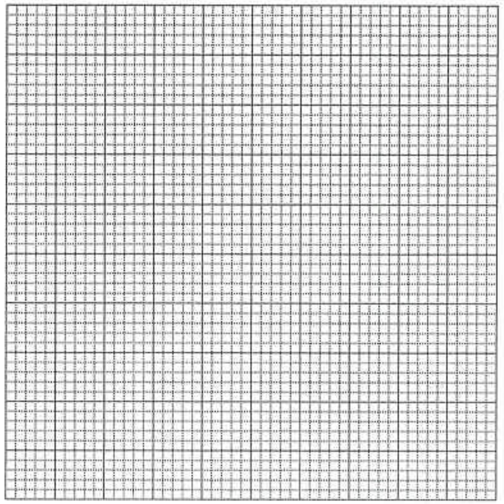


Ammeter reading = ____________

11. (b) (ii) Measurements are repeated with different settings of the variable resistor. The Table shows the data obtained.

Trial	Voltmeter Reading V / V	Ammeter Reading I / A
1	1.4	0.22
2	2.8	0.42
3	4.1	0.64
4	5.6	0.82

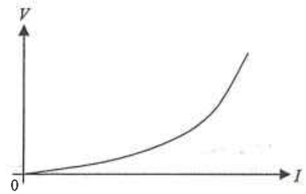
Plot a graph of voltmeter reading against ammeter reading in the Figure below. Use a scale of 1 cm representing 1 V and 0.1 A.



(iii) From the graph plotted in (b) (ii), find the resistance of the resistance wire. (2 marks)

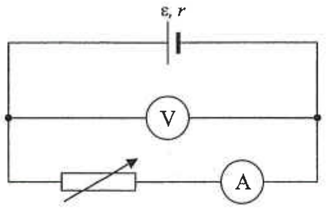
(c) Now the resistance of a filament light bulb is studied using the same experimental setup. The voltage-current graph obtained is shown in Figure (c). Explain why the graph is not a straight line. (2 marks)

Figure (c)

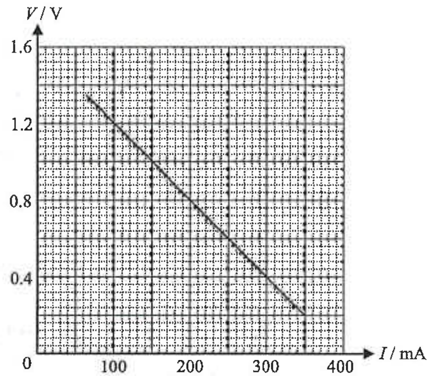


Part B : HKAL examination questions

12. **< HKAL 1995 Paper I - 8 >**



The above circuit is employed to measure the e.m.f., ε, and the internal resistance, r, of a dry cell. Assume that the voltmeter and the ammeter used are ideal.



The voltmeter readings, V, and the ammeter readings, I, obtained for different rheostat settings are used to plot the above graph.

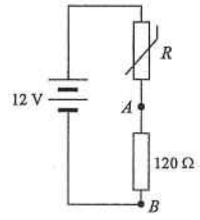
(a) Express V in terms of ε, I and r. (1 mark)

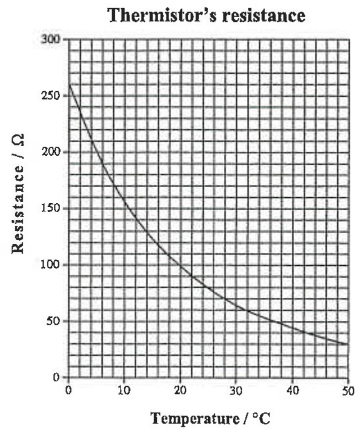
(b) Hence deduce from the graph the e.m.f. and the internal resistance of the cell. (2 marks)

Part C : HKDSE examination questions

13. **< HKDSE 2013 Paper IB - 10 >**

(a) In the circuit shown in the below Figure, a 12 V battery of negligible internal resistance is connected with a thermistor R and a resistor of resistance 120 Ω. The graph shows the variation of the thermistor's resistance with temperature.

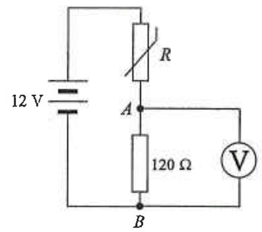




(i) Find the resistance of the thermistor R at 25°C. (1 mark)

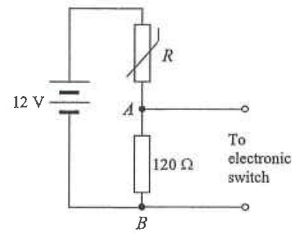
(ii) What is the potential difference V_{AB} across A and B at 25°C ? (2 marks)

(b)



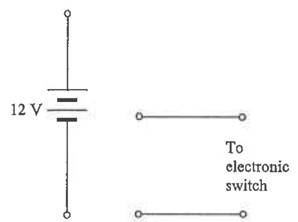
Kelly wants to confirm the above calculation by measuring V_{AB} using a voltmeter of about 1 kΩ resistance. She finds that the reading registered is slightly different from the value found in (a) despite making careful measurements. Explain why this is so. Suggest how the accuracy of the measurement could be improved. (3 marks)

13. (c) (i)



The potential difference V_{AB} is used to drive an electronic switch connected across AB to turn on a fan if temperature rises above a certain value such that V_{AB} is 6.0 V or above. Using the information provided in the graph, find the minimum temperature needed to keep the fan on. Show you working. (2 marks)

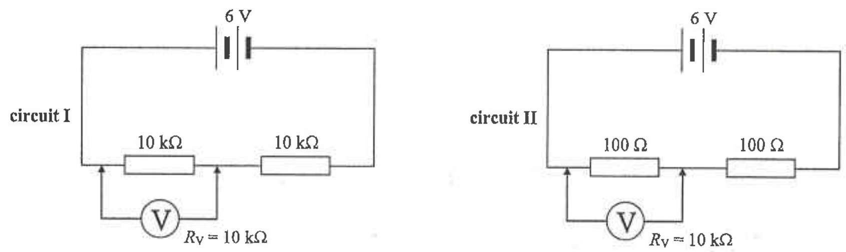
(ii)



Without using additional components, complete the new circuit diagram below to illustrate how the circuit can be modified to turn on a heating device when temperature falls below a certain value. Explain the action of the circuit. No calculation is required. (3 marks)

14. **< HKDSE 2016 Paper IB - 7 >**

(a) The circuits in the above Figure each contains two resistors connected in series with a 6 V battery of negligible internal resistance. The resistors in circuit I are 10 kΩ each while those in circuit II are 100 Ω each.

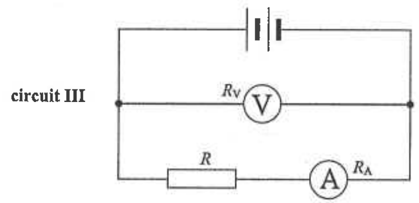


A voltmeter of internal resistance R_V = 10 kΩ is used to measure the potential difference across one of the resistors as shown.

(i) What would be the respective voltmeter readings ? (3 marks)

(ii) In fact, the potential difference across each resistor before connecting the voltmeter is 3 V in both circuits. Explain why this voltmeter gives a relative inaccurate value for circuit I. Hence state the general principle of selecting a suitable voltmeter for such measurement. (2 marks)

(b) Circuit III shows a possible method for measuring resistance using a voltmeter and an ammeter. The internal resistance for the voltmeter and the ammeter are R_V and R_A respectively and their readings V_m and I_m give the measured resistance $R_m = \frac{V_m}{I_m}$. The true resistance value of the resistor is R.



(i) State which reading(s), V_m, I_m or both, do(es) **NOT** give the *true voltage* across the resistor and/or the *true current* passing through the resistor. Hence write down an equation relating R_A, R_m and R. (2 marks)

(ii) Find the percentage error associated with R_m when measuring the resistance of this resistor.
Given : R_V = 10 kΩ, R_A = 1 Ω and R = 10 Ω. (2 marks)

15. **< HKDSE 2017 Paper IB - 8 >**

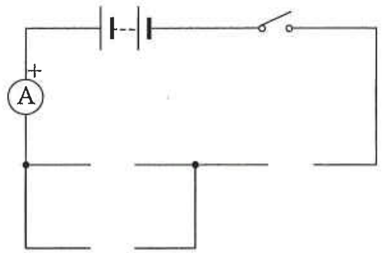
A student uses the following apparatus to measure the resistance of a tungsten filament light bulb.

a battery, a switch, a variable resistor, an ammeter, a voltmeter, a light bulb

(a) Figure 1 shows an incomplete circuit for the experiment. The '+' symbol represents the positive terminal of the ammeter.

Use suitable circuit symbols to complete the circuit, and mark the positive terminal of the voltmeter with '+'. (3 marks)

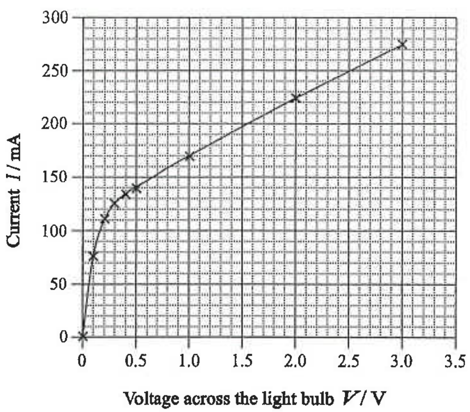
Figure 1



The table below and Figure 2 show the results obtained.

Voltage across the light bulb V / V	0	0.1	0.2	0.3	0.4	0.5	1.0	2.0	3.0
Current I / mA	0	76	112	126	133	139	170	226	273

Figure 2



(b) Briefly explain the variation of the resistance of the light bulb with the voltage across the light bulb. (2 marks)

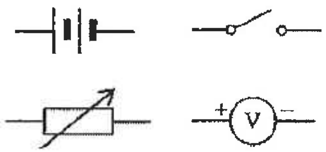
15. (c) The student claims that since the resistance of the light bulb is not a constant, the equation $R = V/I$ cannot be used to calculate the resistance of the light bulb. Briefly explain why his claim is wrong. (1 mark)

(d) Determine the resistance of the light bulb at V = 0.1 V and 2.5 V. (3 marks)

(e) It is given that the cross-sectional area of the tungsten filament in the light bulb is 1.66×10^{-9} m^2, and the resistivity of tungsten at room temperature is about 5.6×10^{-8} Ω m. Estimate the length of the tungsten filament in the light bulb using the appropriate resistance found in (d). (3 marks)

16. <HKDSE 2019 Ppaper-IB-7>

You are provided with a battery (of fixed e.m.f. ξ and internal resistance r), a variable resistor (with several known resistance values R to be selected), a switch, a voltmeter (assumed ideal) and a few connecting wires.



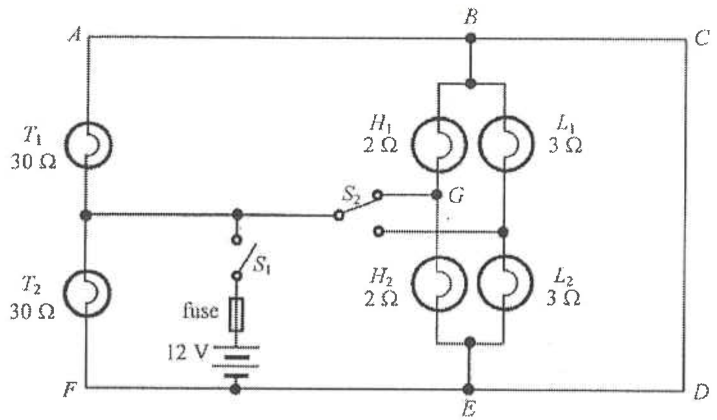
(a) With the aid of a circuit diagram, describe the procedure of an experiment to study how the terminal voltage V delivered by the battery depends on the resistance R connected to it. State **ONE** precaution of the experiment. (5 marks)

(b) Describe the variation of V with R and express V in terms of ξ, r and R. (2 marks)

17. < HKDSE 2020 Paper 1B -8>

Figure 8.1 shows a simplified circuit of the lighting system of a car. Each of the taillights (T_1, T_2), high-beam headlights (H_1, H_2) and low-beam headlights (L_1, L_2) has resistance 30 Ω, 2 Ω and 3 Ω respectively. The internal resistance of the 12 V battery and the resistance of the fuse are negligible.

;ure 8.1



When switch S_1 is closed and switch S_2 is set at the position shown in Figure 8.1, only T_1 and T_2 as well as H_1 and H_2 are lit. The current drawn from the battery is at a maximum in this setting.

(a) Explain why L_1 and L_2 are **not lit**. (1 mark)

(b) (i) What is the potential difference across the taillight T_2 ? (1 mark)

(ii) Indicate on Figure 8.1 the direction of current in each of the branches AB, GB and BC. Which branch carries the largest current ? (3 marks)

(c) Calculate the power delivered by the battery and show that the equivalent resistance of the circuit is slightly less than 1 Ω in this setting. (4 marks)

(d) Based on your answer in (c), explain whether a fuse rating of 15 A is suitable for this circuit or not. (2 marks)

Question Solution

1. (a) From 0 V to 1 V, Ohm's Law is obeyed. [1]

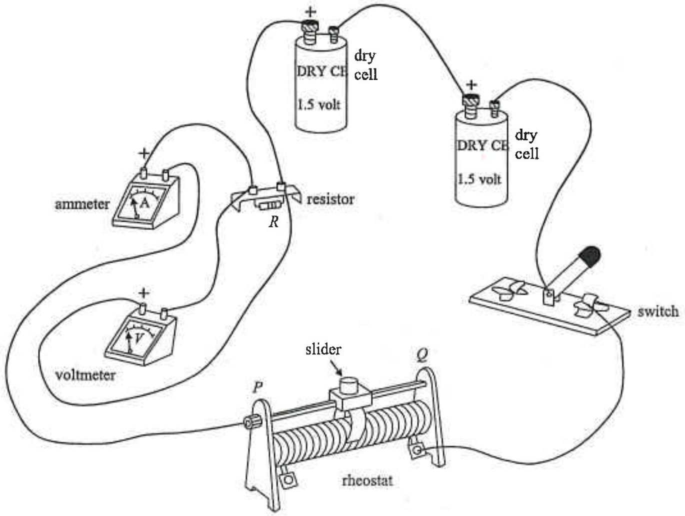
(b) The temperature of the lamp increases, [1]

thus the resistance of the lamp increases. [1]

(c) (i) $R = \frac{V}{I} = \frac{0.5}{0.375} = 1.33\ \Omega$ <accept 1.3 Ω to 1.4 Ω> [1]

(ii) $R = \frac{V}{I} = \frac{1.5}{0.97} = 1.55\ \Omega$ <accept 1.53 Ω to 1.56 Ω> [1]

2. (a)



<Cells, switch, rheostat, resistor and ammeter in series> [5]

<voltmeter is connected in parallel to resistor> [2]

(b) Towards P [1]

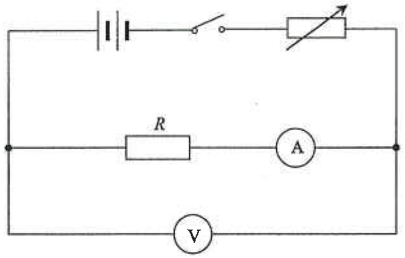
so that the resistance is maximum [1]

and current is smallest. [1]

(c) Reading of voltmeter : no change [1]

Reading of ammeter : no change [1]

2. (d) [3]

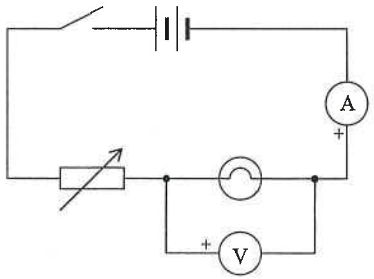


< The cells, the switch, the rheostat, the resistor and the ammeter are in series > [1]

< The voltmeter is connected in parallel > [1]

< The voltmeter is connected across the resistor and the ammeter > [1]

3. (a) [5]



(b) The reading increases [2]

(c) (i) 440 mA [1]

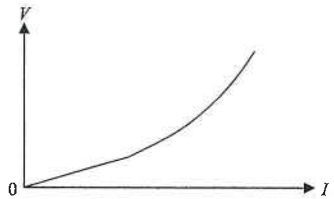
(ii) 2.6 V [1]

$\therefore\ R = \frac{V}{I} = \frac{2.6}{0.44} = 5.91\ \Omega$ [2]

(d) (i) (1) Temperature increases [1]

(2) Resistance increases [1]

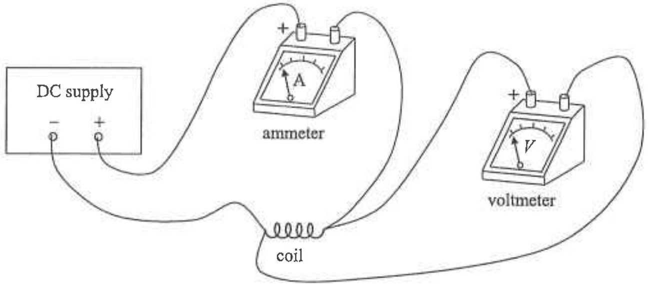
(ii)



< initial portion is a straight line > [1]

< final portion curves upwards ? [1]

4. (a)



< ammeter in series with the coil and supply > [1]

< voltmeter in parallel with the coil > [1]

< polarity of the ammeter correct > [1]

< polarity of the voltmeter correct > [1]

(b) Immerse the coil into the water in a water bath. [1]
Then measure the temperature of the water [1]
by a thermometer. [1]

(c) $R = \dfrac{V}{I}$ [1]

$= \dfrac{12}{2}$ [1]

$= 6\ \Omega$ [1]

(d) Resistance increases when temperature increases. [2]

(e) Ammeter reading increases. [1]
Voltmeter reading remains unchanged. [2]

5. (a) (i) Current : $I = \dfrac{V}{R} = \dfrac{4.7}{470}$ [1]

$= 0.01\ \text{A}$ [1]

(ii) Voltage across the device $D = 6 - 4.7 = 1.3\ \text{V}$ [1]

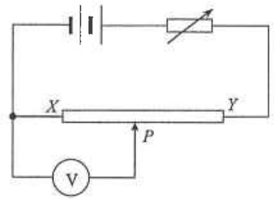
Resistance of the device $D = \dfrac{1.3}{0.01} = 130\ \Omega$ [1]

(iii) Temperature of the device $D = 20^\circ\text{C}$ < from the graph > [1]

(b) When temperature increases, resistance of the device D decreases. [1]
Voltage across the device D thus decreases. [1]
Therefore, voltmeter reading increases. [1]

6. (a) $F = 100\ \text{N}$ [1]

(b) (i)



< For correct symbols > [1]

< Battery, variable resistor and XY in series > [1]

< Polarity of battery : (+) to Y > [1]

< Voltmeter in parallel with PX > [1]

(ii) Current $= \dfrac{V}{R} = \dfrac{4.5}{40 + 20} = 0.075\ \text{A}$ [1]

When P touches Y,

voltmeter reading $= IR = (0.075)(20) = 1.5\ \text{V}$ [1]

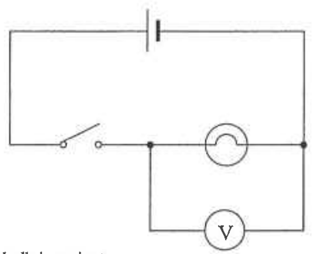
(iii) (1) Distance of P from $X = \dfrac{1.2}{1.5} \times 20$ [1]

$= 16\ \text{cm}$ [1]

(2) Since extension of spring $= 16\ \text{cm}$, From Figure 2 [1]
stretching force $= 320\ \text{N}$ [1]

(iv) His suggestion is appropriate.
If the resistance of the variable resistor is reduced, the voltage across XY is increased. [1]
Thus a change in the position of P will result in a greater change in the voltmeter reading. [1]
So the sensitivity of the device is increased. [1]

7. (a)



< Cell, switch and bulb in series > [1]

< Bulb and sensor in parallel > [1]

< Correct circuit symbols > [1]

7. (b) (i) lifetime of lithium cells = 8.2 hours < accept 8 to 9 hours >

lifetime of alkaline cells = 4.4 hours < accept 4 to 5 hours > [1]

Since $\frac{8.2}{4.4} = 1.86 \neq 5$

so the claim is not correct. [1]

(ii) Lifetime of the cells : [1]

zinc-carbon = 1.4 hours < accept 1.3 to 1.5 hours >

alkaline = 4.4 hours < accept 4.4 to 4.5 hours >

lithium = 8.2 hours < accept 8.2 to 8.3 hours >

Cost per hour for zinc-carbon cells = $\frac{1.5}{1.4}$ = \$ 1.07 < accept 1.00 to 1.15 > [1]

Cost per hour for alkaline cells = $\frac{3.8}{4.4}$ = \$ 0.864 < accept 0.84 to 0.86 >

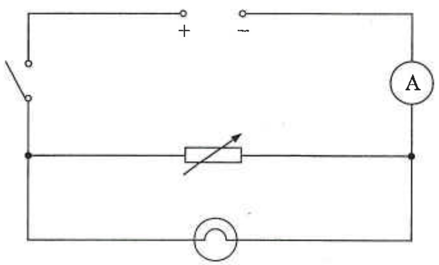
Cost per hour for lithium cells = $\frac{25}{8.2}$ = \$ 3.05 < accept 3.01 to 3.05 >

So alkaline cells are the best buy. [1]

8. (a) (i) Since the brightness of the bulb is unchanged,

thus the voltage across the bulb is unchanged when the resistance of the rheostat is reduced. [1]

(ii)



< rheostat and light bulb in parallel > [1]

< all the symbols and connections correct > [1]

(iii) Initial resistance of R = 15 Ω < OR > Final resistance of rheostat = 5 Ω

Current through $R = \frac{3}{15}$ = 0.2 A Current through $R = \frac{3}{5}$ = 0.6 A [1]

Current through the bulb = 2.6 − 0.2 = 2.4 A Current through the bulb = 3 − 0.6 = 2.4 A [1]

Resistance of the light bulb = $\frac{3}{2.4}$ = 1.25 Ω [1]

8. (b) When the resistance R decreases, the current through the dry cells increases. [1]

The voltage across the internal resistance of the dry cells increases. [1]

Thus, the voltage across the light bulb decreases. [1]

Therefore, the brightness of the bulb decreases.

(c) Mary is not correct [1]

Reason : (ONE of the following) [1]

* since the light bulb is shorted
* since there is no current flowing through the light bulb
* since the voltage across the light bulb is zero

9. (a) $E = m\,c\,\Delta T$ [1]

$= (0.09)\,(2100)\,(42 - 20)$

$= 4158 \text{ J} \approx 4160 \text{ J}$ [1]

(b) Electrical energy changes to heat and light energy. [1]

< OR >

Electrical energy changes to internal energy. [1]

< OR >

Electrical energy changes to heat. [1]

(c) (i) $P = VI = (12)\,(1.4) = 16.8$ W [1]

Electrical energy : $E = Pt = (16.8)\,(300) = 5040$ J [1]

Light energy = 5040 − 4160 = 880 J < accept 5040 − 4158 = 882 J > [1]

Any ONE of the following : [1]

* No energy lost to the surroundings.
* The voltmeter is ideal.
* The resistance of the connecting wires is negligible.

(ii) Percentage = $\frac{880}{5040} \times 100\%$ < accept $\frac{882}{5040} \times 100\%$ > [1]

= 17.5 % [1]

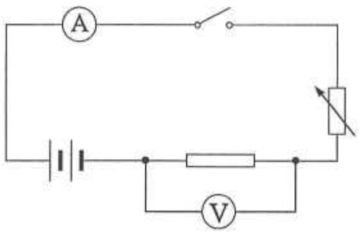
10. Connect the two crocodile clips across a certain length of the thin nichrome wire. [1]

Record the ammeter reading. [1]

Repeat the experiment using the thicker nichrome wire of the same length. [1]

The ammeter reading should be larger, showing that the resistance of the thicker wire is smaller. [1]

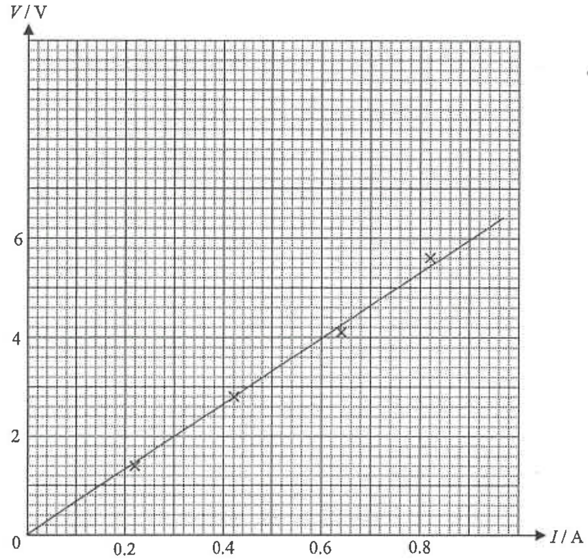
11. (a)



< The voltmeter is connected in parallel across the resistor only. > [1]

(b) (i) Reading = 0.32 A [1]

(ii)



< Correct labels with units and correct scale > [1]

< Data points plotted correctly > [1]

< Best-fitted straight line drawn > [1]

(iii) R = slope of the straight line [1]

$= \frac{6.0}{0.9} = 6.67\ \Omega$ < Acceptable range of R : 6.36 – 6.83 Ω > [1]

(c) As the temperature of the filament increases with the current, [1]

its resistance increases with the temperature. [1]

12. (a) $\varepsilon = V + Ir$

$\therefore V = -Ir + \varepsilon$ [1]

(b) ε = y-intercept = 1.6 V [1]

r = – slope = 4 Ω [1]

13. (a) (i) $R = 80\ \Omega$ [1]

(ii) $V_{AB} = 12 \times \frac{120}{120+80}$ [1]

$= 7.2\ \text{V}$ [1]

(b) As R_V and 120 Ω are in parallel, their equivalent resistance is smaller than 120 Ω. [1]

Therefore, the voltage shared across AB is smaller than that expected. [1]

The accuracy can be improved by using a voltmeter with resistance much higher than 120 Ω. [1]

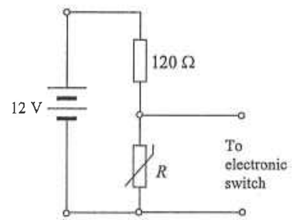
(c) (i) $V_{AB} = 6\ \text{V}$

$\therefore V_R = 12 - 6 = 6\ \text{V}$

$\therefore R = 120\ \Omega$ [1]

Minimum temperature is 16°C < accept 15 to 16 °C > [1]

(ii)



< circuit diagram : 120 Ω and R are interchanged > [1]

When temperature falls below a certain value, resistance of R increases. [1]

Voltage across R increases to 6 V or above, the heating device is then turned on. [1]

14. (a) (i) Circuit I : $R = 10\ \text{k}\Omega$

Equivalent resistance $= \frac{10}{2} = 5\ \text{k}\Omega$

$V = 6 \times \frac{5}{5+10}$ [1]

$= 2\ \text{V}$ [1]

14. (a) (i) Circuit II : $R = 100\ \Omega$

Equivalent resistance $= (\frac{1}{100} + \frac{1}{10000})^{-1} = 99.01\ \Omega$

$V = 6 \times \frac{99.01}{99.01 + 100}$

$= 2.985$ V < accept 2.99 V > < accept 3 V > [1]

(ii) In circuit I, the resistance of the part of circuit decreases significantly after the voltmeter is connected. [1]

OR

In circuit I, the resistance of the voltmeter is comparable to the resistance of the resistor in parallel. [1]

Resistance of voltmeter should be much higher than the resistance of the resistor connected in parallel. [1]

(b) (i) V_m does not give the true voltage for the resistor. [1]

$R_m = R + R_A$ [1]

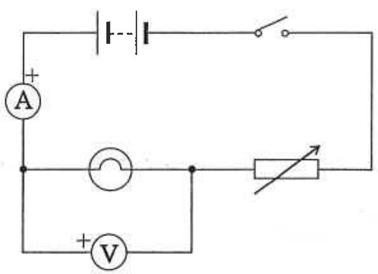
(ii) For circuit III :

$R_m = 10 + 1 = 11\ \Omega$

Percentage error $= \frac{11-10}{10} \times 100\%$ [1]

$= 10\ \%$ [1]

15. (a)



< correct symbols of light bulb, voltmeter and variable resistor (rheostat) > [1]

< correct positions of the components > [1]

< correct positive terminal of the voltmeter > [1]

(b) As the voltage across the light bulb increases, temperature of the light bulb increases, [1]

thus its resistance increases. [1]

(c) $R = \frac{V}{I}$ is the definition of resistance. [1]

It can be applied to all conductors even if the resistance is not constant.

15. (d) At 0.1 V : $R = \frac{0.1}{76 \times 10^{-3}} = 1.32\ \Omega$ [1]

At 2.5 V : $R = \frac{2.5}{250 \times 10^{-3}} = 10\ \Omega$ [2]

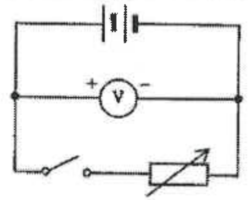
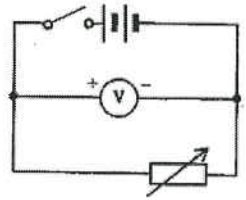
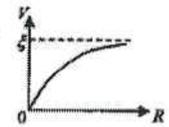
(e) At room temperature, resistance is 1.32 Ω. [1]

By $R = \rho \frac{\ell}{A}$

$\therefore\ (1.32) = (5.6 \times 10^{-8}) \times \frac{\ell}{(1.66 \times 10^{-9})}$ [1]

$\therefore\ \ell = 0.0391$ m < accept 0.039 m > [1]

16.

Solution	Marks	Remarks
(a) 	1A 1A	Correct circuit with correct symbol Correct polarity Alternative circuit 
Close the switch and record corresponding V and R readings Adjust the resistance R to lower/other value(s) and repeat the experiment	1A 1A	
Precaution: - First set the variable resistor to its maximum / a large value - Open the switch after each measurement - Any reasonable answer } Any ONE	1A	
	5	
(b) Terminal voltage V delivered increases with increasing (loading) resistance R (or graphical representation) $V = \xi \frac{R}{R+r}$ OR $V = \xi - \frac{\xi}{R+r} r$	1A 1A	Accept: 
	2	

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe as seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

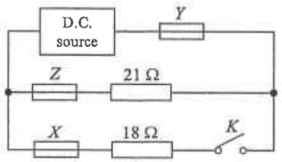
EM3 : Domestic Electricity

The following list of formulae may be found useful :

Resistance and resistivity	$R = \dfrac{\rho l}{A}$
Resistors in series	$R = R_1 + R_2$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$
Power in a circuit	$P = IV = I^2 R$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 33 >**



In the circuit shown, Y is a 5 A fuse, Z and X are 3 A fuses. When the switch K is open the current passing through the 21 Ω resistor is 2.4 A. When K is closed, which of the fuses will be blown ?

A. X only
B. Y only
C. Z only
D. X and Z only

2. **< HKCE 1982 Paper II - 26 >**

The table below shows the voltage and power rating for various electrical appliances. Which of the electric appliances has the smallest working resistance ?

	Appliance	Voltage	Power / W
A.	Air-conditioner	200	2000
B.	Television	200	250
C.	Heater	100	2000
D.	Hair-dryer	100	20

3. **< HKCE 1982 Paper II - 28 >**

A set of Christmas tree lights consists of 20 bulbs in series. Each bulb has a rating of "10 V 5 W". One of the bulbs burns out and Jimmy goes to buy a replacement. When he gets back, he finds that although the new bulb is marked 5 W, it looks dimmer than the others when the lights are turned on. The most probable reason for this is that the new bulb

A. has a smaller current flowing through it.
B. has a filament with a higher resistance.
C. has been shorted accidentally.
D. is designed to work at a lower voltage.

4. < HKCE 1982 Paper II - 29 >

Fifteen bulbs, each labelled '200 V 60 W', are connected in parallel to a 200 V supply. Which of the following fuses should be used in the circuit ?
A. 2 A
B. 3 A
C. 4 A
D. 5 A

5. < HKCE 1983 Paper II - 35 >

Eight 100 W lamps and one 1000 W heater are all connected in parallel to a mains supply of 200 V. Which of the following should be used ?
A. 5 A fuse
B. 10 A fuse
C. 30 A fuse
D. 50 A fuse

6. < HKCE 1984 Paper II - 30 >

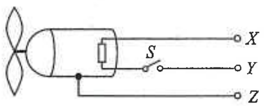
Which of the following has the greatest current when it is operated at 200 V ?
A. a lamp with a resistance of 400 Ω
B. a rice-cooker with rating of 400 W at 200 V
C. an electric iron with rating of 400 W at 220 V
D. a hair-dryer with rating of 600 W at 200 V

7. < HKCE 1984 Paper II - 27 >

Two heaters of rating '1 kW, 200 V' and '2 kW, 200 V' respectively are connected in series to a 200 V supply. What is the total power consumed by the heaters ?
A. 3 kW
B. 1.5 kW
C. 1 kW
D. 0.67 kW

8. < HKCE 1984 Paper II - 35 >

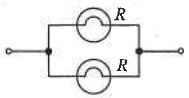
In the figure shown, S is a switch to turn on and off the electric fan. X, Y and Z are wires to be connected to the three terminals of a plug. How should X, Y and Z be connected to the three pins (E, L and N) of a given plug ?

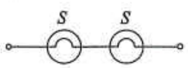


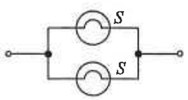
	Earth	Live	Neutral
A.	X	Y	Z
B.	Y	X	Z
C.	Z	Y	X
D.	X	Z	Y

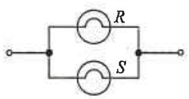
9. < HKCE 1985 Paper II - 37 >

Electric bulbs R are of rating "40 W, 200 V" and electric bulbs S are of rating "60 W, 200 V". Which of the following combinations would produce the maximum brightness if connected to the same voltage ?

A.


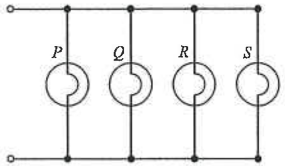
B.


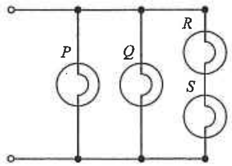
C.


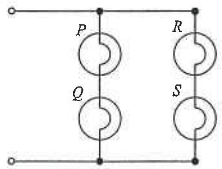
D.


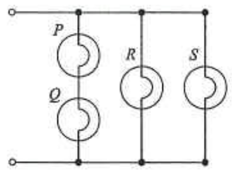
10. < HKCE 1986 Paper II - 36 >

P and Q are bulbs of rating "40 W, 200 V" while R and S are of rating "60 W, 200 V". Which of the following circuits gives the maximum brightness ?
(Assume all circuits are connected to the same voltage.)

A.


B.


C.


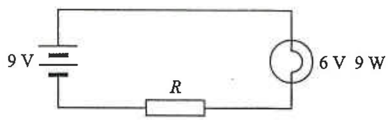
D.


11. < HKCE 1986 Paper II - 32 >

An electric heater of rating "2000 W, 200 V" and an electric cooker of rating "500 W, 200 V" are connected in parallel to a 200 V a.c. source. The total power of the two appliances is
A. 500 W.
B. 1500 W.
C. 2000 W.
D. 2500 W.

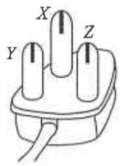
12. < HKCE 1987 Paper II - 29 >

The circuit shows a lamp of rating '6 V, 9 W' connected in series with a resistor R and a 9 V battery. What should be the resistance of R if the lamp is to work as rated ?



A. 2 Ω
B. 3 Ω
C. 4 Ω
D. 5 Ω

13. **< HKCE 1987 Paper II - 27 >**



In the three-pin plug as shown, X, Y and Z are respectively connected to the

	X	Y	Z
A.	earth	neutral	live
B.	earth	live	neutral
C.	neutral	earth	live
D.	neutral	live	earth

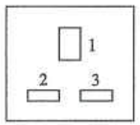
14. **< HKCE 1988 Paper II - 33 >**

A 3-pin plug is connected to a boiler of rating "2000 W, 200 V". Which of the following statements is/are true ?

(1) A 5 A fuse should be used in the circuit.
(2) The fuse should be placed on the brown wire of the cable.
(3) The yellow and green wire of the cable should be connected to the earth pin.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

15. **< HKCE 1989 Paper II - 39 >**



A standard three-pin socket on the wall is shown in the figure. Which of the following is correct ?

	Pin (1)	**Pin (2)**	**Pin (3)**
A.	neutral	live	earth
B.	neutral	earth	live
C.	earth	live	neutral
D.	earth	neutral	live

16. **< HKCE 1989 Paper II - 37 >**

Operating voltage	220 V / 50 Hz
Power	1500 W
Fuse Rating	30 A

The diagram shows the label attached to an electric appliance. How much electrical energy is supplied to the appliance in 2 hours ?

A. 2.0 kWh
B. 2.5 kWh
C. 3.0 kWh
D. 6.0 kWh

17. **< HKCE 1991 Paper II - 28 >**

For safety, the correct way of connecting the fuse and switch to electrical appliances should be

A. fuse in live wire, switch in neutral wire.
B. fuse in earth wire, switch in live wire.
C. both in neutral wire.
D. both in live wire.

18. **< HKCE 1991 Paper II - 36 >**

Two light bulbs A and B of ratings '10 W, 6 V' and '5 W, 6 V' respectively are connected in series to a 6 V battery. Which of the following is/are correct ?

(1) The resistance of A is smaller than that of B.
(2) The current through A is the same as that through B.
(3) A is brighter than B.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

19. **< HKCE 1993 Paper II - 33 >**

Which of the following is NOT a correct unit for the corresponding physical quantity ?

	Physical quantity	**Unit**
A.	charge	coulomb
B.	current	ampere
C.	resistance	ohm
D.	voltage	joule

20. **< HKCE 1994 Paper II - 30 >**

Operating voltage	220 V / 50 Hz
Power	500 W

The diagram shows the label attached to a rice cooker. Which of the following statements is/are true when the cooker is working at its rated values ?

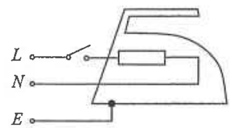
(1) The resistance of the cooker is 96.8 Ω.
(2) The cooker draws a current of 4.4 A from the mains supply.
(3) The cooker consumes 1 kWh of electrical energy in 2 hours.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

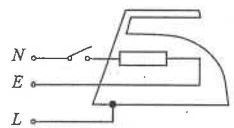
21. **< HKCE 1994 Paper II - 29 >**

Which of the following diagrams correctly shows the connection of the wires of an iron to the pins of a plug ?
(L : Live, N : Neutral, E : Earth)

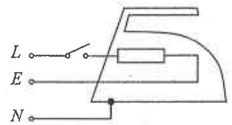
A.



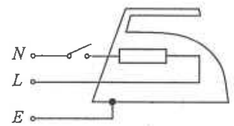
B.



C.



D.

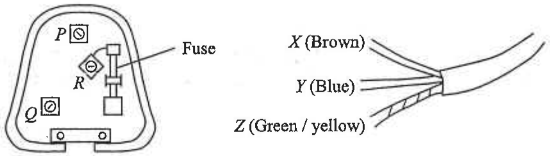


22. **< HKCE 1995 Paper II - 28 >**

Which of the following values is equivalent to one kilowatt hour ?

A. 1000 W
B. 1000 J
C. 3.6×10^6 W
D. 3.6×10^6 J

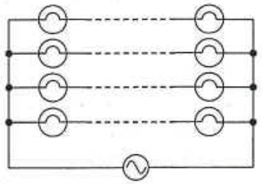
23. **< HKCE 1995 Paper II - 35 >**



The diagram above shows a three-pin plug and the wires connected to it. To which of the pins should each of the wires X, Y and Z be connected ?

	P	***Q***	***R***
A.	Z	Y	X
B.	Y	X	Z
C.	Y	Z	X
D.	Z	X	Y

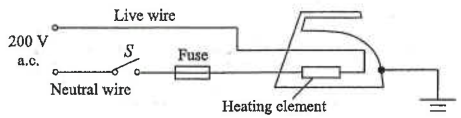
24. **< HKCE 1995 Paper II - 30 >**



A Christmas tree is illuminated with four strings of light bulbs. Each string has ten identical light bulbs connected in series as shown in the figure. If one light bulb suddenly burns out, which of the following will happen ?

A. Only that light bulb will go out.
B. One light bulb in each string will go out.
C. One string of light bulbs will go out.
D. All of the light bulbs will go out.

25. **< HKCE 1996 Paper II - 34 >**



The switch S and the fuse of an iron are incorrectly fitted in the neutral wire as shown above. Which of the following statements is correct ?

A. The iron will not operate even when S is on.
B. The iron will still operate even when S is off.
C. The iron will still operate, but if there is a high current the fuse will not blow.
D. The iron will still operate, but the heating element will remain at a high voltage even when S is off.

26. **< HKCE 1997 Paper II - 28 >**

The kilowatt-hour is a unit of

A. charge.
B. current.
C. energy.
D. power.

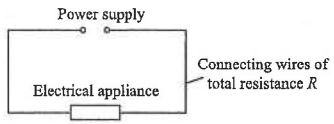
27. **< HKCE 1997 Paper II - 30 >**

Which of the following statements about the earth wire in an electric iron is/are correct ?

(1) The earth wire should be connected to the metal body of the iron.
(2) If the iron is working properly, no current pass through the earth wire.
(3) In case the neutral wire is broken, the earth wire provides a spare wire for the return path to the mains socket.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

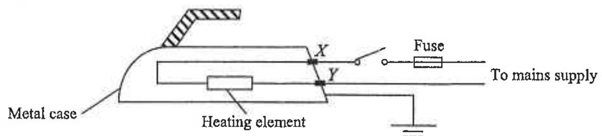
28. **< HKCE 1998 Paper II - 33 >**



An electric appliance is connected to a power supply of voltage V by long connecting wires of total resistance R as shown in the circuit. It is found that the current passing through the appliance is only $\frac{1}{2}I_o$, where I_o is the current required for the appliance to work at its rated value. Which of the following changes could increase the current through the appliance to I_o ?

	Voltage of power supply	**Total resistance of connecting wires**
A.	increases to $2V$	remains unchanged
B.	increases to $2V$	reduces to $R/2$
C.	remains unchanged	increases to $2R$
D.	remains unchanged	reduces to $R/2$

29. **< HKCE 2000 Paper II - 35 >**



The above diagram shows the main parts of an electric iron. In which of the following situations will the fuse blow when the switch is closed ?

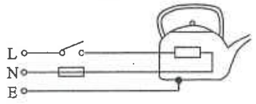
(1) The insulation at contact point X is worn out so that the wire touches the metal case.
(2) The insulation at contact point Y is worn out so that the wire touches the metal case.
(3) The heating element is broken.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

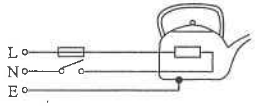
30. **< HKCE 2001 Paper II - 31 >**

Which of the following diagrams shows the correct connection of the fuse and switch of an electric kettle to the mains supply ? (L : live, N : neutral, E : earth)

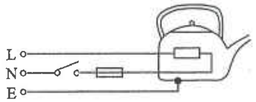
A.



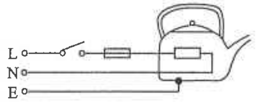
B.



C.



D.



31. **< HKCE 2001 Paper II - 32 >**

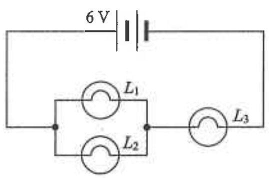
Two electric heaters X and Y are of ratings '110 V, 40 W' and '110 V, 80 W' respectively. Which of the below deductions about the two heaters is/are correct ?

(1) The operating resistance of X is twice that of Y.
(2) X will consume a power of 80 W when it is connected to a 220 V mains supply.
(3) Both heaters work at their rated values when they are connected in series to a 220 V mains supply.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

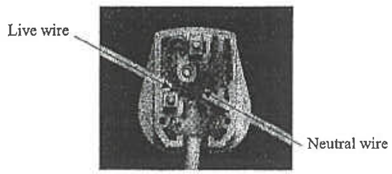
32. **< HKCE 2002 Paper II - 34 >**

Three identical lamps L_1, L_2 and L_3 of ratings '6 V, 12 W' are connected to a 6 V battery as shown in the figure. Which of the following statements is correct ?



A. The voltage across L_2 is 3 V.
B. The current passing through L_1 is 2 A.
C. The total power drawn from the battery is 12 W.
D. The total power dissipated in L_1 and L_2 is smaller than that in L_3.

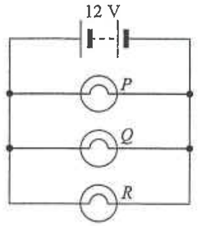
33. **< HKCE 2002 Paper II - 36 >**



If the live and neutral wires of an electric kettle are mistakenly interchanged inside the plug as shown above, which of the following will happen ?

A. The kettle will not operate.
B. The fuse of the kettle will blow.
C. The metal case of the kettle will still stand at a high voltage even when the switch of the kettle is off.
D. The heating element of the kettle will still stand at a high voltage even when the switch of the kettle is off.

34. **< HKCE 2003 Paper II - 34 >**

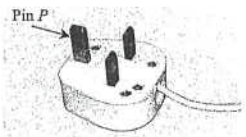


Three light bulbs P, Q and R of ratings '24 V, 80 W', '12 V, 80 W' and '12 V, 40 W' respectively are connected in parallel to a 12 V battery. Which of the bulbs will be the brightest, and which will be the dimmest ?

	The brightest	The dimmest
A.	P	Q
B.	P	R
C.	Q	P
D.	Q	R

35. **< HKCE 2003 Paper II - 35 >**

The photograph shows a three-pin plug of an appliance. Which of the following is a function of pin P ?



A. It prevents the appliance from being short-circuit.
B. It protects the user from getting an electric shock.
C. It provides a return path for the current.
D. It can break the circuit when the current flowing through the appliance is too large.

36. **< HKCE 2003 Paper II - 36 >**

ENERGY LABEL
能源 標籤

Brand 牌子	XXX
Model 型號	XXX
Annual Energy Consumption kWh/year 每年耗電量 每年千瓦小時 Actual consumption will depend on where the appliance is located and how it is used. Assume 260 washes per year. 其耗電量視乎電器的安裝地點及使用方式。 現假設每年洗衣 260 次。	250
Energy Efficiency Grade 能源效益級別	X
Washing Machine Category 洗衣機類別	XXX
EEL Registration Number 能源標籤登記號碼	XXX

The figure shows the energy label of a washing machine. If the average working time per wash is 1.8 hours, estimate the average electric power consumed by the machine.

A. 450 W
B. 534 W
C. 962 W
D. 1731 W

37. < HKCE 2004 Paper II - 33 >

One day, Donald used the following electrical appliances at home :

Appliance	Rating	Duration	Cost of electricity
electric heater	220 V, 2500 W	30 minutes	C_1
television	220 V, 270 W	5 hours	C_2
lamp	220 V, 150 W	8 hours	C_3

Which of the following relationships is correct ?
A. $C_1 > C_2 > C_3$
B. $C_2 > C_1 > C_3$
C. $C_2 > C_3 > C_1$
D. $C_3 > C_2 > C_1$

38. < HKCE 2005 Paper II - 20 >

The following table shows three electrical appliances which Clara used in a certain month :

Appliance	Rating	Duration
air-conditioner	220 V, 1200 W	250 hours
television	220 V, 250 W	80 hours
computer	220 V, 150 W	60 hours

Calculate the cost of electricity used. Note : 1 kW h of electricity costs $ 0.86.
A. $ 62.25
B. $ 73.79
C. $ 282.94
D. $ 536.64

39. < HKCE 2005 Paper II - 21 >

If a 15 A fuse is installed in the plug of an electric kettle of rating value '220 V, 900 W', which of the following descriptions is correct ?
A. The kettle will not operate.
B. The kettle will be short-circuited.
C. The output power of the kettle will be increased.
D. The chance of the kettle being damaged by an excessive current will be increased.

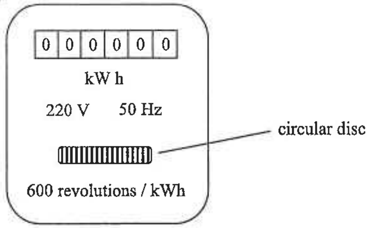
40. < HKCE 2006 Paper II - 24 >

An electrical appliance is protected by a fuse in a domestic circuit. When the appliance is switched on, the fuse blows immediately. Which of the following statements is/are possible reason(s) for this phenomenon ?
(1) The resistance of the appliance is too large.
(2) The appliance is short-circuited.
(3) The rated value of the fuse is too small.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

41. < HKCE 2006 Paper II - 40 >

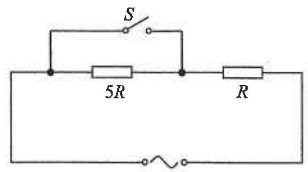
Two light bulbs are marked '220 V, 50 W' and '220 V, 100 W' respectively. If they are connected in series to a 220 V mains supply, what is the current drawn from the mains supply ?
A. 0.15 A
B. 0.23 A
C. 0.46 A
D. 0.68 A

42. < HKCE 2006 Paper II - 21 >



The figure shows the label of a kilowatt-hour meter connected to a mains supply. When an appliance is switched on for 2 minutes, the circular disc rotates through 24 complete revolutions. What is the electric power consumed by the appliance ?
A. 900 W
B. 1200 W
C. 1800 W
D. 2400 W

43. < HKCE 2006 Paper II - 41 >



In the circuit shown, the resistors represent the heating elements in a rice cooker. The resistances of the elements are $5R$ and R respectively. The rice-cooker can be operated in two modes, namely, cooking and keeping warm. The power consumed by the cooker in the cooking mode is 600 W when S is closed. What is the power consumed by the rice-cooker in the mode of keeping warm when S is open ?
A. 100 W
B. 120 W
C. 150 W
D. 180 W

44. < HKCE 2006 Paper II - 39 >

An electric appliance draws a current 2 A when it is operating at 220 V. Which of the following is the best description of the current and the voltage of each wire of the electric appliance when it is connected to a 220 V mains supply ?

	Live wire		Neutral wire		Earth wire	
	Current	Voltage	Current	Voltage	Current	Voltage
A.	2 A	220 V	1 A	220 V	1 A	0
B.	2 A	220 V	2 A	220 V	0	0
C.	2 A	220 V	2 A	0	0	0
D.	2 A	220 V	0	0	0	0

45. < HKCE 2007 Paper II - 18 >

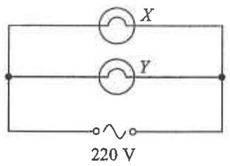
A household circuit breaker is marked '220 V, 15 A'. Now an electric iron rated '220 V, 1100 W' and a cooker rated '220 V, 550 W' are connected in parallel to the mains socket. How many light bulbs rated '220 V, 100W' at most can still be connected in parallel to the mains without triggering the circuit breaker ?
A. 12
B. 16
C. 17
D. 20

46. < HKCE 2008 Paper II - 22 >

A lighting system consists of 3 bulbs, each rated '220 V 30 W'. These three bulbs should be connected in parallel to the 220 V mains supply. However, the bulbs are wrongly connected in series to the mains supply. What is the power dissipation of the wrongly connected system ?
A. 3.33 W
B. 10 W
C. 30 W
D. 90 W

47. **< HKCE 2009 Paper II - 18 >**

Two identical bulbs, X and Y, are connected in parallel to the mains. The current passing through X is 0.4 A. What is the energy consumed by the two bulbs in 5 hours ?



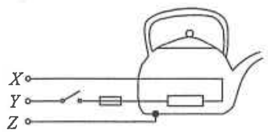
A. 0.44 kWh
B. 0.88 kWh
C. 440 kWh
D. 880 kWh

48. **< HKCE 2009 Paper II - 20 >**

The power ratings and resistances of two light bulbs are "24 W, 6 Ω" and "9 W, 4 Ω" respectively. If these two light bulbs are connected in parallel to a power supply, what is the maximum current drawn from the power supply so that both light bulbs are working within the rated power ?

A. 2.0 A
B. 2.5 A
C. 3.5 A
D. 4.8 A

49. **< HKCE 2009 Paper II - 23 >**

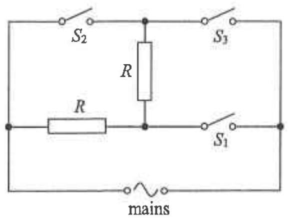


Which of the following is the correct connection of X, Y and Z to the mains ?

	X	Y	Z
A.	live	earth	neutral
B.	live	neutral	earth
C.	neutral	earth	live
D.	neutral	live	earth

50. **< HKCE 2009 Paper II - 41 >**

A mains heater has two identical heating elements of same resistance R.

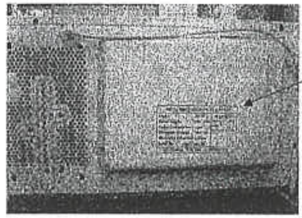


When S_1 and S_2 are closed and S_3 is open, the power of the heater is P. What is the power of the heater when S_1 and S_2 are open and S_3 is closed ?

A. 0.25 P
B. 0.5 P
C. 2 P
D. 4 P

51. **< HKCE 2010 Paper II - 16 >**

The photo below shows the back of a microwave oven.



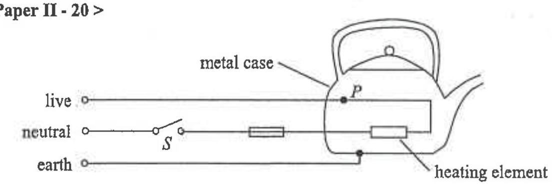
Power supply :	220 V – 50 Hz
Power consumption :	1150 W
Microwave output :	750 W
Microwave frequency :	2450 MHz

Which of the following statements is/are correct ?

(1) The current flowing through the microwave oven is about 3.4 A.
(2) Around 65% of electrical energy is converted into energy carried by microwave.
(3) The wavelength of the microwave emitted is about 0.12 m.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

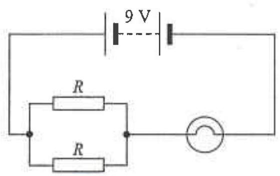
52. **< HKCE 2010 Paper II - 20 >**



In the figure above, the kettle is wired incorrectly. Which of the following statements is correct when point P is accidentally connected to the metal case ?

A. The kettle will still operate at its rated value when S is closed.
B. The fuse will blow when S is closed.
C. The heating element will burn out when S is closed.
D. A current will flow through the live wire even when S is open.

53. **< HKCE 2010 Paper II - 19 >**

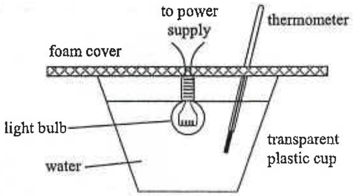


In the circuit above, the rating of the bulb is "6 V, 12 W". Find the resistance of R so that the bulb will work at its rated value.

A. 2 Ω
B. 3 Ω
C. 4 Ω
D. 6 Ω

54. < HKCE 2011 Paper II - 11 >

As shown in the figure, a 2 W light bulb is immersed into 50 g of water. The bulb is operating at its rated value. After 10 minutes, the temperature of the water increases by 4.5°C. Estimate the amount of light emitted during the 10 minutes.



Given : specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

A. 255 J
B. 690 J
C. 945 J
D. 1200 J

Part B : HKAL examination questions

55. < HKAL 1980 Paper I - 22 >

Torch bulbs marked "3 V, 1.5 W", are to be used in a circuit by using 6 V battery. What should be the number of bulbs connected in the circuit if the steady current drawn from the battery is to be 2 A and each bulb gives normal brightness ?

A. 2
B. 3
C. 4
D. 8

56. < HKAL 1983 Paper I - 43 >

A set of Christmas tree lights consists of 20 light bulbs in series connected to a supply of 200 V. Each light bulb has a rating of "10 V, 5 W". When one bulb burns out, Jenny goes to buy a replacement. When she gets back, she finds that although the new bulb is marked 5 W, the light it gives is dimmer than the other bulbs. Which of the following is a possible reason ?

(1) The supply voltage has dropped below 200 V.
(2) The current through the circuit is less than 0.5 A.
(3) The rated voltage of the new bulb is less than 10 V.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part C : Supplemental exercise

57. In a household circuit, as more lamps are switched on, which of the following statements are correct ?

(1) The equivalent resistance of the whole circuit increases.
(2) The total power consumption increases.
(3) The total current drawn increases.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

58. Which of the following statements concerning the fuse in an electrical appliance are correct ?

(1) A fuse is made of a metal with low melting point.
(2) If the fuse in an electrical appliance is blown, it should not be replaced by a piece of copper wire.
(3) If copper is used to replace the blown fuse, it will cause short circuit of the appliance as copper has low resistance.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

59. Small light bulbs of rating "12 V, 6 W" are to be used in a circuit. The voltage of the power supply is 24 V and the current drawn from the supply is 2 A. What is the number of light bulbs connecting in the circuit so that each light bulb is under normal rating ?

A. 2
B. 4
C. 8
D. 16

60. Which of the following statements concerning two light bulbs with rated values, '200 V, 100 W' and '200 V, 40 W', are correct ?

(1) The energy dissipated by the '200 V, 100 W' light bulb is greater than that of the '200 V, 40 W' light bulb when they work at their rated values.
(2) The current flowing through the '200 V, 100 W' light bulb is greater than that of the '200 V, 40 W' light bulb when they work at their rated values.
(3) The resistance of the '200 V, 100 W' light bulb is greater than that of the '200 V, 40 W' light bulb when they work at their rated values.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

61. Which of the following concerning the household circuit is/are correct ?

(1) Fuse should be installed in the live wire of an electrical appliance.
(2) Switch should be installed in the neutral wire of an electrical appliance.
(3) Current always flows from the live wire through the appliance to the neutral wire.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

62. Which of the following statements concerning two light bulbs with rated values, '200 V, 100 W' and '200 V, 40 W', is/are correct ?

(1) The resistance of the '200 V, 100 W' light bulb is greater than that of the '200 V, 40 W' light bulb.
(2) The current flowing through the '200 V, 100 W' light bulb is greater than that of the '200 V, 40 W' light bulb when they are connected in series.
(3) The power dissipated by the '200 V, 100 W' light bulb is smaller than that of the '200 V, 40 W' light bulb when they are connected in series.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part D : HKDSE examination questions

63. < HKDSE Sample Paper IA - 26 >

If a 15 A fuse is installed in the plug of an electric kettle of rating value '220 V, 900 W', state what happens when the kettle is plugged in and switched on.

A. The kettle will not operate.
B. The kettle will be short-circuited.
C. The output power of the kettle will be increased.
D. The chance of the kettle being damaged by an excessive current will be increased.

64. < HKDSE Sample Paper IA - 25 >

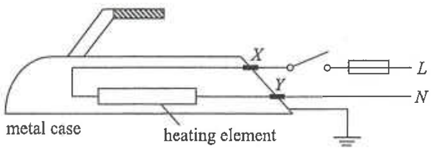
The table shows three electrical appliances which Clara used in a certain month :

Appliance	Rating	Duration
air-conditioner	220 V, 1200 W	250 hours
television	220 V, 250 W	80 hours
computer	220 V, 150 W	60 hours

Calculate the cost of electricity used. Note : 1 kW h of electricity costs \$ 0.86.

A. \$ 62.25
B. \$ 73.79
C. \$ 282.94
D. \$ 536.64

65. < HKDSE Practice Paper IA - 30 >



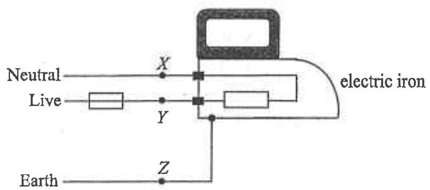
The figure above shows the main parts of an electric iron. In which of the following situations will the fuse blow when the switch is closed ?

A. The heating element is broken and becomes an open circuit.
B. The earth wire is worn out and becomes disconnected.
C. The insulation at contact point X is worn out so that the wire touches the metal case.
D. The insulation at contact point Y is worn out so that the wire touches the metal case.

66. < HKDSE 2012 Paper IA - 33 >

The figure shows a simple domestic circuit for an electric iron. The fuse will blow when which of the following points are short-circuited ?

(1) X and Y
(2) Y and Z
(3) X and Z



A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

67. < HKDSE 2013 Paper IA - 33 >

Which of the following domestic electrical appliances consumes a power close to 1 kW in normal working conditions ?

A. an electric fan
B. a microwave oven
C. a fluorescent lamp
D. a TV set

68. < HKDSE 2015 Paper IA - 28 >

Which statement is **NOT** a reason why mains socket at home are connected in parallel instead of a series circuit ?

A. Electrical appliances connected to different sockets can be switched on or off independently.
B. Voltage supplied to each socket is fixed and all electrical appliances can operate at their rated voltage.
C. The current supplied can be reduced and thinner cables can then be used.
D. When an electrical appliance breaks down and becomes an open circuit, other appliances can still work normally.

69. < HKDSE 2015 Paper IA - 29 >

An electric iron of 1800 W sold in Hong Kong (220 V 50 Hz) is connected to a 110 V 60 Hz mains socket in another country. How does its performance compare on the same ironing setting ?

A. The electric iron does not work because the a.c. supply is 60 Hz instead of 50 Hz.
B. The electric iron is as hot as it is used in Hong Kong.
C. The electric iron is hotter than when it is used in Hong Kong.
D. The electric iron is colder than when it is used in Hong Kong.

70. < HKDSE 2016 Paper IA - 28 >

A television set in stand-by mode consumes 1.5 W. If it is in this mode for 16 hours a day, estimate the carbon dioxide (CO_2) emission due to the electricity consumed in stand-by mode in a 30-day month.

Given : 1 kW h of electricity consumed corresponds to 0.8 kg CO_2 emission from the power station.

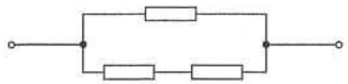
A. 0.576 kg
B. 0.720 kg
C. 576 kg
D. 720 kg

71. < HKDSE 2017 Paper IA - 25 >

Which of the following statements about the use of a fuse is correct ?

A. A fuse should be installed in the neutral wire.
B. A fuse is not required in an electrical appliance with double insulation.
C. A 5A fuse is suitable for a heater of rating '220 V, 1500 W'.
D. The melting point of a fuse should be lower than that of copper.

72. < HKDSE 2018 Paper IA - 24 >

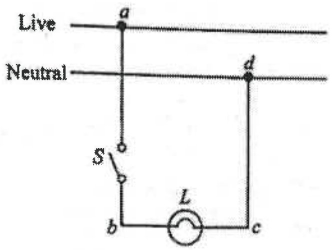


Three identical resistors are arranged as shown. The rated power of each resistor is 12 W. If no resistor exceeds its rated power, what is the maximum power dissipation in such an arrangement ?

A. 16 W
B. 18 W
C. 20 W
D. 24 W

73. <HKDSE 2020 Paper IA-24>

The figure shows part of a domestic lighting circuit in which the bulb L does not light up when switch S is closed.



The circuit is then checked with switch S closed. Using a voltage tester to touch points b and c in turns, the tester indicates that both points are at high voltage. When touching points a and d in turns, the tester indicates only point a is at high voltage. Which of the following can be a reason for the fault ?

A. The switch S has been damaged.
B. The filament of bulb L has been burnt out and becomes an open circuit.
C. There is a short circuit between a and d.
D. There is an open circuit between c and d.

74. <HKDSE 2020 Paper IA-25>

The battery shown has a capacity of 1100 mA h. How much energy is delivered when the battery operates normally at a current of 250 mA for one hour ? Assume that the battery's operating voltage remains at 3.7 V during that period.

A. $(3.7 \times \frac{250}{1000} \times 3600)$ J

B. $(3.7 \times \frac{1100}{1000} \times 3600)$ J

C. $(3.7 \times \frac{250}{1000} \times 1)$ J

D. $(3.7 \times \frac{1100}{1000} \times 1)$ J

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. B	11. D	21. A	31. A	41. A	51. D	61. A	71. D
2. C	12. A	22. D	32. D	42. B	52. D	62. B	72. B
3. D	13. B	23. A	33. D	43. A	53. B	63. D	73. D
4. D	14. D	24. C	34. C	44. C	54. A	64. C	74. A
5. B	15. D	25. D	35. B	45. B	55. D	65. C	
6. D	16. C	26. C	36. B	46. B	56. B	66. C	
7. D	17. D	27. C	37. B	47. B	57. C	67. B	
8. C	18. C	28. A	38. C	48. B	58. A	68. C	
9. C	19. D	29. A	39. D	49. D	59. C	69. D	
10. A	20. C	30. D	40. D	50. A	60. A	70. A	

M.C. Solution

1. B

Voltage across 18 Ω = voltage across 21 Ω = (2.4)(21) = 50.4 V

$I_X = \dfrac{50.4}{18} = 2.8\text{ A} < 3\text{ A}$ ∴ fuse X will not be blown

$I_Y = I_X + I_Z = 2.8 + 2.4 = 5.2\text{ A} > 5\text{ A}$ ∴ fuse Y will be blown

2. C

A. $R = \dfrac{V_r^2}{P_r} = \dfrac{(200)^2}{(2000)} = 20\ \Omega$

B. $R = \dfrac{(200)^2}{(250)} = 160\ \Omega$

C. $R = \dfrac{(100)^2}{(2000)} = 5\ \Omega$

D. $R = \dfrac{(100)^2}{(20)} = 50\ \Omega$

∴ Heater has the smallest resistance.

3. D

× A. If current is smaller current, then all bulbs would become dimmer

× B. If the resistance is higher, then it should give greater power as $P = I^2 R$, and thus become brighter

× C. If the bulb is shorted accidentally, then it does not work and would not look dimmer

✓ D. As $R = \dfrac{V_r^2}{P_r}$, for the same rated power 5 W but lower rated voltage, the new bulb has smaller resistance

by $P = I^2 R$, the new bulb has smaller power and thus looks dimmer

4. D

$I = \dfrac{P_r}{V_r} \times 15 = \dfrac{60}{200} \times 15 = 4.5\text{ A}$

Value of fuse should be equal to or greater than I

∴ 5 A is the appropriate one

5. B

$I = \dfrac{P_1}{V}\times 8 + \dfrac{P_2}{V} = \dfrac{100}{200}\times 8 + \dfrac{1000}{200} = 9\text{ A}$

Value of fuse should be equal to or greater than I ⇒ 10 A is the appropriate one

6. D

By $R = \dfrac{V_r^2}{P_r}$, for hair dryer : $R = \dfrac{(200)^2}{(600)} = 66.7\ \Omega$ which is the smallest resistance.

∴ It gives the greatest current for a given voltage.

7. D

$R_{1\text{kW}} = \dfrac{(200)^2}{1000} = 40\ \Omega$ and $R_{2\text{kW}} = \dfrac{(200)^2}{2000} = 20\ \Omega$

∴ Equivalent resistance = 40 + 20 = 60 Ω

∴ $P = \dfrac{V^2}{R} = \dfrac{(200)^2}{(60)} = 0.67\text{ kW}$

8. C

Earth : Z (connected to the metal case of the electric fan)

Live : Y (this wire has a switch)

Neutral : X (giving a returning path)

9. C

$R_R = \dfrac{(200)^2}{40} = 1000\ \Omega$, $R_S = \dfrac{(200)^2}{60} = 667\ \Omega$

(1) smaller resistances in parallel gives smaller equivalent resistance (by $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$),

(2) smaller equivalent resistance ⇒ larger current ⇒ maximum brightness (for same voltage)

∴ C gives the maximum brightness.

10. A

All resistors in parallel must give the smallest equivalent resistance, thus it gives the maximum brightness

11. D

For the two appliances working in rated values, $P = 2000 + 500 = 2500$ W.

12. A

As $V_R = 3$ V

$\therefore I = \frac{P_r}{V_r} = \frac{9}{6} = 1.5$ A

$\therefore R = \frac{V_R}{I} = \frac{3}{1.5} = 2\ \Omega$

13. B

The longest pin X is the Earth pin.

Pin Y is the Live pin and pin X is the Neutral pin.

14. D

× (1) $I = \frac{P_r}{V_r} = \frac{2000}{200} = 10\text{ A} > 5\text{ A}$ $\therefore$ 5 A fuse should not be used, otherwise, it will be blown.

✓ (2) As the brown wire is the live wire, the fuse should be placed on it to allow the fuse cutting off the circuit when the current is too large.

✓ (3) Yellow and green wire is the earth wire.

15. D

Pin 1 is the Earth socket.

Pin 2 is the Neutral socket.

Pin 3 is the Live socket.

16. C

$E = Pt$

$= (1.5) \times (2) = 3$ kWh

17. D

Fuse is used to limit the current of circuit. Switch is used to turn off the appliance from the circuit.

Both of them should be connected to the live wire,

so that the appliance is cut off from high voltage when the circuit is disconnected.

18. C

✓ (1) By $R \propto \frac{V_r^2}{P_r} \propto \frac{1}{P_r}$ $\therefore$ A : larger rated power $P_r \Rightarrow$ smaller resistance R

✓ (2) In series $\Rightarrow$ same current passing through

× (3) By $P = I^2R$, A : smaller resistance and same current $\Rightarrow$ smaller power output $\Rightarrow$ dimmer

19. D

Voltage : unit V (volt)

20. C

✓ (1) $R = \frac{V_r^2}{P_r} = \frac{(220)^2}{500} = 96.8\ \Omega$

× (2) $I_r = \frac{P_r}{V_r} = \frac{500}{220} = 2.27$ A

✓ (3) $E = Pt = (0.5) \times (2) = 1$ kWh

21. A

The switch should be connected in the live wire L so that the iron can be cut off from high voltage when it is off.

The earth wire E should be connected to the metal case of the iron.

22. D

1 kWh $= (1000\text{ W}) \times (60 \times 60\text{ s}) = 3.6 \times 10^6$ J

23. A

P : Earth wire $\Rightarrow$ Green/yellow $\Rightarrow Z$

Q : Neutral wire $\Rightarrow$ Blue $\Rightarrow Y$

R : Live wire $\Rightarrow$ Brown $\Rightarrow X$

24. C

One light bulb burnt out $\Rightarrow$ no current flow through that series

$\Rightarrow$ all bulbs in that string will go out

25. D

× A. S is on $\Rightarrow$ circuit completed $\Rightarrow$ iron will operate

× B. S is off $\Rightarrow$ circuit not completed $\Rightarrow$ iron will not operate

× C. High current $\Rightarrow$ fuse will blow $\Rightarrow$ circuit cut $\Rightarrow$ iron will not operate

✓ D. S is not in live wire $\Rightarrow$ the heating element is still at high voltage even when S is off.

26. C

kWh = kW · h = $(P)(t)$ = Energy

27. C

✓ (1) Presence of Earth wire connected to metal case
$\Rightarrow$ provides a path for conduction of current to the Earth
$\Rightarrow$ prevent electric shock

✓ (2) Current returns back to power supply via **neutral** wire instead.

× (3) Earth wire is not connected to mains socket, if neutral wire is broken, no current flows.

28. A

$I = \frac{I_o}{2}$ $\Rightarrow$ resistance of appliance = resistance of wires = R

$\therefore$ equivalent resistance of the electrical appliance and the connecting wires $= 2R$

By $V = IR$

If voltage of power supply : $V \rightarrow 2V$ and no change to the resistance

$\therefore$ It gives a current of I_o.

29. A

✓ (1) Current flows to the ground directly $\Rightarrow$ no current through the heating element $\Rightarrow$ short circuit $\Rightarrow$ current becomes very large $\Rightarrow$ fuse blows

× (2) Current flows through the heating element before reaching the metal case $\Rightarrow$ no increase in I

× (3) Heating element broken $\Rightarrow$ the circuit not completed $\Rightarrow$ no current flows through the fuse

30. D

Both the switch and the fuse should be connected to the live wire

31. A

✓ (1) By $R = \frac{V_r^2}{P_r}$, the rated power of X is halved of that of Y, thus the resistance is twice of that of Y.

× (2) Since $P = \frac{V^2}{R}$ $\therefore P \propto V^2$ $\therefore$ when voltage is doubled, the power should be 4 times.

× (3) Since their resistances are not equal, the voltage across each heater will not be 110 V

32. D

Resistance of lamp $= 6^2 / 12 = 3\ \Omega$

Total resistance $= 3/2 + 3 = 4.5\ \Omega$

Current flow from the battery $= 6/4.5 = 1.33$ A

Voltage across $L_3 = 1.33 \times 3 = 4$ V

Voltage across L_1 and $L_2 = 6 - 4 = 2$ V $\therefore$ A is not correct.

Current through $L_1 = 1.33/2 = 0.67$ A $\therefore$ B is not correct.

Total power drawn from the battery $= 6 \times 1.33 = 8$ W $\therefore$ C is not correct.

Total power dissipated in L_1 and $L_2 = 1.33^2 \times 1.5 = 2.7$ W

Power dissipated in $L_3 = 1.33^2 \times 3 = 5.3$ W $\therefore$ D is correct.

33. D

If the live and neutral wires are interchanged, then the switch would become connected on the neutral wire.
In this case, when the switch is off, the kettle will still stand at a high voltage.
However, the kettle would work properly when the switch is on.

34. C

Light bulb P is not under rated condition, since $P \propto V^2$

$\therefore V \rightarrow \frac{1}{2}V \Rightarrow P \rightarrow \frac{1}{4}P$ $\therefore$ actual power of P is 20 W

Light bulb Q is under rated condition, thus the actual power is 80 W

Light bulb R is also under rated condition, thus the actual power is 40 W.

The brightest light bulb is Q and the dimmest light bulb is P.

35. B

Pin P is the earth pin which is connected to the metal case of the electric appliance.
When the live wire accidentally touches the metal case, the earth wire provides a low resistance path to conduct the current to the earth, thus prevent the electric shock of human bodies.

36. B

No. of washes per year $= 260$ Average time per wash $= 1.8$ hours

Total operating time $= 260 \times 1.8 = 468$ hours

By $E = Pt$

$\therefore$ (250 kWh) $= P$ (468 h)

$\therefore P = 0.534$ kW $= 534$ W

37. B

Electric heater : $E = \frac{2500}{1000}\text{ kW} \times \frac{30}{60}\text{ h} = 1.25\text{ kWh}$

Television : $E = \frac{270}{1000}\text{ kW} \times 5\text{ h} = 1.35\text{ kWh}$

Lamp : $E = \frac{150}{1000}\text{ kW} \times 8\text{ h} = 1.20\text{ kWh}$

Since the cost is proportional to the amount of electrical energy used $\therefore C_2 > C_1 > C_3$

38. C

Total electrical energy used $= 1.2\text{ kW} \times 250\text{ h} + 0.25\text{ kW} \times 80\text{ h} + 0.15\text{ kW} \times 60\text{ h} = 329$ kW h

Cost of electricity $= 329 \times \$\,0.86 = \$\,282.94$

39. D

× A. The kettle will operate no matter which fuse is installed.

× B. The kettle will not be short-circuited unless the live touches the neutral.

× C. The kettle will still work properly with the rated power of 900 W.

✓ D. Since the rated current $= 900/220 = 4.09$ A. The fuse value of 15 A is too high.
If the current exceeds the 4.09 A but less than 15 A,
the fuse will not blow and the kettle may be damaged.

40. D

× (1) If the resistance is too large, the current would be too small, and the fuse would not blow.

✓ (2) If the appliance is short-circuited, the current would become very large and the fuse will blow.

✓ (3) If the rated value of the fuse is too small, then the rated current may exceed the fuse value and the fuse will blow.

41. A

Resistance of the '220 V, 50 W' light bulb $= \frac{(220)^2}{(50)} = 968\ \Omega$

Resistance of the '220 V, 100 W' light bulb $= \frac{(220)^2}{(100)} = 484\ \Omega$

Total equivalent resistance of the two light bulbs in series $= 968 + 484 = 1452\ \Omega$

Current drawn from the mains supply $= \frac{220}{1452} = 0.15$ A

42. B

According to the label, 600 revolutions indicate an electrical energy of 1 kWh, i.e. 3600 000 J.

For 24 revolutions, $E = 24 \times \frac{3600000}{600} = 144000$ J

Electric power : $P = \frac{E}{t} = \frac{144000}{2 \times 60} = 1200$ W

43. A

When S is closed, the $5R$ resistor is shorted. The equivalent resistance of the whole circuit is R.

When S is open, the $5R$ and R resistors are in series. The equivalent resistance of the whole circuit is $6R$.

By $P = \frac{V^2}{R} \propto \frac{1}{R}$ $\therefore$ Power consumed in the mode of keeping warm $= 600 \times \frac{R}{6R} = 100$ W

44. C

Live wire : current drawn is 2 A
voltage is at high voltage of 220 V

Neutral wire : current is equal to that of live wire, i.e. 2 A
voltage is at low voltage of 0 V

Earth wire : no current through earth wire when operating, i.e. 0 A
no voltage in the earth wire, i.e. 0 V

45. B

Maximum power given by the mains socket without triggering the circuit breaker $= VI = 220 \times 15 = 3300$ W

Assume n light bulbs at most can be connected. $\therefore$ $1100 + 550 + 100n = 3300$ $\therefore n = 16.5$

Thus, maximum number of light bulbs that can be connected = 16.

46. B

Resistance of each bulb $= \frac{V_r^2}{P_r} = \frac{(220)^2}{(30)} = 1613\ \Omega$

Total equivalent resistance for three bulbs in series $= 1613 \times 3 = 4840\ \Omega$

Total power dissipated $= \frac{V^2}{R} = \frac{(220)^2}{(4840)} = 10$ W

47. B

Total current given out by the mains supply $= 0.4 \times 2 = 0.8$ A

Total power given out by the mains supply : $P = VI = (220)(0.8) = 176$ W

Total energy consumed : $E = Pt = (0.176\text{ kW}) \times (5\text{ h}) = 0.88$ kWh

48. B

By $R = \frac{V_r^2}{P_r}$

By $(6) = \frac{V_r^2}{(24)}$ $\therefore V_r = 12$ V $\therefore$ Rated voltage of the 6 Ω light bulb is 12 V.

By $(4) = \frac{V_r^2}{(9)}$ $\therefore V_r = 6$ V $\therefore$ Rated voltage of the 4 Ω light bulb is 6 V.

As the two light bulbs are in parallel, they must have the same applied voltage V.

If the applied voltage is 12 V, then the 4 Ω light bulb would be burnt, thus the applied voltage should only be 6 V.

Equivalent resistance of the circuit : $R = \frac{6 \times 4}{6+4} = 2.4\ \Omega$

Current delivered from the power supply : $I = \frac{V}{R} = \frac{6}{2.4} = 2.5$ A

OR

Current delivered from the power supply : $I = \frac{6}{6} + \frac{6}{4} = 2.5$ A

49. D

Y is live as switch and fuse are on the live wire.

X is neutral to complete the circuit.

Z is the earth that is connected to the metal case of the appliance.

50. A

When S_1 and S_2 are closed and S_3 is open, the two resistors are in parallel, equivalent resistance is $\frac{1}{2}R$.

When S_1 and S_2 are open and S_3 is closed, the two resistors are in series, equivalent resistance is $2R$.

The equivalent resistance is increased 4 times.

By $P = \frac{V^2}{R}$, as power is inversely proportional to the resistance, the power should become $\frac{1}{4}$.

Thus the power is $0.25P$.

51. D

× (1) By $P = VI$ $\therefore$ $(1150) = (220)\,I$ $\therefore$ $I = 5.23$ A

✓ (2) Percentage of energy carried by the microwave = 750 / 1150 = 65%

✓ (3) Wavelength : $\lambda = v/f = (3 \times 10^8) / (2450 \times 10^6) = 0.12$ m

52. D

× A. When S is closed, current would flow from live to the metal case and then to earth as it is a shorted path, thus no current would flow through the heating element and the kettle will not operate.

× B. As the current would not flow through the heating element and the fuse, the fuse would not blow.

× C. As there is no current flowing through the heating element, the heating element would not burn out.

✓ D. When S is open, current can still flow through the live wire to the metal case, and then to the earth wire to complete the circuit.

53. B

Rated current = $\dfrac{P_r}{V_r} = \dfrac{12}{6} = 2$ A

Voltage across the two resistors = 9 − 6 = 3 V

Equivalent resistance of the two resistors = $\dfrac{V}{I} = \dfrac{3}{2} = 1.5\ \Omega$

As the two resistors are in parallel : $\dfrac{R}{2} = 1.5$ $\therefore$ $R = 3\ \Omega$

54. A

Electrical energy supplied to the light bulb = Pt = (2) (10 × 60) = 1200 J

Heat energy given out by the light bulb = $mc\Delta T$ = (0.050) × (4200) × (4.5) = 945 J

Light energy given out by the light bulb = 1200 − 945 = 255 J

55. D

Total power given out by the battery = VI = (6) × (2) = 12 W

For each light bulb to give normal brightness, the power given out by each light bulb is 1.5 W.

Total number of light bulbs in the circuit = $\dfrac{12}{1.5} = 8$

56. B

× (1) Voltage dropped below 200 V ⇒ all light bulbs would become dimmer

× (2) Smaller current ⇒ all light bulbs become dimmer

✓ (3) As $R = \dfrac{V^2}{P}$, for same rated power 5 W but lower rated voltage, the new bulb has smaller resistance

As $P = I^2 R$ for light bulbs in series, $P \propto R$ $\therefore$ the new bulb has less power than the other bulbs

57. C

× (1) As more lamps are switched on in parallel, the equivalent resistance should decrease.

✓ (2) As more power is given to the lamps, the total power consumption increases.

✓ (3) As the equivalent resistance decreases, more current is drawn from the supply.

58. A

✓ (1) Fuse should be made of metal with low melting point so that it would be melted by the heating effect of the excess current.

✓ (2) Copper has a high melting and cannot be melted easily, thus even the current exceeds the rated current of the fuse, copper would not be melted and blown.

× (3) Both the fuse and the copper wire have negligible resistance, as they are connected in series to the appliance, they would not cause short circuit of the appliance.

59. C

For the bulb being fully lit,

(1) Number of bulbs in each series path = $\dfrac{24}{12} = 2$

(2) Current flowing through each parallel circuit = current flowing through each bulb = $\dfrac{P}{V} = \dfrac{6}{12} = 0.5$ A

Number of parallel circuit connected to power supply = $\dfrac{2}{0.5} = 4$

$\therefore$ Total number of bulbs = 2 × 4 = 8

OR

Power given out by the power supply = VI = (24) × (2) = 48 W

Number of light bulbs = $\dfrac{48}{6} = 8$

60. A

✓ (1) When they work at their rated values, power given out by the '200 V, 100 W' light bulb is 100 W which is greater than the 40 W given out by the '200 V, 40 W' light bulb.

✓ (2) By $P = VI$, as the power given out by the '200 V, 100 W' light bulb is greater, the current drawn is greater.

× (3) By $R = V_r^2 / P_r$, as the power given out by the '200 V, 100 W' light bulb is greater, its resistance is smaller.

61. A

✓ (1) Fuse should be installed in the live wire, so that the appliance is cut off from high voltage when the fuse is blown.

× (2) Switch should also be connected to the live wire, so that the appliance is cut off from high voltage when the switch is off.

× (3) Since household circuit is an a.c. circuit, current flows from L to N and from N to L alternately.

62. B

× (1) By $R = V_r^2 / P_r$, as the rated power P_r of the '200 V, 100 W' light bulb is greater, its resistance is smaller.

× (2) When they are connected in series, the current flowing through each of them must be the same.

✓ (3) As the resistance of the '200 V, 100 W' light bulb is smaller, by $P = I^2 R$, same current I in series, thus, $P \propto R$, therefore, the power dissipated is smaller.

63. D

× A. The kettle will operate no matter which fuse is installed.

× B. The kettle will not short-circuited unless the live touches the neutral.

× C. The kettle will still work properly with the rated power of 900 W.

✓ D. Since the rated current = 900 / 220 = 4.09 A $\therefore$ the fuse value of 15 A is too high. If the current exceeds 4.09 A but less than 15 A, the fuse will not blow and the kettle may be damaged.

64. C

Total electrical energy used = 1.2 kW × 250 h + 0.25 kW × 80 h + 0.15 kW × 60 h = 329 kW h

Cost of electricity = 329 × \$ 0.86 = \$ 282.94

65. C

If the insulation at X is worn out, once the switch is closed,
current would flow from the Live wire through the metal case to the Earth wire.
As the resistance of the metal case is negligible, current would be very large and the fuse would blow.

66. C

✓ (1) If X and Y are short circuited, current would not flow through the resistor and becomes very large.

✓ (2) If Y and Z are short circuited, current would not flow through the resistor and becomes very large.

× (3) If X and Z are short circuited, current must still flow through the resistor and would not be too large.

67. B

A microwave oven normally has a power around 1000 W.
Other appliances : electric fan, fluorescent lamp and TV, have power much less than 1000 W.

68. C

In parallel circuit, current supplied by the mains is the sum of current in each parallel path.
Current cannot be reduced by using parallel circuit.

69. D

× A. The frequency of the a.c. mains does not affect the working of an electric iron.

× B. As the applied voltage is smaller than that in Hong Kong, thus the power cannot be the same.

× C. As the applied voltage is smaller than that in Hong Kong, thus the power cannot be higher.

✓ D. For the same resistance of an appliance : $P = V^2 / R$ $\therefore P \propto V^2$
Since the mains voltage of country X is lower, the power given out is smaller, thus the iron is colder.

70. A

$E = Pt = (0.0015\text{ kW}) \times (16\text{ h} \times 30) = 0.72\text{ kW h}$

Carbon dioxide emission = 0.72 × 0.8 = 0.576 kg

71. D

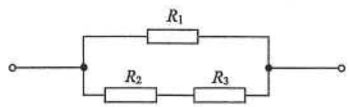
× A. Fuse should be installed in the live wire.

× B. The fuse is still required to limit the current to avoid overheating.
For electrical appliance with double insulation, there is no metal case, thus, earth wire is not needed.

× C. For a heater of rating '220 V, 1500 W', the rated current : $I_r = 1500 / 220 = 6.82$ A
A 5A fuse is not suitable as it would be blown when the heater is switched on.

✓ D. Fuse has a low melting point that it can melt and break the circuit once current exceeds the rated current.
Thus, its melting point must be lower than that of copper wire.

72. B



Since the voltage of R_1 is equal to the sum of voltage of R_2 and R_3,
R_1 should work under rated power to give $P_1 = 12$ W.
Since the voltage of R_2 is halved of R_1,
by $P = V^2 / R \propto V^2$, the power of R_2 is one-fourth of R_1

$P_2 = 12 \times \left(\frac{1}{2}\right)^2 = 3\text{ W}$

Since the voltage of R_3 is equal to that of R_2, thus $P_3 = P_2 = 3$ W
Total power = 12 + 3 + 3 = 18 W

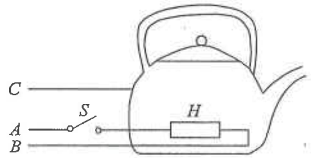
The following list of formulae may be found useful :

Resistance and resistivity	$R = \frac{\rho l}{A}$
Resistors in series	$R = R_1 + R_2$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
Power in a circuit	$P = IV = I^2 R$
Energy transfer during heating or cooling	$E = mc\Delta T$
Energy transfer during change of state	$E = l\Delta m$

Part A : HKCE examination questions

1. < HKCE 1981 Paper I - 8 >

Socket　　　　Plug



Electric kettle

The above figure shows a 220 V supply socket, a 3-pin plug, and an electric kettle with a rating : '220V 1.65 kW'. The kettle has 3 wires A, B, C leading from it. Wire A is joined through a switch S to the heating element H of the kettle ; wire B completes the circuit of the kettle ; wire C is joined to the metal case of the kettle.

(Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1})

(a) (i) To which of the pins X, Y, Z of the plug should each of the wires A, B, C of the kettle be connected ? (3 marks)

(ii) What is the function of the 'earth' terminal in the socket ? (1 mark)

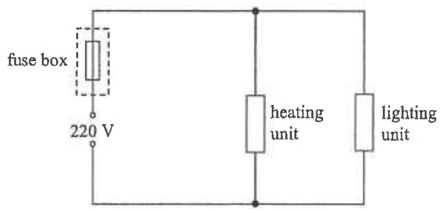
1. (b) (i) A 15 A fuse is connected to the socket. Which line : earth, neutral and live, should the fuse be placed ? (1 mark)

(ii) Find the maximum number of kettles that can be joined in parallel to the socket without blowing the fuse. (3 marks)

(c) (i) If the efficiency of the kettle is 80%, how long will it take to heat 1 kg of water from 20°C to 100°C ? (4 marks)

(ii) If the cost of electricity is \$0.80 per kWh, how much does this heating process cost ? (3 marks)

2. < HKCE 1983 Paper I - 7 >



A household electric circuit consists of a heating unit (220 V, 1100 W) and a lighting unit (220 V, 220 W) connected in parallel to the mains of 220 V as shown in the above figure.

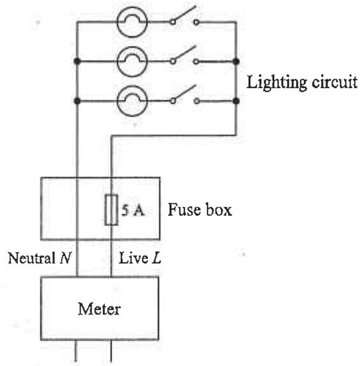
(a) Find the maximum current drawn from the mains. (2 marks)

(b) Is a 5 A fuse suitable for use in the fuse box ? Explain briefly. (2 marks)

(c) If electrical energy costs \$0.90 per kWh and the whole system is switched on for 150 hours, what will be the cost of the electricity used ? (2 marks)

3. < HKCE 1986 Paper I - 7 >

The figure shows a simplified system of a 220 V domestic circuit. N and L denote the neutral and live wires respectively.



(a) Give a reason why the lamps are all connected in parallel instead of in series. (2 marks)

(b) The light bulbs of the circuit shown in the above figure are all marked "60 W 220 V". Suppose that all the light bulbs are switched on. (5 marks)

(i) What is the total resistance of the lighting circuit ?

(ii) What is the total current drawn from the power supply ?

(c) (i) Explain the use of the fuse in the circuit. (2 marks)

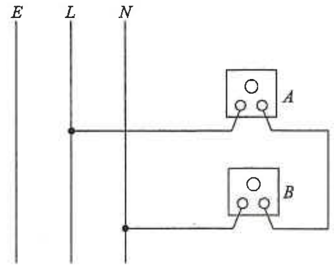
(ii) Give a reason why the switches should be connected to the live wire L instead of to the neutral wire N. (2 marks)

(iii) What physical quantity does the meter measure ? (2 marks)

(d) The household voltage supply in Hong Kong has changed from 200 V a.c. to 220 V a.c. in 1995. Give one reason for the change. (2 marks)

4. < HKCE 1988 Paper I - 7 >

Given socket A and socket B, an unqualified electrical technician wires the two sockets to the live L, the neutral N, the earth E of the 220 V mains supply for a heater rated at "220 V, 1000 W" and a cooker rated at "220 V, 800 W" as shown in the figure below. (The sockets are viewed from the front.)



(a) (i) If either one of these appliances is plugged into one of the sockets, would there be any current drawn from the mains with the switch of the appliance on ? Explain briefly. (2 marks)

(ii) If both appliances are plugged into the sockets, would the appliances work at the rated power (1000 W and 800 W) with switches on ? Explain briefly. (2 marks)

(iii) Draw a diagram to show how the two sockets should be connected to the live, the neutral and the earth of the mains supply with a fuse placed at a proper position. (4 marks)

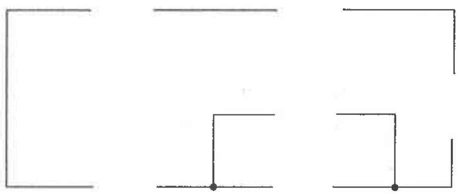
(b) Suppose the heater and the cooker are switched on in the correct wiring circuit for 2 hours, calculate

(i) the total current drawn from the mains supply, and (3 marks)

(ii) the total cost of electricity if one kilowatt-hour of electric energy costs \$0.90. (2 marks)

5. **< HKCE 1992 Paper I - 5 >**

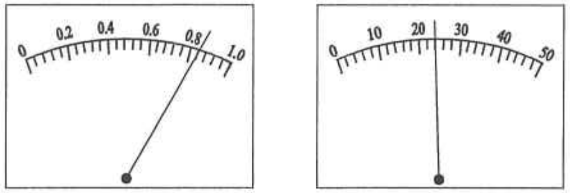
A student uses the following components to measure the resistance of a light bulb : A battery, an ammeter, a voltmeter, a switch, a variable resistor and the light bulb. An incomplete circuit for the experiment is shown below :



(a) On the above figure, use suitable circuit symbols to complete the circuit. Indicate on your diagram the positive terminals of the ammeter and voltmeter with "+" signs. (5 marks)

(b) What is the function of the variable resistor in the circuit ? (2 marks)

(c) The below figure shows the result obtained in the experiment.



Voltmeter (0 – 1 V) Ammeter (0 – 50 mA)

(i) What is (1) the voltmeter reading, (2) the ammeter reading ? (2 marks)

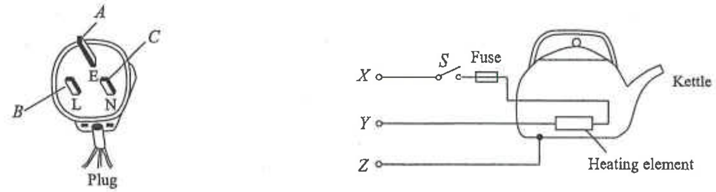
(ii) Calculate the resistance of the light bulb. (2 marks)

(d) The rating of the light bulb is "220 V, 110 W".

(i) Calculate the resistance of the bulb when it is working at its rated value. (2 marks)

(ii) Explain why the resistance found in (d)(i) is much greater than that found in (c)(ii). (2 marks)

6. **< HKCE 1998 Paper I - 4 >**



The above Figure shows a 3-pin plug and a kettle.

(a) To which of the pins *A*, *B* and *C* of the plug should each of the wires *X*, *Y* and *Z* of the kettle be connected ? (2 marks)

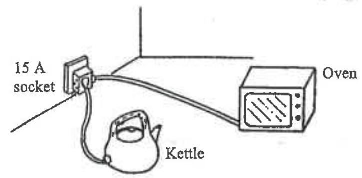
(b) (i) Explain why it is safer to have pin *A* of the plug longer than the other two pins. (2 marks)

(ii) Explain why switch *S* of the kettle is connected in wire *X* instead of wire *Y*. (2 marks)

(c) The rating of the kettle is '220 V, 2000 W'.

(i) If the kettle is switched on for half an hour, calculate the cost of electricity. (Given : One kilowatt-hour of electricity costs $0.9.) (2 marks)

(ii)



A housewife plugs the kettle and an oven of rating '220 V, 2500 W' into a 15 A socket as shown in the above figure. Explain why this connection is dangerous. Show your calculations. (3 marks)

(d) A student makes the following note in his book :

In case either wire *X* or *Y* touches the metal case of the kettle accidentally, the kettle will stop working.

Explain whether the student's note is correct. (3 marks)

7. < HKCE 1999 Paper I - 1 >

Figure 1

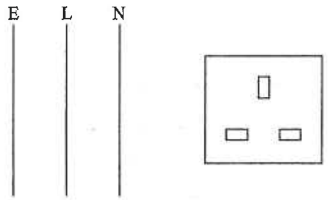


Figure 1 shows the front view of a socket and the earth (E), live (L) and neutral (N) wires of the 220 V mains supply.

(a) On Figure 1, show how the socket is connected to the mains supply. (2 marks)

(b)

Figure 2

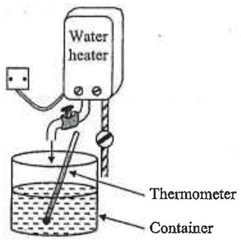
Model No. : CS301
220 V 50 Hz
2500 W

Figure 2 shows the label attached to an electrical appliance. If the appliance is switched on for 150 hours in a month, calculate the cost of electricity. (Given : 1 kWh of electricity costs \$ 0.87.) (2 marks)

8. < HKCE 2001 Paper I - 9 >

(a)

Figure 1



Mary wants to estimate the efficiency of an electric water heater in her kitchen. She uses a container to collect the water and a thermometer to measure the temperature (see Figure 1). She finds that when the heater is switched on, 1.6 kg of water at 23°C is heated to 67°C in one minute. The rating value of the heater is '220 V, 6000 W' and the specific heat capacity of water is 4200 J kg^{-1} °C^{-1}.

(i) Find the energy absorbed by the 1.6 kg of water in one minute. (2 marks)

(ii) Estimate the efficiency of the heater. (3 marks)

(iii) State one reason to explain why the efficiency found in (ii) is less than 100%. (1 mark)

8. (b)

Figure 2

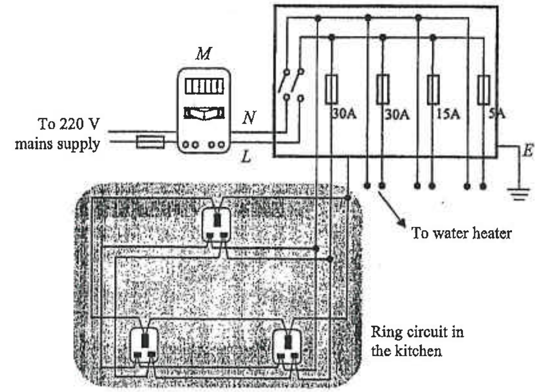


Figure 2 shows a household electrical wiring circuit. The mains cable (containing live and neutral wires) is connected to a consumer unit via a meter *M*. At the consumer unit, the wires branch out into a number of parallel circuits. Figure 2 also shows the power circuit in the kitchen. It is in the form of a ring circuit with three sockets tapped off from the ring.

(i) Name the meter *M*. What physical quantity does the meter record ? (2 marks)

(ii) The following appliances are connected to the ring circuit in the kitchen :

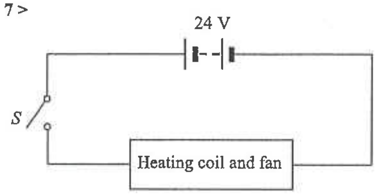
Appliances	Rating
a refrigerator	220 V , 600 W
an electric kettle	220 V , 2000 W
an oven	220 V , 1500 W

If the appliances are all switched on, find the total current drawn from the mains supply. (3 marks)

(iii) Explain why the water heater mentioned in part (a) is not connected to the sockets in the rings circuit but directly connected to the mains via a separate circuit. (2 marks)

(iv) State one advantage of the ring circuit arrangement. (2 marks)

9. < HKCE 2002 Paper I - 7 >



In a science project competition, a student constructs a hand-dryer. He connects an electric fan of rating '20 W, 24 V' and a heating coil to a 24 V power supply as shown in the Figure 1. When switch S is closed, the fan will operate at its rated value.

(a) Are the fan and the heating coil connected in series or in parallel ? Explain your answer. (2 marks)

(b) If the output power of the heating coil is 200 W, find

(i) the operating resistance of the heating coil,

(ii) the total current drawn from the power supply when S is closed. (4 marks)

10. < HKCE 2003 Paper I - 8 >

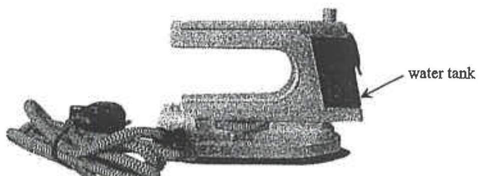


Figure 1

Figure 1 shows a travel steam iron with a rated power output of 1100 W. The water tank in the iron is filled with water. When the iron is turned on, water drips continuously from the tank to a hot plate inside the iron, generating steam for ironing clothes. Assume the initial temperature of the water drops is 20°C.

Given : Specific heat capacity of water = 4200 J kg^{-1} °C^{-1},
specific latent heat of vaporization of water = 2.26×10^6 J kg^{-1}.

(a) Calculate the energy required to vaporize 1 kg of water at 20°C into steam. (2 marks)

10. (b) Assume that 80% of the power output of the iron is used to generate steam. Estimate the maximum mass of steam that can be generated by the iron in 1 s. (2 marks)

(c) The iron is designed to operate at 220 V or 110 V with the same power output of 1100 W.

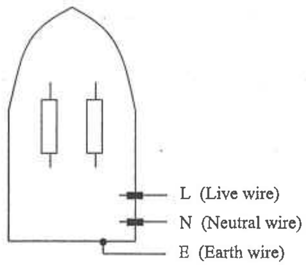
(i) In each of the following cases, find the resistance of the heating element of the iron :

(1) when operating at 220 V,

(2) when operating at 110 V. (3 marks)

(ii)

Figure 2



The heating element of the iron consists of two identical resistance wires as shown in Figure 2.

(1) Draw **two** diagrams to show how the resistance wires are connected when the iron is operating at 220 V and at 110 V respectively. (3 marks)

(2) What is the resistance of each resistance wire ? (1 mark)

(iii) A tourist switches the iron to the 220 V mode but connects it to a 110 V supply. Explain whether the iron can function normally. (3 marks)

11. **< HKCE 2006 Paper I - 6 >**

Rated Capacity	24.1 litres
Heating time (15°C → 65°C)	24.3 minutes

The above Figure shows the energy label of a water heater from which some information is listed in the above Table.

Given : mass of 1 litre of water = 1 kg,

specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

(a) The heating element of a water heater is usually installed on the lower position of the water tank. Suggest one reason for this design. (1 mark)

(b) Using the information in the above Table,

(i) estimate the energy required to heat a full tank of water from 15°C to 65°C, (2 marks)

(ii) hence estimate the current drawn by the water heater when it is operating at 220 V. (3 marks)

(c) Explain why thick wires are used to connect the water heater to the mains supply. (2 marks)

12. **< HKCE 2008 Paper I - 7 >**

Figure 1 shows a ceiling lamp in Jack's home. The lamp has two filament light bulbs, each rated "220 V 40 W". The lamp is turned on or off by a switch (see Figure 2) on the wall.

Figure 1

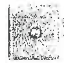


Figure 2

(a) Give **two advantages** of connecting the two light bulbs to the 220 V mains supply in parallel. (2 marks)

(b) Explain why the switch should be connected to the live wire of the mains supply. (2 marks)

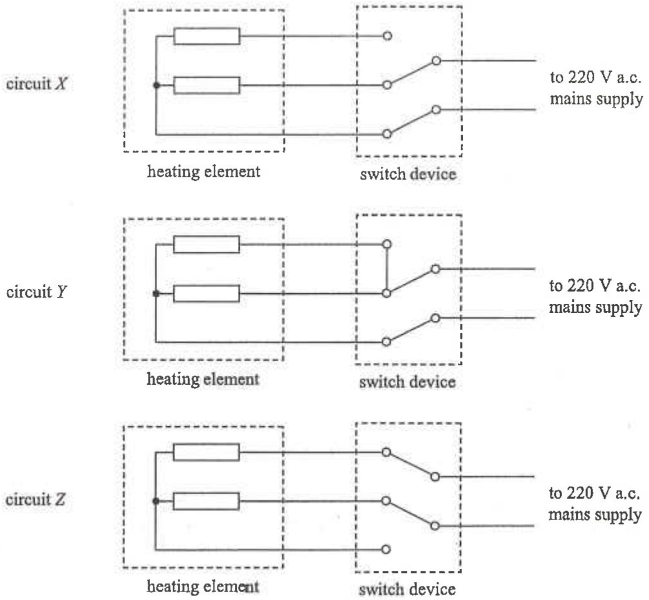
(c) Jack decides to replace each filament light bulb with an energy saving bulb of the same brightness. The Table below shows the details of the two kinds of bulbs. Considering the price of the bulbs and the electricity fee, find the total money saved **per energy saving bulb** after operating for 4000 hours.

		Price per bulb	Power	Electricity fee
	filament light bulb	\$ 5	40 W	\$ 0.95 / kW h
	energy saving bulb	\$ 35	8 W	

(3 marks)

13. **< HKCE 2010 Paper I - 9 >**

A hair dryer with a plastic case has three settings of power output : high, medium and low. The settings are selected by the use of a switch device. The Figure below shows the circuits of these three settings in random order. All the resistors in the heating element have the same resistance of 50 Ω. The hair dryer is connected to 220 V a.c. mains supply.



(a) Find the power delivered by circuit *Y*. (3 marks)

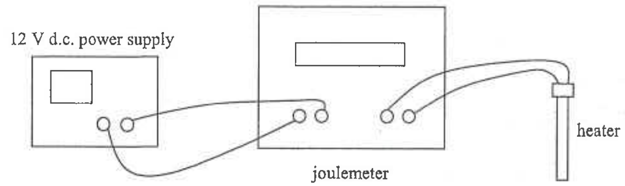
(b) Fill in *X*, *Y* and *Z* in the appropriate spaces in the below Table. (1 mark)

Power output settings	Circuit
Low	
Medium	
High	

(c) Explain why the hair dryer does not need an earth wire. (1 mark)

Part B : HKDSE examination questions

14. **< HKDSE Practice Paper IB - 9 >**



A 12 V heater is operated under a steady d.c. voltage of 12 V. The energy consumed by the heater in 2 minutes is measured by a joulemeter as shown in the Figure. The initial and final readings of the joulemeter are 126 J and 2525 J respectively.

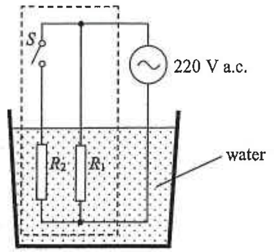
(a) Estimate the electrical power of the heater. (2 marks)

(b) Hence, find the current through the heater. (2 marks)

(c) A 5 A fuse is installed in the power supply. Explain whether the fuse will blow if another identical heater is connected in parallel with the original heater. (2 marks)

15. **< HKDSE 2012 Paper IB - 8 >**

In the circuit shown in the Figure, resistors R_1 and R_2 represent the heating elements in a heater using mains supply. Both resistors are immersed in water.



The heater can be operated in two modes, namely, heating and keeping warm, and it is controlled by the switch S. The power consumed by the heater in the heating mode is 550 W and in the mode of keeping warm is 88 W. The mains voltage is 220 V a.c.

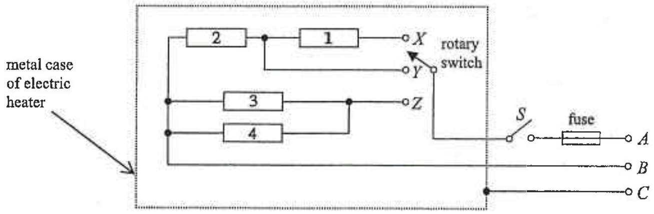
(a) In which mode is the heater operating when switch S is open ? (1 mark)

(b) Find the resistance of R_1. (2 marks)

(c) When switch S is closed, calculate the current passing through resistor R_2. (3 marks)

16. **< HKDSE 2014 Paper IB - 8 >**

The Figure shows the schematic diagram of an electric heater consisting of four identical heating elements, each having a rated value of '500 W 220 V'. A user can use the rotary switch to select one of the three modes of operation X, Y, Z. Wires A, B, C from the heater are connected to the 220 V a.c. mains via a 3-pin plug.



(a) Find the resistance R of a heating element. (1 mark)

16. (b) What is the total power dissipated when mode X is selected ? Assume that the resistance of each heating element remains unchanged. (2 marks)

(c) Without the need of calculations, explain which mode of operation has the largest total power dissipation. (2 marks)

(d) (i) If fuses 3 A, 5 A and 13 A are available, determine which will be the most suitable to limit an excess current. Show your work. (3 marks)

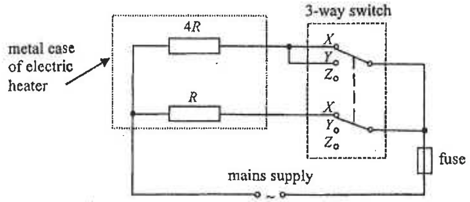
(ii) A student claims that since a.c. is used for the heater, the switch S can be installed in either wire A or wire B. Comment on this claim. (2 marks)

(iii) If a fault resulted in the live wire having contact with the metal case of the heater, which wire, A, B or C, could prevent an electric shock of a person touched the case of the heater ? Explain. (2 marks)

17. **< HKDSE 2018 Paper IB - 8 >**

(a) Figure 1 shows the schematic diagram of an electric heater which can operate in two modes, namely, 'heating' and 'keeping warm'. The heating elements of resistances $4R$ and R are connected to the mains supply via a 3-way switch with its two poles tied together. That is, both poles can be connected to one of the three pairs of terminals X, Y or Z.

Figure 1



(i) To which pairs of terminals, X, Y or Z, should the switch connect to when the heater is in 'heating' mode ? (1 mark)

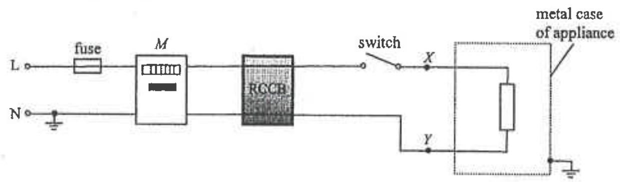
17. (a) The power consumed by the heater in 'heating' mode is 800 W.

(ii) Calculate the current drawn from the 220 V mains supply when the heater is in 'heating' mode. (2 marks)

(iii) Find the power consumed by the heater in the mode of 'keeping warm'. (3 marks)

(b) Figure 2 shows a simplified domestic circuit connected to an electrical appliance via a fuse, a meter M, a residual current circuit breaker (RCCB) and a switch.

Figure 2



(i) What physical quantity does the meter M record ? (1 mark)

(ii) An RCCB is a kind of safety device that cuts off the supply automatically whenever there is a small difference between the currents in the live (L) and neutral (N) wires. State, in each of the following situations, which device(s) will respond (i.e. the fuse blows and/or the RCCB cuts off the supply).

(1) A short circuit occurs between points X and Y. (1 mark)

(2) A short circuit occurs between point Y and the metal case of the appliance. (1 mark)

There is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) (i) $A \longrightarrow Y$ [1]

$B \longrightarrow Z$ [1]

$C \longrightarrow X$ [1]

(ii) To prevent electric shock if there is any leakage of electricity to the metal case. [1]

OR

To prevent electric shock by conducting the current to the Earth through the earth wire. [1]

(b) (i) Live [1]

(ii) Rated current of each kettle $= \frac{P}{V}$ [1]

$= \frac{1650}{220} = 7.5\text{ A}$ [1]

Maximum number of kettle $= \frac{15}{7.5}$

$= 2$ [1]

(c) (i) Actual power given to the water $= 1650 \times 80\% = 1320\text{ W}$ [1]

Energy required to heat 1 kg of water $= (1) \times (4200) \times (100 - 20) = 336\,000\text{ J}$ [1]

Time taken $= \frac{336000}{1320}$ [1]

$= 255\text{ s}$ [1]

(ii) $E = 1.65\text{ kW} \times \frac{255}{3600}\text{h}$ [1]

$= 0.117\text{ kW h}$ [1]

OR

$E = \frac{336000}{3600000} \times \frac{100}{80}$ [1]

$= 0.117\text{ kW h}$ [1]

Cost $= 0.117 \times 0.80$

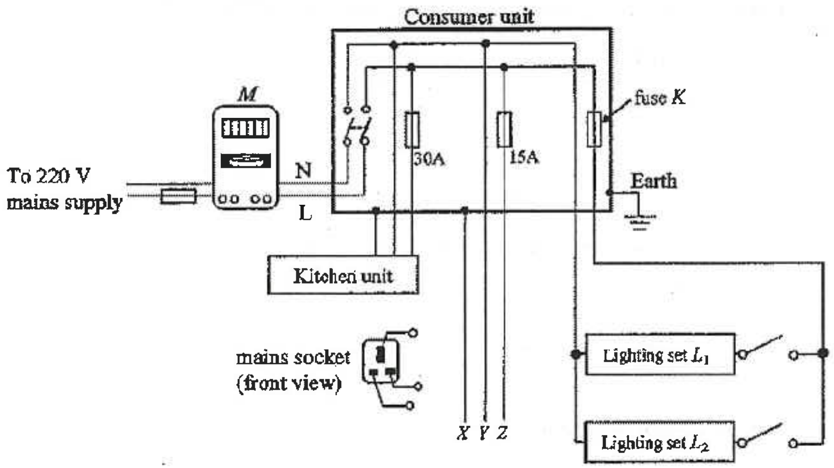
$= \$\,0.0936$ <accept \$ 0.0933> [1]

2. (a) Total power $= 1100 + 220 = 1320\text{ W}$ [1]

$\therefore I = \frac{P}{V} = \frac{1320}{220} = 6\text{ A}$ [1]

18. <HKDSE 2019 Ppaper-IB-8>

Figure 8.1 shows a household electrical wiring circuit. The mains cable (containing live wire L and neutral wire N) is connected to a consumer unit via a kilowatt-hour meter M. At the consumer unit, the wires branch out into a number of parallel circuits.



ure 8.1

(a) Indicate on Figure 8.1 how the mains socket should be connected to wires X, Y and Z. (1 mark)

(b) Lighting sets L_1 and L_2 of power ratings 300 W and 450 W respectively are connected in parallel to the branch with fuse K.

(i) State one advantage of connecting L_1 and L_2 in parallel instead of in series to the branch. (1 mark)

(ii) If fuses marked 3 A, 5 A, 10 A and 13 A are available, which one is the most suitable to be fuse K ? Explain your choice. (3 marks)

(c) The kitchen unit includes the following electrical appliances:

	rating	effective time of operation at rated value per day
a refrigerator	220 V, 500 W	8 hours
an electric kettle	220 V, 2000 W	0.5 hour
an induction cooker	220 V, 3000 W	2 hours

How much should be paid per day to run these appliances if 1 kW h of electrical energy costs \$0.9 ?
(3 marks)

2. (b) No ! [1]

The fuse will blow. [1]

(c) E = 1.32 kW × 150 h = 198 kW h [1]

Cost = 198 × 0.9 = \$ 178.2 [1]

3. (a) Any **ONE** of the reasons below : [2]

* ✱ Each lamp can be switched on and off independently
* ✱ Even if one lamp is burnt, the other lamps can still operate properly
* ✱ The voltage across each lamp is 220 V to give out rated power.

(b) (i) Resistance of each light bulb $= \frac{V^2}{P}$ [1]

$= \frac{(220)^2}{(60)} = 807\ \Omega$ [1]

Total resistance $= \frac{807}{3}$

$= 269\ \Omega$ [1]

(ii) Total current $= 3 \times \frac{60}{220}$ [1]

$= 0.818$ A [1]

(c) (i) To prevent the overloading of the wire. [2]

OR

To limit the flow of current in the circuit. [2]

(ii) To ensure that the lamps are cut off from live when the switches are open. [2]

(iii) Energy [2]

(d) Either **ONE** of the followings : [2]

* ✱ To match with the international standard
* ✱ To increase the power output

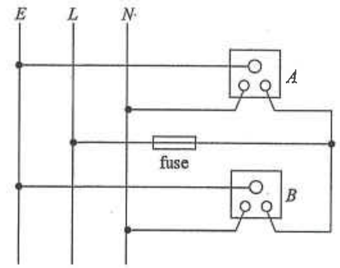
4. (a) (i) No ! [1]

Sockets A and B are connected in series to the mains. [1]

(ii) No ! [1]

When both appliances are plugged in, the voltage across each socket is less than 220 V. [1]

4. (a) (iii) [4]



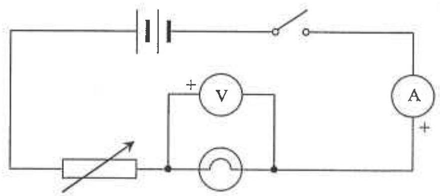
(b) (i) $I = \frac{P}{V}$ [1]

Total current $= \frac{1000}{220} + \frac{800}{220} = 8.18$ A [2]

(ii) Energy used = (1.0 + 0.8) kW × 2 h = 3.6 kW h [1]

Cost = 3.6 × 0.9 = \$ 3.24 [1]

5. (a)



< Battery, ammeter, switch, variable resistor and light bulb in series with correct symbols > [3]

< Voltmeter in parallel with the light bulb > [1]

< +ve terminal of voltmeter and ammeter correct > [1]

(b) The variable resistor is used to vary the current flowing through the bulb. [2]

(c) (i) (1) 0.84 V [1]

(2) 24 mA [1]

(ii) $R = \frac{V}{I} = \frac{0.84}{0.024} = 35\ \Omega$ [2]

(d) (i) Operating resistance $= \frac{V^2}{P} = \frac{(220)^2}{(110)}$ [1]

$= 440\ \Omega$ [1]

(ii) When the bulb is working at its rated value, its temperature is much higher, [1]

so resistance increases. [1]

6. (a) X is connected to B.

Y is connected to C.

Z is connected to A.

< 1 mark for one of them correct > [1]

< 1 mark for the other two correct > [1]

(b) (i) To ensure the metal case of the kettle is earthed before the heating element is connected to the live wire. [2]

OR

The long pin opens the shutter that blocks the other two apertures to prevent accidental insertion of metal objects. [2]

(ii) S is connected in wire X because the heating element will be cut off from the live wire when S is switched off. [2]

OR

If S is connected in wire Y, the heating element will still be at live wire even when S is switched off. [2]

(c) (i) $E = 2\ \text{kW} \times 0.5\ \text{h} = 1\ \text{kW h}$ [1]

Cost $= \$\,0.9 \times 1 = \$\,0.9$ [1]

(ii) Current drawn from the mains supply

$$= \frac{2000}{220} + \frac{2500}{220}$$ [2]

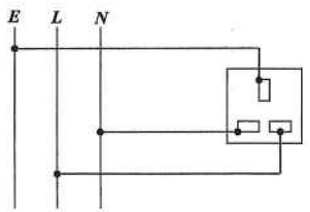
$$= 20.5\ \text{A}$$

Since the current exceeds 15 A, the connection is dangerous and the fuse will blow. [1]

(d) If wire X touches the case, a short circuit will be set up between the live wire and the earth, [1]
the fuse will blow and the kettle will stop working. [1]

If wire Y touches the metal case, the circuit is still completed, so the kettle will continue to work. [1]

7. (a)



< For earth wire > [1]

< For neutral and live wire > [1]

(b) Energy used $= 2.5\ \text{kW} \times 150\ \text{h} = 375\ \text{kW h}$ [1]

Cost of electricity $= 375 \times 0.87 = \$\,326$ < accept $\$\,326.25$ > [1]

8. (a) (i) $E = m\,c\,\Delta T$ [1]

$= (1.6) \times (4200) \times (67 - 23) = 296\ 000\ \text{J}$ < accept 295 680 J or 296 kJ > [1]

(ii) Power output $= \dfrac{E}{t} = \dfrac{295680}{60} = 4930\ \text{W}$ < accept 4928 W > [1]

Efficiency $= \dfrac{\text{Power output}}{\text{Power input}}$ [1]

$= \dfrac{4928}{6000} \times 100\% = 82.1\%$ < accept 82.2% > [1]

(iii) Any **ONE** of the following : [1]

∗ Some energy is lost to the surroundings

∗ Some energy is absorbed by the container

(b) (i) It is a kilowatt-hour meter. [1]

It measures the electrical energy used. [1]

(ii) Total power $= 600 + 2000 + 1500 = 4100\ \text{W}$ [1]

$I = \dfrac{P}{V} = \dfrac{4100}{220}$ [1]

$= 18.6\ \text{A}$ [1]

(iii) The water heater draws a large current from the mains supply. [1]

If other electric appliances are connected together, overloading may occur. [1]

(iv) Any **ONE** of the following : [2]

∗ If the ring circuit is broken at one point, the ring circuit can still function.

∗ Current is divided into two halves via two paths, thus thinner cables can be used.

∗ Since current is divided into two halves, the chance of overloading is reduced.

9. (a) The fan and the heating coil are connected in parallel. [1]

So that they can operate at their rated values. [1]

(b) (i) $R = \dfrac{V^2}{P}$ [1]

$= \dfrac{24^2}{200} = 2.88\ \Omega$ [1]

(ii) $I = \dfrac{P}{V}$ [1]

$= \dfrac{20 + 200}{24} = 9.17\ \text{A}$ [1]

10. (a) $E = m l_f + m c \Delta T$

$= (1)(2.26 \times 10^6) + (1)(4200)(100 - 20)$ [1]

$= 2\ 596\ 000$ J [1]

(b) Useful energy output in 1 s $= (1100)(1) \times 80\% = 880$ J [1]

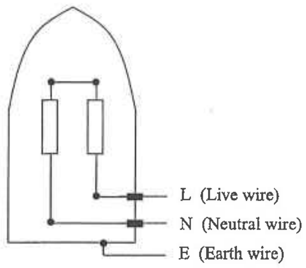
Maximum mass of steam generated in 1 s $= \dfrac{880}{2596000} = 3.39 \times 10^{-4}$ kg [1]

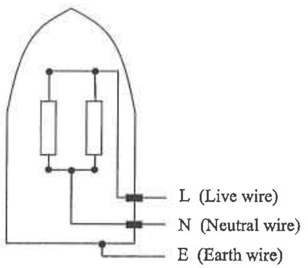
(c) (i) (1) $R = \dfrac{V^2}{P}$ [1]

$= \dfrac{(220)^2}{1100} = 44\ \Omega$ [1]

(2) $R = \dfrac{(110)^2}{1100} = 11\ \Omega$ [1]

(ii) (1) 220 V mode 110 V mode





< In 220 V mode, the two resistors are in series > [1]

< In 110 V mode, the two resistors are in parallel > [1]

< All the connections are correct > [1]

(2) Resistance of each wire $= 22\ \Omega$ [1]

(iii) The iron cannot function properly. [1]

When the iron is in 220 V mode, its resistance is 44 Ω.

Thus the power output $= \dfrac{(110)^2}{44} = 275$ W [1]

This power is much smaller than the rated value. [1]

11. (a) The water can be heated uniformly by convection. [1]

(b) (i) $E = m c \Delta T$ [1]

$= (24.1)(4200)(65 - 15) = 5.06 \times 10^6$ J [1]

11. (b) (ii) $E = P t$ [1]

$(5.06 \times 10^6) = P(24.3 \times 60)$ $\therefore P = 3470$ W

$P = VI$ [1]

$(3470) = (220) I$ $\therefore I = 15.8$ A [1]

(c) Thick wires has smaller resistance, [1]

thus reduce the heating effect of current on the wires. [1]

OR

Thin wires are not used since their resistance is greater [1]

and thus the wires may be over-heated. [1]

12. (a) Both light bulbs can work under rated voltage. [1]

When one light bulb burns out, the other light bulb can still work. [1]

(b) When the switch is off, the light bulb is cut off from high voltage. [1]

Thus no electric shock occurs when the light bulb is touched. [1]

(c) Total cost of filament light bulb $= 5 + 4000 \times \dfrac{40}{1000} \times 0.95 = \$\ 157$ [1]

Total cost of energy saving bulb $= 35 + 4000 \times \dfrac{8}{1000} \times 0.95 = \$\ 65.4$ [1]

Total money saved $= 157 - 65.4 = \$\ 91.6$ [1]

13. (a) Equivalent resistance : $R = \dfrac{50 \times 50}{50 + 50} = 25\ \Omega$ [1]

$P = \dfrac{V^2}{R}$ [1]

$= \dfrac{220^2}{25} = 1936$ W < accept 1940 W > [1]

(b) [1]

Power output settings	Circuit
Low	Z
Medium	X
High	Y

(c) Any **ONE** of the following : [1]

* The hair dryer has a plastic case.
* The case of the hair dryer is an insulator.
* The hair dryer has double insulation.

14. (a) $P = \dfrac{E}{t} = \dfrac{(2526-126)}{2\times 60}$ [1]

$= 20\text{ W}$ [1]

(b) By $P = VI$

$\therefore\ (20) = (12)\,I$ [1]

$\therefore\ I = 1.67\text{ A}$ [1]

(c) Total current $= 1.67\times 2 = 3.34\text{ A}$ [1]

As the total current is less than 5 A, the fuse will not blow. [1]

15. (a) keeping warm [1]

(b) By $P = \dfrac{V^2}{R}$

$\therefore\ (88) = \dfrac{(220)^2}{R_1}$ [1]

$R_1 = 550\ \Omega$ [1]

(c) Power given out by the resistor $R_2 = 550 - 88 = 462\text{ W}$ [1]

By $P = VI$

$\therefore\ (462) = (220)\,I_2$ [1]

$\therefore\ I_2 = 2.1\text{ A}$ [1]

16. (a) $R = \dfrac{(220)^2}{(500)} = 96.8\ \Omega$ [1]

(b) $P = \dfrac{V^2}{R_{eq}} = \dfrac{(220)^2}{(96.8+96.8)}$ [1]

$= 250\text{ W}$ [1]

OR

$P_1 = P_2 = \dfrac{V^2}{R} = \dfrac{(110)^2}{(96.8)} = 125\text{ W}$ [1]

Total power $= 125\times 2 = 250\text{ W}$ [1]

OR

$I = \dfrac{V}{R_{eq}} = \dfrac{(220)}{(96.8+96.8)} = 1.136\text{ A}$

$P = I^2 R_{eq} = (1.136)^2\times(96.8\times 2) = 250\text{ W}$ [1]

16. (c) Mode Z has the largest power dissipation, [1]

since the equivalent resistance of mode Z is the smallest. [1]

(d) (i) Mode Z draws the largest current. [1]

$I = \dfrac{220}{96.8}\times 2 = 4.55\text{ A}$ [1]

OR

$I = \dfrac{500}{220}\times 2 = 4.55\text{ A}$ [1]

The 5 A fuse would be the most suitable one. [1]

(ii) The claim is not correct. The switch must be installed in the wire A which is the live wire [1]

so that the heater is cut off from high voltage when the switch is off. [1]

(iii) Wire C is the Earth wire that could prevent an electric shock [1]

since current would be conducted from the case through this wire to the Earth. [1]

17. (a) (i) To X [1]

(ii) $P = VI$ $\quad\therefore\ (800) = (220)\,I$ [1]

$\therefore\ I = 3.64\text{ A}$ [1]

(iii) By $P = \dfrac{V^2}{R} + \dfrac{V^2}{4R} = \dfrac{5V^2}{4R}$

$\therefore\ (800) = \dfrac{5\,(220)^2}{4R}$ [1]

$\therefore\ R = 75.625\ \Omega$

To keep warm :

$P = \dfrac{V^2}{4R} = \dfrac{(220)^2}{4\,(75.625)}$ [1]

$= 160\text{ W}$ [1]

OR

$(800) = \dfrac{V^2}{R} + \dfrac{V^2}{4R} = \dfrac{5V^2}{4R}$ [1]

$P_{warm} = \dfrac{V^2}{4R}$ [1]

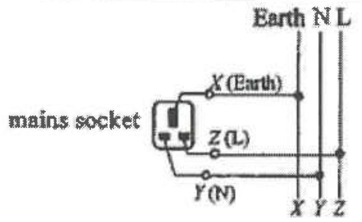
$= (800)\times\dfrac{1}{5} = 160\text{ W}$ [1]

(b) (i) electrical energy [1]

(ii) (1) only the fuse blows [1]

(2) only the RCCB cuts off the supply [1]

18. (a)



1A

1

(b) (i) - If one of the lighting sets / circuits fails, the other (in parallel) can still operate, i.e. both work independently.
- Both can work at the rated power.
- Any reasonable answer

Any ONE — 1A

1

(ii) $P = IV$

$(300 + 450) = I(220)$ — 1M

$I = 3.409091\text{ A} \approx 3.41\text{ A}$ — 1A

$$\boxed{I = \frac{P_1}{V} + \frac{P_2}{V} = \frac{300}{220} + \frac{450}{220}}$$

Thus 5 A fuse should be used. — 1A

3

(c) Electrical energy used per day

$= 0.500\text{ kW} \times 8\text{ h} + 2\text{ kW} \times 0.5\text{ h} + 3\text{ kW} \times 2\text{ h}$ — 1M

$= 11\text{ kW h}$

Cost $= \$0.9 / \text{kW h} \times 11\text{ kW h}$ — 1M

$= \$9.9$ — 1A

3

The following list of formulae may be found useful :

Force on a moving charge in a magnetic field	$F = BQv\sin\theta$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \frac{\mu_0 I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \frac{\mu_0 NI}{L}$

Use the following data wherever necessary :

Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\text{ H m}^{-1}$
Charge of electron	$e = 1.60 \times 10^{-19}\text{ C}$
Electron rest mass	$m_e = 9.11 \times 10^{-31}\text{ kg}$
Acceleration due to gravity	$g = 9.81\text{ m s}^{-2}$ (close to the Earth)

Part A : HKCE examination questions

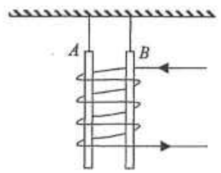
1. < HKCE 1981 Paper II - 33 >

Which of the following will be deflected by a magnetic field ?

(1) Electromagnetic waves
(2) A beam of electrons
(3) A beam of protons

A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

2. < HKCE 1981 Paper II - 32 >

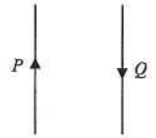


The figure shows two iron rods A and B suspended by two light strings so that they are close together. Their lower ends are inside a solenoid. When a current flows through the solenoid, what will happen to A and B ?

	A	B
A.	moves to the left	moves to the right
B.	moves to the right	moves to the left
C.	moves to the right	moves to the right
D.	moves to the left	moves to the left

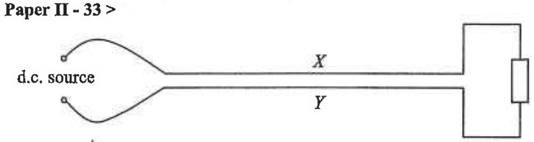
3. < HKCE 1984 Paper II - 28 >

P and Q are two long parallel straight wires carrying currents as shown.
What is the direction of the force on Q ?



A. to the left
B. to the right
C. out of this page
D. into this page

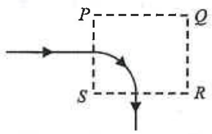
4. < HKCE 1986 Paper II - 33 >



Two close, long, parallel, straight metal wires X and Y form part of the circuit shown above. X and Y

A. attract each other.
B. repel each other.
C. first repel and then attract each other.
D. first attract and then repel each other.

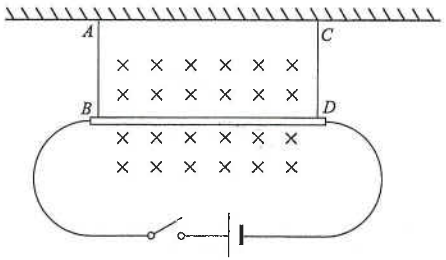
5. < HKCE 1988 Paper II - 32 >



The figure shows the path of an electron in a magnetic field $PQRS$. What should be the direction of the magnetic field ?

A. PQ
B. QR
C. into the paper
D. out of the paper

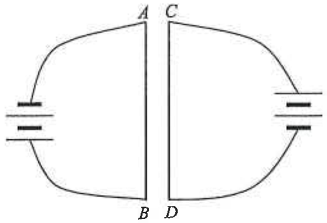
6. < HKCE 1990 Paper II - 31 >



In the figure shown above, a copper rod is suspended horizontally by two insulating threads AB and CD, and the direction of the magnetic field is into the paper. What happens when the switch of the circuit is closed ?

A. The copper rod will move into the paper.
B. The copper rod will move out of the paper.
C. The tension in each thread is decreased.
D. The tension in each thread is increased.

7. < HKCE 1991 Paper II - 32 >



Two long parallel wires AB and CD are connected to batteries as shown in the figure. The force acting on CD is

A. in a direction to the left.
B. in a direction to the right.
C. in a direction out of the paper.
D. in a direction into the paper.

8. < HKCE 1992 Paper II - 33 >

A small compass is placed near a long current carrying wire. In which of the following diagrams is/are the compass needle pointing in the correct direction ?

(1) Compass above the wire

(2) Compass below the wire

(3) Current flowing out of paper

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

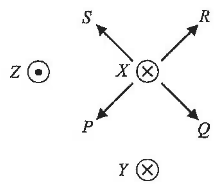
9. < HKCE 1993 Paper II - 35 >

A motor lifts a load of 40 N vertically upwards at a steady speed of 0.2 m s^{-1}. The voltage applied to the motor is 12 V and the current drawn is 2 A. Find the efficiency of the motor.

A. 12%
B. 16.7%
C. 33.3%
D. 66.7%

10. < HKCE 1994 Paper II - 33 >

The diagram shows three long straight wires X, Y and Z. X and Y carry currents flowing into the paper while Z carries a current flowing out of the paper. The currents are all equal in magnitude. What is the direction of the resultant force acting on X ?

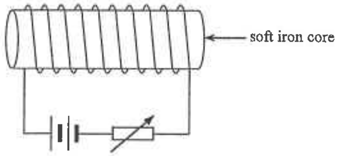


A. P
B. Q
C. R
D. S

11. **< HKCE 1995 Paper II - 31 >**

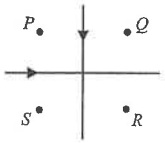
Which of the following involve(s) the application of electromagnets ?
(1) An electric bell
(2) A telephone receiver
(3) A moving-coil loudspeaker
A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

12. **< HKCE 1995 Paper II - 34 >**



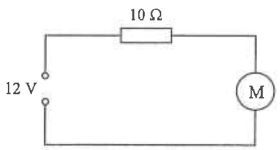
The above diagram shows a simple electromagnet. Which of the following can increase the strength of the electromagnet ?
(1) Decreasing the resistance of the variable resistor.
(2) Replacing the soft iron core with one made of steel.
(3) Replacing the battery with a 50 Hz a.c. source.
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

13. **< HKCE 1996 Paper II - 35 >**



Two long insulated wires carrying equal currents are placed perpendicular to each other on a table as shown in the figure. The points P, Q, R and S are all of equal distances from the wires. At which point(s) is the resulting magnetic field pointing out of the paper ?
A. P only
B. Q only
C. R only
D. S only

14. **< HKCE 1998 Paper II - 31 >**

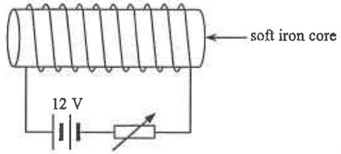


A motor is connected in series with a 10 Ω resistor and a 12 V power supply as shown. If the current in the circuit is 0.5 A, find the power consumed by the motor.
A. 3.5 W
B. 5 W
C. 6 W
D. 7 W

15. **< HKCE 1998 Paper II - 32 >**

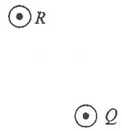
The above diagram shows the cross-section of three parallel straight wires X, Y and Z. X and Y carry currents flowing out of the paper and Z carries a current flowing into the paper. What is the direction of the resultant force acting on Y ?
A. towards the left
B. towards the right
C. upwards
D. downwards

16. **< HKCE 2001 Paper II - 36 >**



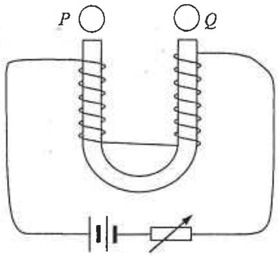
The figure shows an electromagnet which is used to pick up iron objects. Which of the following can increase the strength of the electromagnet ?
(1) increasing the number of turns of the coil
(2) reducing the resistance of the variable resistor
(3) replacing the battery with a 12 V a.c. power supply
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

17. **< HKCE 2002 Paper II - 32 >**



P, Q and R are three parallel straight wires carrying equal currents flowing out of the paper. R is equidistant from P and Q. What is the direction of the resultant force acting on R by P and Q ?
A. →
B. ←
C. ↑
D. ↓

18. **< HKCE 2003 Paper II - 37 >**



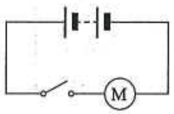
Two compasses P and Q are placed near the poles of an electromagnet as shown above. In which of the following diagrams are the north poles of the compass needles pointing in the correct directions ?

	P	***Q***
A.	↓	↑
B.	↓	↓
C.	↑	↑
D.	↑	↓

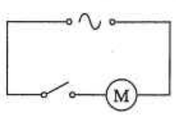
19. **< HKCE 2004 Paper II - 30 >**

David wants to design a battery-powered toy car. Which of the following circuits should he use ?

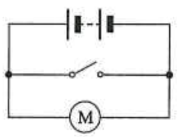
A.



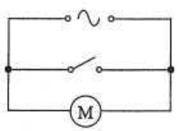
B.



C.



D.



20. **< HKCE 2004 Paper II - 34 >**

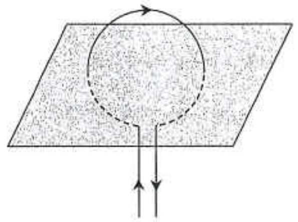
• R

$P \otimes$ $\otimes Q$

Two parallel straight wires P and Q carry equal currents flowing into the paper. A compass is placed at a point R where $PR = QR$. In which of the following diagrams is the north pole of the compass needle pointing in the correct direction ? The effect of the Earth's magnetic field may be ignored.

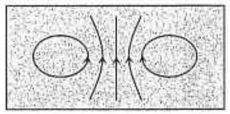
A. ← B. → C. ↑ D. ↓

21. **< HKCE 2005 Paper II - 22 >**

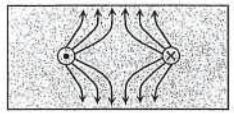


Which of the following diagrams shows the magnetic field pattern formed around a flat circular current-carrying coil, in the plane as shown above ?

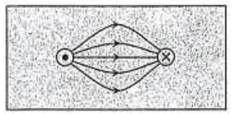
A.



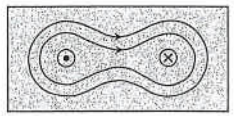
B.



C.



D.

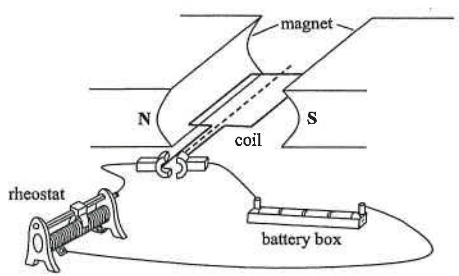


22. **< HKCE 2005 Paper II - 23 >**

The figure shows a simple motor. Which of the following changes can increase the turning effect of the coil ?

(1) using a stronger magnet
(2) reducing the resistance of the rheostat
(3) using a coil with a smaller number of turns

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

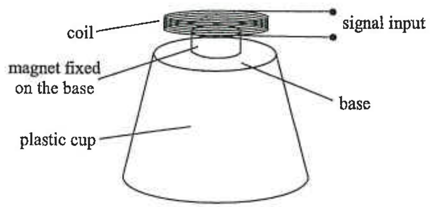


23. **< HKCE 2006 Paper II - 36 >**

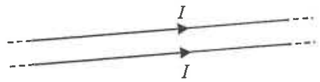
The diagram shows a home-made device which can produce sound. In the device, a magnet is fixed to the base of a plastic cup. When a signal passes through the coil, the base vibrates to produce a sound. Which of the following methods can make the sound louder ?

(1) using a stronger magnet
(2) inserting a copper rod into the coil
(3) increasing the number of turns in the coil

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)



24. **< HKCE 2008 Paper II - 19 >**

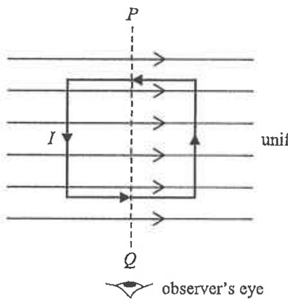


Two parallel wires carry equal currents flowing in the same direction. Which of the following statements are correct ?

(1) The magnetic forces acting on the two wires form an action-reaction pair.
(2) The two wires attract each other.
(3) If the directions of the current in the two wires are both reversed, the wires will repel each other.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

25. **< HKCE 2008 Paper II - 42 >**

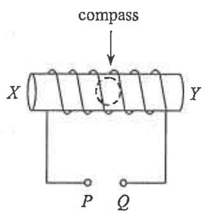


The above figure shows a rectangular loop of wire carrying a steady current I. The rectangular loop can rotate freely about PQ. If a uniform magnetic field to the right is applied, which of the following is correct ?

	Resultant magnetic force acting on the rectangular loop	Rotation of the rectangular loop about PQ
A.	non-zero	clockwise
B.	non-zero	anti-clockwise
C.	zero	clockwise
D.	zero	anti-clockwise

26. **< HKCE 2008 Paper II - 43 >**

A compass is placed inside an air-cored solenoid XY which is connected to a d.c. supply with terminals P, Q as shown. If the end X of the solenoid behaves as magnetic north pole, what are the polarity of the terminal P and the direction in which the north pole of the compass needle points ?



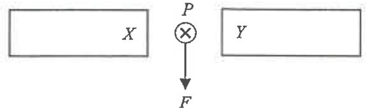
(The tip of the arrow represents the north pole of the compass needle.)

	Polarity of P	Compass
A.	+	←
B.	+	→
C.	−	←
D.	−	→

27. **< HKCE 2009 Paper II - 22 >**

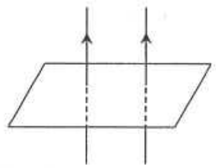
A current carrying wire, perpendicular to the plane of the paper, is located at P. P is in the midway between two identical bar magnets with unknown polarities X and Y as shown in the figure. The current in the wire is flowing into the paper. The magnetic force F acting on the wire is downward. Which of the following statements are correct ?

(1) X is a north pole and Y is a south pole.
(2) F is reversed if the current direction is reversed.
(3) F is larger if stronger bar magnets are used.



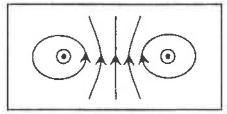
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

28. **< HKCE 2009 Paper II - 21 >**

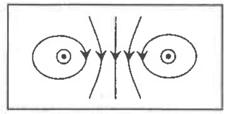


The figure above shows two parallel straight wires carrying equal currents. Which of the following diagrams correctly shows the resultant magnetic field lines ?

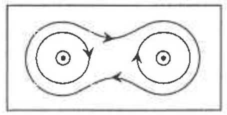
A.



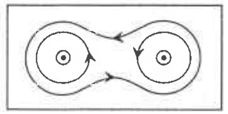
B.



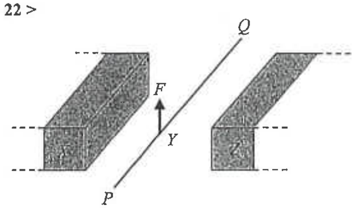
C.



D.



29. **< HKCE 2010 Paper II - 22 >**



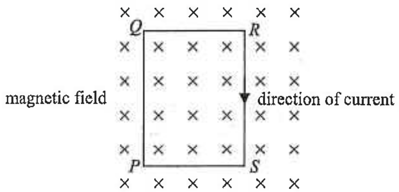
A current carrying wire Y is placed between two bar magnets as shown above. The wire experiences an upward force. Which of the following is/are the possible combination(s) of the direction of the current in Y and the magnetic poles of X and Z ?

	pole X	current direction in Y	pole Z
(1)	N	from P to Q	S
(2)	S	from P to Q	N
(3)	N	from Q to P	S

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

30. < HKCE 2011 Paper II - 21 >

Rectangular coil *PQRS* is carrying a current flowing in clockwise direction. It is placed inside a uniform magnetic field pointing into the paper as shown in the figure below.



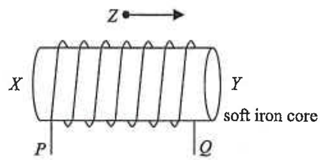
Which of the following statements are correct ?

(1) A magnetic force pointing to the right acts on *RS*.
(2) No magnetic force acts on *QR*.
(3) The resultant magnetic force acting on the coil is zero.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

31. < HKCE 2011 Paper II - 41 >

In the figure below, the arrow shows the direction of the magnetic field at *Z* due to a current-carrying solenoid.



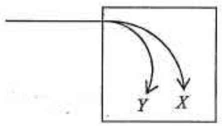
The direction of current through the solenoid and the magnetic north pole of the solenoids are

	Direction of current	Magnetic north pole
A.	from *P* to *Q*	*X*
B.	from *P* to *Q*	*Y*
C.	from *Q* to *P*	*X*
D.	from *Q* to *P*	*Y*

Part B : HKAL examination questions

32. < HKAL 1980 Paper I - 44 >

Two charged particles *X* and *Y* enter a region where a magnetic field acts perpendicular to the plane of their motion. The resulting paths shown in the diagram may be affected by the mass, charge and initial speed of the particles. Which of the following quantities alone could cause the observed difference in the paths ?



(1) *X* has a smaller mass than *Y*.
(2) *X* has a smaller charge than *Y*.
(3) *X* has a greater speed than *Y*.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

33. < HKAL 1980 Paper I - 46 >

Which of the following affects the magnetic field strength on the axis of a long solenoid ?

(1) The diameter of the solenoid
(2) The number of turns per unit length of the solenoid
(3) The current flowing through the solenoid

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

34. < HKAL 1981 Paper I - 44 >

A free electron travelling horizontally with speed v enters a uniform vertical magnetic field B. Which of the following statements is/are correct ?

(1) The path of the electron is circular on a vertical plane.
(2) The speed of the electron remains constant.
(3) The radius of curvature of the path of the electron is inversely proportional to the magnetic field B.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

35. < HKAL 1981 Paper I - 13 >

A vertical wire of 0.4 m long carries a constant current of 5 A. It is placed in a magnetic field of strength 10^{-3} T, which dips at an angle of 30° to the horizontal. Determine the magnetic force acting on the wire.

A. 5.0×10^{-4} N
B. 8.7×10^{-4} N
C. 1.5×10^{-3} N
D. 1.7×10^{-3} N

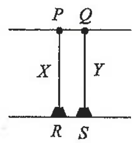
36. < HKAL 1982 Paper I - 43 >

A solenoid with a solid core has a diameter d and n turns per length. It carries a current I. The magnetic field B inside is

(1) independent of d.
(2) proportional to n.
(3) independent of the material of the core.

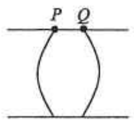
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

37. < HKAL 1982 Paper I - 19 >

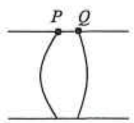


X and *Y* are identical flexible conducting wires, suspended from fixed points *P* and *Q*. The bottom parts of the wires *R* and *S* are also fixed. When a current 2 A is passed from *R* to *P* through *X*, and a current 1 A is passed from *Q* to *S* through *Y*, which of the following diagrams best represents the shapes of the two wires ?

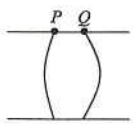
A.



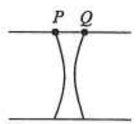
B.



C.



D.



38. **< HKAL 1983 Paper I - 18 >**

Two parallel wires attract each other with a force F when the same current passes through them. If the current is doubled and the distance between the wires is also doubled, the force of attraction will become

A. $\frac{1}{4}F$.

B. $\frac{1}{2}F$.

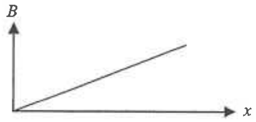
C. F.

D. $2F$.

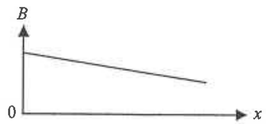
39. **< HKAL 1985 Paper I - 25 >**

Which of the following graphs best represents the variation of the strength of the magnetic field B along the axis of a long solenoid carrying a constant current, with the distance x from the centre of the solenoid along the axis to one of its end ?

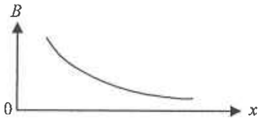
A.



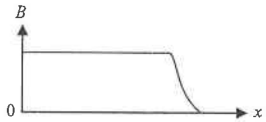
B.



C.



D.



40. **< HKAL 1985 Paper I - 27 >**

A small particle with mass 3.2×10^{-26} kg and charge -1.6×10^{-19} C enters a uniform magnetic field of flux density 0.08 T at a speed of 10^5 m s^{-1}, as shown in the above figure. It will

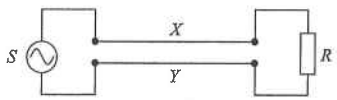
A. pass undeviated through the magnetic field.

B. be deflected upward in a circular arc of radius 0.25 m.

C. be deflected upward in a circular arc of radius 0.50 m.

D. be deflected downward in a circular arc of radius 0.25 m.

41. **< HKAL 1987 Paper I - 34 >**



As shown in the figure, S is an a.c. supply of frequency 50 Hz connected to a resistor R via two long, parallel, straight metal wires X and Y. The magnetic forces acting on X and Y

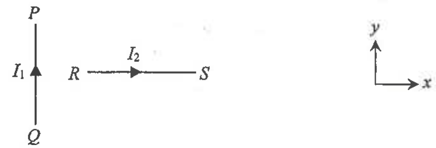
A. are always equal to zero.

B. always attract.

C. always repel.

D. sometimes attract and sometimes repel; the frequency of variation is 50 Hz.

42. **< HKAL 1988 Paper I - 38 >**



In the above figure, PQ is a fixed long wire carrying a current I_1. RS is another wire perpendicular to PQ. When a current I_2 flows through RS in the direction shown, the magnetic force on the wire RS

A. acts in the $+y$ direction.

B. acts in the $-y$ direction.

C. acts in the $+x$ direction.

D. acts in the $-x$ direction.

43. **< HKAL 1988 Paper I - 37 >**

A particle of mass m and charge q moves in a circular orbit inside a magnetic field B. The time taken for a single orbit is

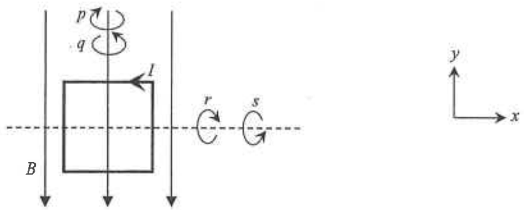
A. $\frac{Bq}{2\pi m}$.

B. $\frac{2\pi m}{Bq}$.

C. $\frac{2mq}{B\pi}$.

D. $\frac{Bm}{2\pi q}$.

44. **< HKAL 1989 Paper I - 32 >**



A square loop carrying a current I is placed in a uniform magnetic field B in the xy plane as shown in the figure. If the loop is free to rotate, the magnetic forces acting on the loop will cause it to

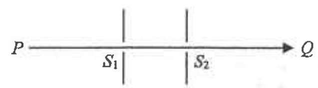
A. rotate about the y-axis as indicated by p.

B. rotate about the y-axis as indicated by q.

C. rotate about the x-axis as indicated by r.

D. rotate about the x-axis as indicated by s.

45. **< HKAL 1990 Paper I - 45 >**



A beam of particles, of different masses, charges, polarities and speeds, travels long PQ and passes through a narrow slit S_1. In the region between S_1 and S_2, an electric field E and a magnetic field B are directed perpendicularly to each other. The E-field acts vertically upward and the B-field acts out of the plane of the paper. The particles that are undeflected and emerge from slit S_2 must have the same

A. polarity.

B. speed.

C. charge.

D. mass.

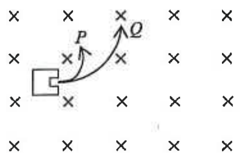
46. < HKAL 1992 Paper I - 36 >

Two parallel straight wires separated by a distance r carry currents in the same direction. Which of the following statements is/are correct ?

(1) The two wires attract each other.
(2) The force acting on each wire is inversely proportional to r^2.
(3) The current in two wires produce a magnetic field with maximum flux density midway between them.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

47. < HKAL 1993 Paper I - 49 >

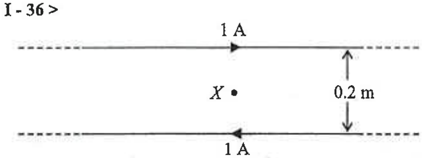


Two particles P and Q of the same charge and mass but moving with different speeds v_P and v_Q respectively enter a region of uniform magnetic field B directed into the plane of the paper. The subsequent circular paths are as shown in the figure. Which of the following statements is/are correct ?

(1) Both particles P and Q are positively charged.
(2) Speed of particle P is smaller than that of Q.
(3) The period of circular motion of P is shorter than that of Q.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

48. < HKAL 1993 Paper I - 36 >



Two long parallel straight wires, each carries a current of 1 A in opposite directions, are separated by a distance of 0.2 m as shown in the figure. The magnetic field at a point X mid-way between the two wires is

A. 2×10^{-6} T out of paper.
B. 2×10^{-6} T into paper.
C. 4×10^{-6} T out of paper.
D. 4×10^{-6} T into paper.

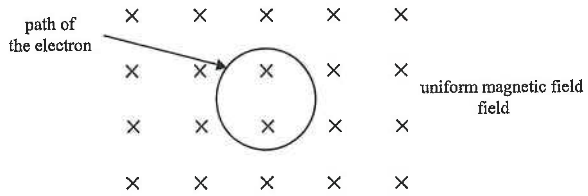
49. < HKAL 1994 Paper IIA - 31 >

For two long, straight parallel conducting wires carrying the same current, the magnitude of the magnetic force acting on a section of the wires would be affected by

(1) the distance between the wires
(2) the length of that section of the wires
(3) the directions of current flowing in the wires

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

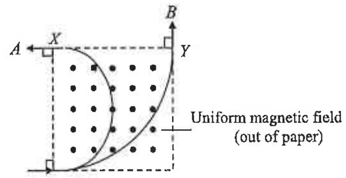
50. < HKAL 1994 Paper IIA - 32 >



An electron moves in a circular path of diameter 0.01 m in a plane with a uniform magnetic field of 0.02 T directed perpendicular into the plane as shown in the figure. Find the speed and the direction of circular motion of the electron.

A. 1.76×10^7 m s^{-1} in anticlockwise direction
B. 1.76×10^7 m s^{-1} in clockwise direction
C. 3.52×10^7 m s^{-1} in anticlockwise direction
D. 3.52×10^7 m s^{-1} in clockwise direction

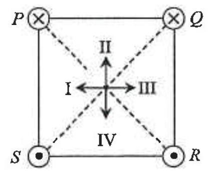
51. < HKAL 1995 Paper IIA - 34 >



Particles A and B moving at the same speed enter a square region of uniform magnetic field as shown. Particle A leaves at X while particle B leaves at Y. If the charge to mass ratio of particle A is k, then the charge to mass ratio of particle B would be

A. $\frac{k}{2}$
B. $\frac{k}{4}$
C. $2k$
D. $4k$

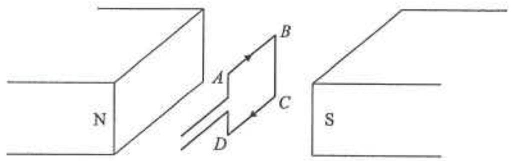
52. < HKAL 1996 Paper IIA - 26 >



Four infinitely long straight parallel wires P, Q, R, S carrying equal currents are situated at the four corners of a square as shown. The currents in P, Q are into paper and those in R, S are out of paper. What is the direction of the resultant magnetic field at the centre of the square ?

A. I
B. II
C. III
D. IV

53. < HKAL 1998 Paper IIA - 30 >

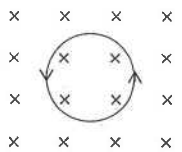


The above diagram shows a rectangular current-carrying coil $ABCD$ in a uniform magnetic field between two pole pieces. The magnetic field is perpendicular to the plane of the coil. Which of the following statements is/are correct ?

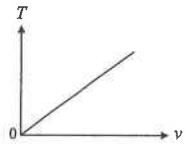
(1) There is a magnetic force acting on the side BC of the coil.
(2) The magnetic forces acting on the coil tend to reduce its area.
(3) There is a resultant force acting on the coil.

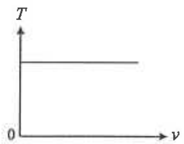
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

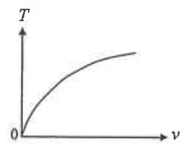
54. < HKAL 1998 Paper IIA - 26 >

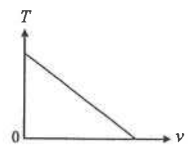


The above figure shows a charged particle moving in a circular orbit with a constant speed v on a plane perpendicular to a uniform magnetic field directed into the paper. Which of the following graphs represents the relation between the time T for the particle to complete a circle and its speed v ?

A. 

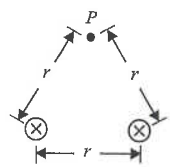
B. 

C. 

D. 

55. < HKAL 1998 Paper IIA - 27 >

Two long, straight parallel wires, each carrying a current I into paper, are separated by a distance r as shown in the figure. What is the magnitude and direction of the resultant magnetic field at the point P at the same distance r from both wires ?



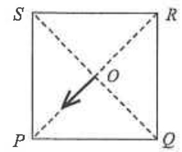
A. $\dfrac{\mu_0 I}{2\pi r}$ to the left

B. $\dfrac{\sqrt{3}\mu_0 I}{2\pi r}$ to the left

C. $\dfrac{\mu_0 I}{\pi r}$ to the left

D. $\dfrac{\sqrt{3}\mu_0 I}{2\pi r}$ to the right

56. < HKAL 2000 Paper IIA - 25 >



Four parallel long straight wires carrying currents of equal magnitude pass vertically through the four corners of a square $PQRS$. In one wire, the current is directed into paper. In the other three wires, the currents are directed out of paper. Which of the following can produce a resultant magnetic field with the indicated direction at the centre O ?

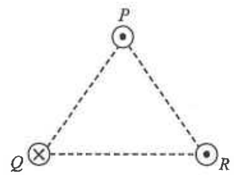
	Current into paper	Current out of paper
A.	P	Q, R, S
B.	Q	P, R, S
C.	R	P, Q, S
D.	S	P, Q, R

57. < HKAL 2000 Paper IIA - 27 >

A beam of charged particles passes through a region of crossed uniform electric and magnetic fields without deflection. Which of the following quantities must be the same for the particles making up this beam ?

A. charge to mass ratio
B. velocity
C. mass
D. sign of charge

58. < HKAL 2002 Paper IIA - 29 >



Three long straight parallel wires P, Q and R carrying currents of the same magnitude are situated at the vertices of an equilateral triangle as shown. The currents in wires P and R are directed out of the paper. Which of the following indicates the direction of the resultant magnetic force acting on the wire P ?

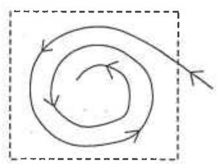
A. 
B. 
C. 
D. 

59. < HKAL 2003 Paper IIA - 31 >

A charged particle enters a region of uniform magnetic field whose direction is normal to the initial velocity of the particle. The subsequent path of the particle is as shown in the figure. Which of the following may be the reason to account for this shape of the path ?

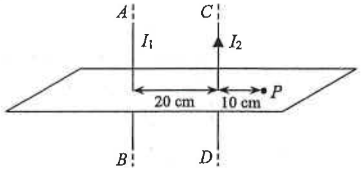
(1) The magnitude of the magnetic field decreases gradually.
(2) The particle loses its charge gradually.
(3) The particle loses its kinetic energy gradually.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only



Magnetic field normal to paper

60. **< HKAL 2003 Paper IIA - 30 >**



In the above figure, AB and CD are two parallel long wires with separation 20 cm carrying currents I_1 and I_2 respectively. The resultant magnetic field at the point P 10 cm from wire CD is zero. If I_2 is equal to 0.6 A, determine the magnitude and direction of the current I_1 in the wire AB.

A. 0.2 A flows in the same direction as I_2

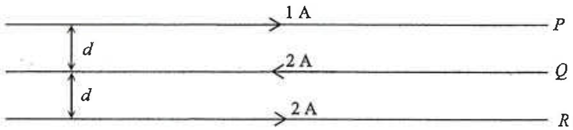
B. 0.2 A flows in the opposite direction as I_2

C. 1.8 A flows in the same direction as I_2

D. 1.8 A flows in the opposite direction as I_2

61. **< HKAL 2004 Paper IIA - 29 >**

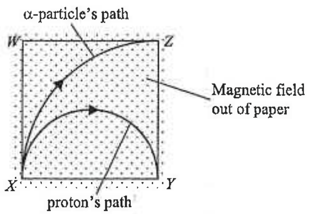
Three long, parallel, straight current-carrying wires P, Q and R are placed in the same plane as shown in the figure.



For two long, parallel, straight wires placed a distance d apart and each carrying a current of 1 A, the magnetic force per unit length is F. What is the resultant magnetic force per unit length acting on the wire R shown in the above figure ?

A. 0
B. F
C. $2F$
D. $3F$

62. **< HKAL 2005 Paper IIA - 18 >**



A proton and an α-particle move in a uniform magnetic field as shown in the above figure. The magnetic field is directed out of the plane of the paper. Within a square region $WXYZ$, the proton takes time t_1 to complete a half circle from X to Y while the α-particle follows a quarter circle from X to Z in time t_2. What is the ratio $t_1 : t_2$?

(Given : mass ratio of an α-particle to a proton is 4 : 1; charge ratio of an α-particle to a proton is 2 : 1.)

A. 1 : 2

B. 1 : 1

C. 2 : 1

D. It cannot be determined as the ratio of their speeds is not given.

63. **< HKAL 2006 Paper IIA - 17 >**

In a vacuum, an electron moves in a circle with speed v in a uniform magnetic field of flux density 1 mT. If an α-particle with speed $\frac{1}{4}v$ is to follow the same path, what magnetic flux density in the opposite direction is required ?

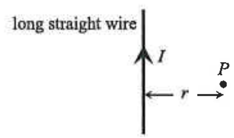
(Given : mass ratio of an α-particle to an electron is 7200 : 1; charge ratio of an α-particle to an electron is 2 : 1.)

A. 0.9 T
B. 1.8 T
C. 3.6 T
D. 7.2 T

64. **< HKAL 2006 Paper IIA - 18 >**

A long straight wire carrying a current I is placed at a distance r from the point P. Both the wire and point P are in the plane of the paper. When the current I increases by 0.5 A, the magnetic flux density B at point P increases by 5.0×10^{-6} T. Find r.

A. 1 cm
B. 2 cm
C. 4 cm
D. 8 cm



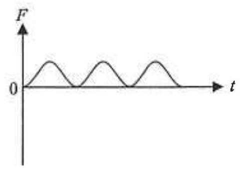
65. **< HKAL 2006 Paper IIA - 16 >**

Two long, parallel wires PQ and RS are connected to a sinusoidal a.c. supply as shown in the figure. Which of the following graph best shows the time variation of the magnetic force F between the two wires ?

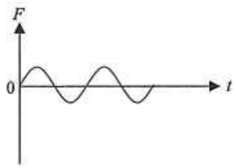
A.

B.

C.



D.



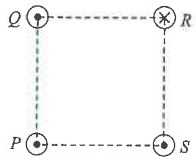
66. **< HKAL 2007 Paper IIA - 20 >**

A beam of charged particles passes through crossed uniform electric and magnetic fields without deflection. If the electric field is removed, the particles will split up into several beams. This splitting may be due to the particles having different

(1) charges
(2) masses
(3) incident velocities

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

67. < HKAL 2007 Paper IIA - 18 >



Four long straight wires perpendicular to the plane of the paper are placed at the four corners of a square *PQRS* as shown in the figure. Same current *I* flows in the wires at *P*, *Q* and *S* directed into the paper while the current flowing along the wire at *R* is in the opposite direction. If the wire at *P* experiences no net magnetic force, find the current flowing in the wire at *R*.

A. $I/\sqrt{2}$

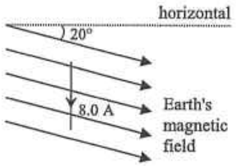
B. $I/2$

C. $\sqrt{2}I$

D. $2I$

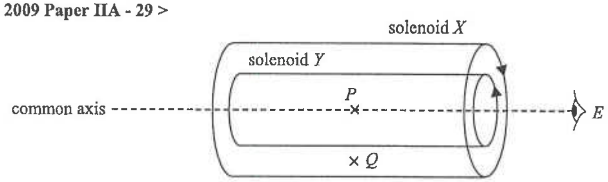
68. < HKAL 2007 Paper IIA - 19 >

A segment of a vertical wire 0.50 m long carrying a current of 8.0 A is placed in the Earth's magnetic field. The direction of the field dips at an angle of 20° to the horizontal. If the magnetic force acting on the wire is 7.5×10^{-5} N, find the magnitude of the Earth's magnetic field.



A. 6.4×10^{-6} T
B. 1.8×10^{-5} T
C. 2.0×10^{-5} T
D. 5.5×10^{-5} T

69. < HKAL 2009 Paper IIA - 29 >



The data about two coaxial long solenoids *X* and *Y* are tabulated below :

	solenoid *X*	solenoid *Y*
radius	5 cm	3 cm
turn density	1200 m^{-1}	2400 m^{-1}
current	1.0 A (clockwise as viewed from *E*)	0.5 A (anticlockwise as viewed from *E*)

Point *P* is on the common axis while point *Q* is 4 cm from the axis. Both *P* and *Q* are well inside the two solenoids. Which of the following statements is/are correct ?

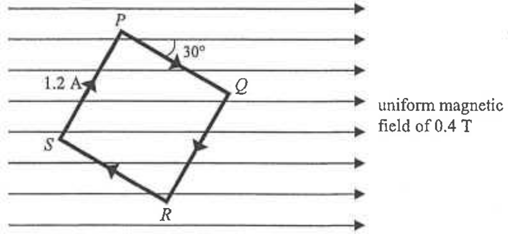
(1) The resultant magnetic field at *P* is zero.

(2) The magnetic field at *Q* is 1.5 mT.

(3) The magnetic field at *Q* points to the left.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

70. < HKAL 2009 Paper IIA - 30 >



A square coil *PQRS*, each side has a length of 0.15 m is placed in a uniform magnetic field of 0.4 T as shown in the figure. The number of turns in the coil is 20 and the current in the coil is 1.2 A. The magnetic field is parallel to the plane of the coil. The side *PQ* makes an angle of 30° with the magnetic field. Find the magnetic force acting on the side *PQ* of the coil.

A. 0.7 N out of the paper

B. 0.7 N into the paper

C. 1.3 N out of the paper

D. 1.3 N into the paper

71. < HKAL 2010 Paper IIA - 28 >

When moving charged particles enter a uniform magnetic field at right angle, they are deflected. This deflection can be increased by

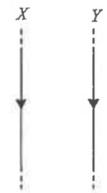
(1) increasing the mass *m* of the particles

(2) increasing the charge *Q* of the particles

(3) increasing the magnitude *B* of the magnetic field

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

72. < HKAL 2011 Paper IIA - 25 >



Two long straight parallel wires, *X* and *Y*, carry equal currents in the same direction as shown in the figure. Wire *X* experiences a magnetic force of 0.1 N. If now a uniform magnetic field pointing into the paper is applied to both wires (NOT shown in figure), the resultant magnetic force acting on wire *X* becomes 0.5 N. Find the resultant magnetic force acting on the wire *Y*. (Neglect the Earth's magnetic field.)

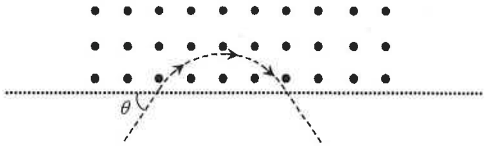
A. 0.3 N m^{-1} to the left

B. 0.3 N m^{-1} to the right

C. 0.6 N m^{-1} to the left

D. 0.6 N m^{-1} to the right

73. < HKAL 2011 Paper IIA - 30 >

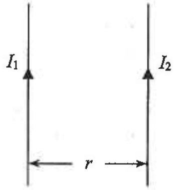


A positively charged particle enters a uniform magnetic field B with a speed v making an angle θ ($0° < \theta \leq 90°$) with the boundary of the field. The magnetic field points out of the paper and the particle leaves the field at the same boundary as shown. The time of transit for the particle inside the magnetic field is

(1) proportional to the angle θ.
(2) dependent on the speed v.
(3) inversely proportional to the field strength B.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

74. < HKAL 2012 Paper IIA - 23 >



Two long straight parallel wires carrying currents I_1 and I_2 (with $I_2 > I_1$) is shown in the figure. The separation between the two wires is r. If now another wire carrying a current I in the same direction is placed midway between the two wires, what would be the magnetic force per unit length experienced by this wire, in both magnitude and direction ?

A. $\frac{\mu_0 I (I_2 - I_1)}{\pi r}$ to the right

B. $\frac{\mu_0 I (I_2 - I_1)}{\pi r}$ to the left

C. $\frac{\mu_0 I (I_1 + I_2)}{\pi r}$ to the right

D. $\frac{\mu_0 I (I_1 + I_2)}{\pi r}$ to the left

75. < HKAL 2013 Paper IIA - 28 >

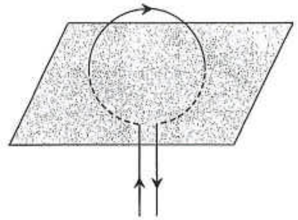
The magnitude of the magnetic field B inside a very long solenoid can be increased by

(1) increasing the current through the solenoid
(2) increasing the number of turns per unit length of the solenoid
(3) decreasing the cross-sectional area of the solenoid

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

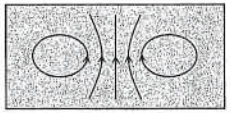
Part C : HKDSE examination questions

76. < HKDSE Sample Paper IA - 29 >

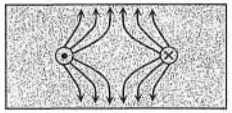


Which diagram shows the magnetic field pattern formed around a flat circular current-carrying coil, in the plane shown ?

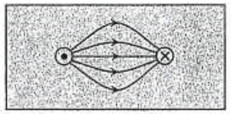
A.



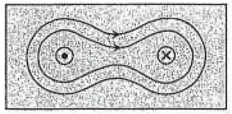
B.



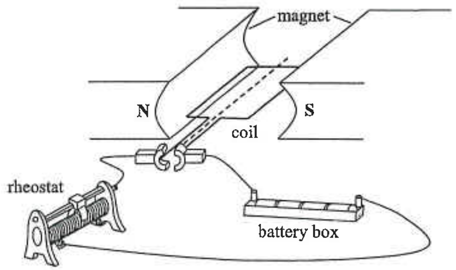
C.



D.



77. < HKDSE Sample Paper IA - 28 >

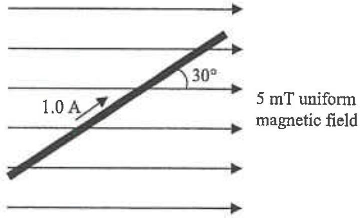


The figure shows a simple motor. Which of the following changes would increase the turning effect of the coil ?

(1) using a stronger magnet
(2) reducing the resistance of the rheostat
(3) using a coil with a smaller number of turns

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

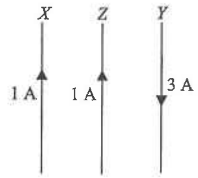
78. **< HKDSE Practice Paper IA - 31 >**



The figure shows a current of 1.0 A flowing in a metal rod of length 0.5 m. The rod is placed inside a region with a uniform magnetic field of strength 5 mT. What is the direction and the magnitude of magnetic force acting on the rod ?

	Direction	Magnitude
A.	into the paper	1.25×10^{-3} N
B.	out of the paper	1.25×10^{-3} N
C.	into the paper	2.17×10^{-3} N
D.	out of the paper	2.17×10^{-3} N

79. **< HKDSE 2012 Paper IA - 29 >**



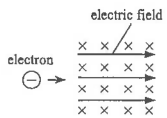
In the above figure shown, X, Y and Z are three long straight parallel wires with Z placed midway between X and Y. X and Z carry currents of 1 A in the same direction while Y carries a current of 3 A in the opposite direction. The magnetic force per unit length experienced by wire X due to wire Z is of magnitude F. The magnetic force per unit length acting on wire Z due to both X and Y is

A. $2F$ to the right.
B. $2F$ to the left.
C. $4F$ to the right.
D. $4F$ to the left.

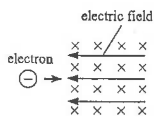
80. **< HKDSE 2012 Paper IA - 30 >**

An electron enters a region in which both a uniform electric field E and a uniform magnetic field B exist. The magnetic field B is pointing into the paper. In which direction should the electric field be applied so that the electron could be undeflected ?

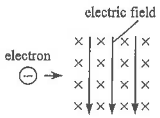
A.



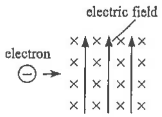
B.



C.

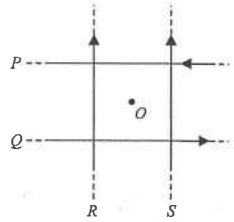


D.



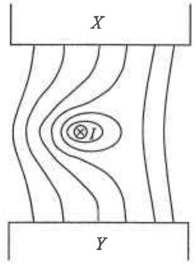
81. **< HKDSE 2013 Paper IA - 27 >**

In the figure, four long straight wires P, Q, R and S in the same plane carry equal currents in the directions shown. The wires are insulated from each other. O is a point on the same plane and is equidistant from each wire. Removing which wire would increase the magnetic field strength at O ?



A. wire P
B. wire Q
C. wire R
D. wire S

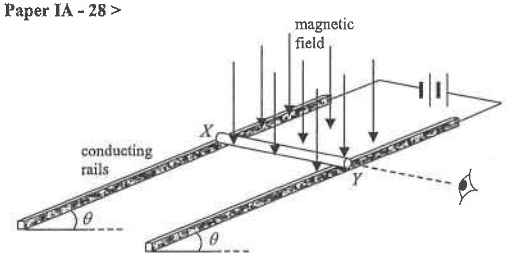
82. **< HKDSE 2013 Paper IA - 26 >**



A straight wire carrying current I pointing into the paper is placed in a magnetic field between pole pieces X and Y. The figure shows the resultant field line pattern. What is the polarity of pole piece X and in what direction is the magnetic force acting on the wire ? Ignore the effect of the Earth's magnetic field.

	polarity of X	direction of magnetic force
A.	N	to right
B.	N	to left
C.	S	to right
D.	S	to left

83. **< HKDSE 2013 Paper IA - 28 >**



A copper rod XY is placed on a pair of smooth inclined conducting rails which are located in a magnetic field applied vertically downward. The rails make an angle θ to the horizontal and a battery is connected to the rails as shown above. Which diagram shown below represents the magnetic force F_B acting on the rod when viewed from end Y ?

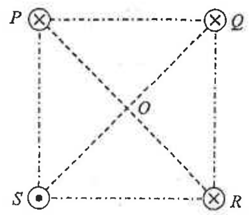
A.

B.

C.

D.

84. **< HKDSE 2014 Paper IA - 26 >**

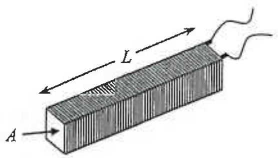


Four long straight parallel wires P, Q, R and S carrying currents of equal magnitude are situated at the vertices of a square as shown. P, Q and R each carries a current directed into the paper while S carries a current directed out of the paper. The direction of the resultant magnetic field at the centre O of the square is along

A. OP.
B. OQ.
C. OR.
D. OS.

85. **< HKDSE 2014 Paper IA - 28 >**

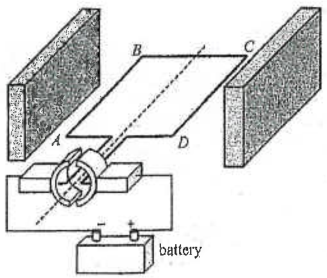
The figure shows a closely packed long solenoid of cross-sectional area A and length L having a total of N turns. If the solenoid carries a constant direct current throughout, which of the following changes can increase the magnetic flux density B at its central cross-section ?



	length	cross-sectional area	total number of turns
A.	$2L$	$2A$	$2N$
B.	L	$2A$	N
C.	$2L$	A	N
D.	L	A	$2N$

86. **< HKDSE 2017 Paper IA - 26 >**

The figure shows a simple d.c. motor, the coil $ABCD$ is mounted between the poles of two slab-shaped magnets.

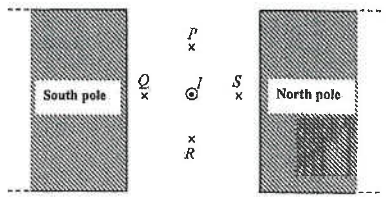


Which of the following statements is correct ?

A. The turning effect is zero when the coil is vertical.
B. The magnetic force acting on BC is the greatest when the coil is horizontal.
C. The direction of the magnetic force acting on AB remains constant.
D. The direction of the current in the coil remains unchanged.

87. **< HKDSE 2018 Paper IA - 27 >**

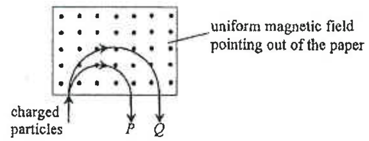
A straight wire carrying a current I pointing out of the paper is placed in a uniform magnetic field between two pole pieces as shown. At which point, P, Q, R or S, can the resultant magnetic field be zero ?



Neglect the effect of the Earth's magnetic field.

A. P
B. Q
C. R
D. S

88. **< HKDSE 2018 Paper IA - 28 >**



P and Q are two particles carrying the same amount of charge but of different masses. They travel with the same speed and enter a uniform magnetic field pointing out of the paper as shown. Semi-circular paths with different radii are described before they emerge from the field. Which descriptions below are correct ?

(1) Both P and Q are positively charged.
(2) P and Q emerge from the field with the same speed.
(3) The mass of Q is greater than that of P.

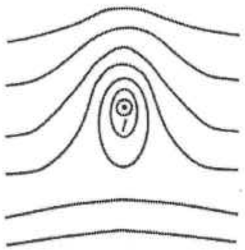
A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

89. <HKDSE 2019 Paper IA-26>

90. <HKDSE 2019 Paper IA-27>

91. <HKDSE 2020 Paper IA-26>

The figure below shows the magnetic field pattern on a horizontal surface around a long vertical straight wire carrying a steady current I pointing out of the paper. The Earth's magnetic field is NOT neglected.

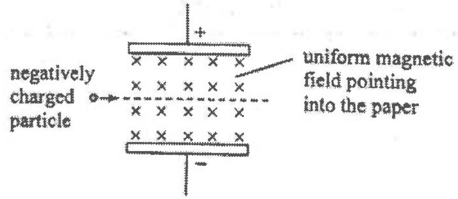


Top view

What are the directions of the following ?

	the horizontal component of the Earth's magnetic field	the magnetic force experienced by the current-carrying wire
A.	←	↓
B.	←	↑
C.	→	↓
D.	→	↑

92. <HKDSE 2020 Paper IA-27>



A negatively charged particle goes undeflected through a region in which a uniform electric field and a uniform magnetic field are set up as shown. The electric field is set up by the potential difference across the two parallel metal plates. Which of the following changes may cause the charged particle to deflect downward ? Neglect the effects of gravity.

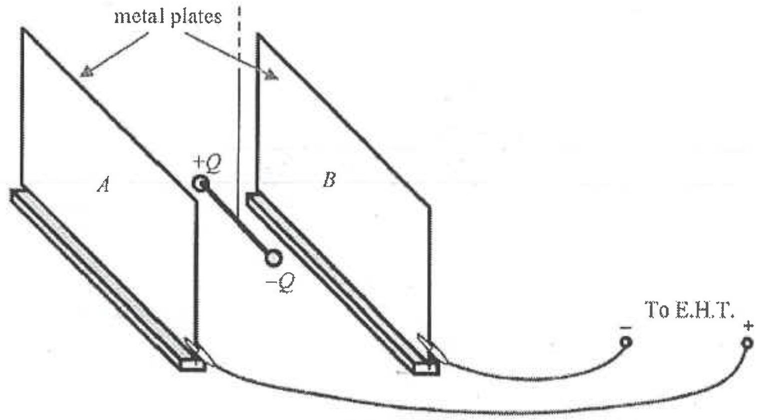
(1) increasing the potential difference across the plates
(2) increasing the magnitude of the charge on the particle
(3) increasing the particle's speed entering the region

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

93. < HKDSE 2020 Paper 1B -9 >

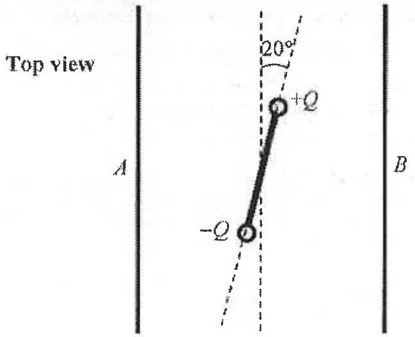
Two small metal spheres are attached to the ends of an insulating rod of length 5.0 cm. They carry charges $+Q$ and $-Q$ respectively of equal magnitude as shown in Figure 9.1. The insulating rod is suspended horizontally between two parallel metal plates, A and B, which are connected to an E.H.T. (extra high tension) supply.

ure 9.1



The rod is parallel to the metal plates when the E.H.T. is off. After the E.H.T. is switched on, an electric field is set up between the plates and the rod is twisted by an angle of 20° as shown in Figure 9.2.

gure 9.2



(a) On Figure 9.2, sketch the electric field lines due to the potential difference across the plates. (2 marks)

(b) The potential difference across A and B is 5.0 kV and the separation between the metal plates is 10 cm. The force due to the electric field acting on each sphere is 2.0×10^{-5} N, find

(i) the moment acting on the rod as shown in Figure 9.2 due to the electric forces on the charged spheres. (2 marks)

*(ii)the strength of the electric field E due to the potential difference across the metal plates.

(iii) the magnitude of the charge Q on the spheres.

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. C	11. B	21. A	31. A	41. C
2. A	12. A	22. A	32. D	42. A
3. B	13. B	23. B	33. D	43. B
4. B	14. A	24. A	34. D	44. D
5. C	15. A	25. C	35. D	45. B
6. C	16. C	26. C	36. C	46. A
7. B	17. D	27. D	37. A	47. C
8. B	18. D	28. D	38. D	48. D
9. C	19. A	29. D	39. D	49. C
10. B	20. B	30. B	40. D	50. B
51. A	61. D	71. D	81. C	91. A
52. A	62. B	72. B	82. C	
53. C	63. A	73. B	83. C	
54. B	64. B	74. A	84. A	
55. D	65. C	75. A	85. D	
56. D	66. C	76. A	86. A	
57. B	67. D	77. A	87. C	
58. A	68. C	78. A	88. D	
59. B	69. D	79. D	**89. C**	
60. D	70. A	80. C	**90. D**	

M.C. Solution

1. C

Charged particles will be deflected by a magnetic field.

× (1) Electromagnetic waves : contain no charged particles.

✓ (2) Beam of electrons : negatively charged particles

✓ (3) Beam of protons : positively charged particles

2. A

When current flows through the solenoid, there is magnetic field inside the solenoid.

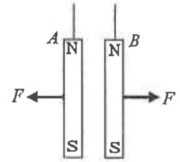
The two iron rods are then magnetized to become electromagnets.

By use of Right hand grip rule, the direction of magnetic field is upwards.

Both the upper ends of the two iron rods are N-pole and lower ends are S-pole.

Since like poles repel, they repel away from each other.

Thus, A moves to the left and B moves to the right.



3. B

There exists repulsive magnetic force between two currents flowing in opposite directions.

∴ Magnetic force on Q is to the right.

4. B

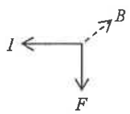
For a d.c. source, there are 2 possible cases.

Case I : Current from wire X to wire Y

Case II : Current from wire Y to wire X.

In both cases, directions of current in the 2 wires are opposite ⇒ repulsion

5. C



(1) From the diagram, a downward force is acting on the electron.

(2) Current carried by the electrons is opposite to direction of motion of electrons.

By Left-hand rule, the magnetic field B should be pointing into the paper.

6. C

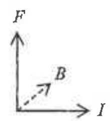
Consider the rod BD,

(1) Direction of current : from B to D,

(2) Direction of B-field : into paper.

By Left-hand rule, an upward force acts on the copper rod

∴ tension in each thread decreases



7. B

Wire AB : current flows from B to A

Wire CD : current flows from C to D

Since the two currents flow in opposite directions, the forces between them are repulsive.

Thus the force acting on CD is towards the right.

8. B

Direction of needle gives the direction of B-field, which can be found by Right-hand screw rule,

× (1) the needle should point upward

✓ (2) a downward B-field acting on the compass

× (3) the needle should point upward

9. C

$$\eta = \frac{P_{out}}{P_{in}} = \frac{F\cdot v}{V\cdot I} = \frac{(40)(0.2)}{(12)(2)} = 33.3\%$$

10. B

For Z and X, current in opposite direction $\Rightarrow$ repulsion $\Rightarrow$ X experiences a force to the right

For Y and X, current in same direction $\Rightarrow$ attraction $\Rightarrow$ X experiences a downward force

$\therefore$ Resultant force acting on X is the vector sum of the above forces, i.e. Q.

11. B

✓ (1) An electric bell contains a soft iron core.
When current flows through the coil, the soft iron becomes an electromagnet.

✓ (2) A telephone receiver make use of the electromagnet
to give varying magnetic force to make the iron diaphragm vibrate.

× (3) Moving-coil loudspeaker is an application of magnetic force acting on current inside a magnetic field.

12. A

✓ (1) $R\downarrow \Rightarrow I\uparrow \Rightarrow$ strength of magnetic field is increased

× (2) Steel : difficult to magnetize and demagnetize $\Rightarrow$ strength of B-field is decreased.

× (3) a.c. source gives the same strength of B-field but the direction of the magnetic field would vary

13. B

Consider the vertical wire : For a downward current, P and S : B-field into paper ; Q and R : B-field out of paper

Consider the horizontal wire : For a current to the right, R and S : B-field into paper ; P and Q : B-field out of paper

For the resulting field out of paper, B-field from **both** wires should be out of paper, i.e., the case for Q.

14. A

Power given out by the cell $= \varepsilon I = (12)\times(0.5) = 6$ W

Power dissipated by the resistor $= I^2 R = (0.5)^2(10) = 2.5$ W

Power consumed by the motor $= 6 - 2.5 = 3.5$ W

OR

Voltage across the motor $= \varepsilon - IR = (12) - (0.5)(10) = 7$ V

Power consumed by the motor $= VI = (7)\times(0.5) = 3.5$ W

15. A

Consider X and Y, same direction of current $\Rightarrow$ attraction $\Rightarrow$ Y to the left

Consider Y and Z, opposite direction of current $\Rightarrow$ repulsion $\Rightarrow$ Y to the left

$\therefore$ Combining the two results, Y experiences a net force to the left.

16. C

✓ (1) Increase the number of turns $\Rightarrow$ strength of magnetic field is increased

✓ (2) Reduce the resistance $\Rightarrow$ Increase the current $\Rightarrow$ strength of magnetic field is increased.

× (3) a.c. source gives the same strength of B-field but the direction of the magnetic field would vary

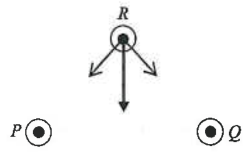
17. D

Currents in wires flowing in the same direction will attract each other

The force acting on R by P will act towards P

The force acting on R by Q will act towards Q

The resultant force acting on R by P and Q is downward.



18. D

By Right hand screw rule,

the magnetic pole at P is North, as the compass needle points away from North, it points upwards ;

the magnetic pole at Q is South, as the compass needle points towards South, it points downwards.

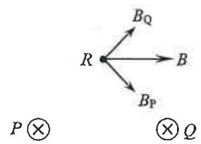
19. A

Since the toy car is battery operated, option B and D are not correct as the supply is a.c.

The switch should be connected in series as shown in A.

Option C is not correct as the battery is shorted when the switch is closed.

20. B



The resultant magnetic field due to B_P and B_Q is the vector sum of them and points towards the right.

Thus the compass needle would point along the B-field direction towards the right.

21. A

By using Right hand screw rule, the magnetic field lines point into the loop.

22. A

✓ (1) Using stronger magnet can increase the strength of the magnetic field, thus increasing the turning effect.

✓ (2) Reducing the resistance of the rheostat can increase the current, thus increasing the turning effect.

× (3) Using a coil with smaller number of turns would decrease the turning effect.

23. B

✓ (1) By using a stronger magnet, a greater magnetic force is produced to give a louder sound.

× (2) Copper is not a magnetic material, it cannot increase the strength of the magnetic field.

✓ (3) By increasing the number of turns, the coil can give a greater magnetic force to have a loud sound.

24. A

✓ (1) These two magnetic forces are equal and opposite and act on each other.

✓ (2) Two currents flowing in the same direction attract each other.

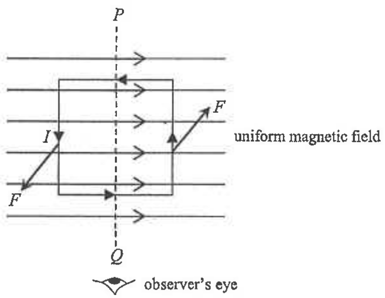
× (3) If the directions of the two currents are both reversed, they are still in the same direction and attract.

25. C

By Left hand rule, the magnetic force acting on the right wire is into the paper and that on the left wire is out of paper.

Since these two forces are equal in magnitude and opposite in direction, their resultant force is zero.

However, these two forces give a clockwise turning effect on the coil to make it rotate.

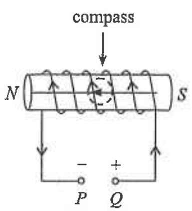


26. C

Since the left hand side of the solenoid is N-pole, by Right hand screw rule, current in solenoid is as shown.

Since the current flows from (+) terminal to (–) terminal of a d.c. supply, Q is (+) and P is (–).

Direction of magnetic field lines inside the solenoid is towards the left, thus the compass needle is towards the left.



27. D

✓ (1) By using Left hand rule, thumb representing magnetic force F points downwards,
the middle finger representing current I points into the paper,
thus the finger representing magnetic field B should point to the right.
Therefore, X is North pole and Y is South pole, to give magnetic field pointing to the right.

✓ (2) If the current direction is pointing out of paper, the magnetic force points upwards, thus reversed.

✓ (3) The magnetic force depends on the strength of the magnetic field,
thus stronger magnets can increase the force F.

28. D

Current out of paper should give magnetic field in anticlockwise direction.

Both currents give anticlockwise magnetic field, and give the resultant pattern as shown in option D.

29. D

× (1) If the pole X is N, then magnetic field is towards the right, thus current should be from Q to P.

✓ (2) If the pole X is S, then magnetic field is towards the left, thus current is from P to Q.

✓ (3) If the pole X is N, then magnetic field is towards the right, thus current is from Q to P.

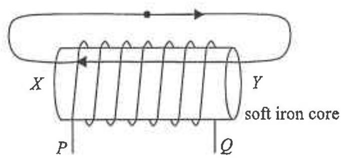
30. B

✓ (1) By Left hand rule, the magnetic force acting on RS is towards the right.

× (2) By Left hand rule, the magnetic force acting on QR is pointing upwards, not zero.

✓ (3) The four magnetic forces acting on the four wires balance each other, thus there is no resultant force.

31. A



The magnetic field line is completed as shown in the figure.

End X is the North pole as magnetic field lines come out here.

By Right hand screw rule, the current is from P to Q through the solenoid.

32. D

From the diagram, the circular path of X has a greater radius, i.e. $r_X > r_Y$

By $F = BQv$ and $F = \dfrac{mv^2}{r}$ $\quad\therefore\ BQv = \dfrac{mv^2}{r}$ $\quad\therefore\ r = \dfrac{mv}{BQ} \propto \dfrac{mv}{Q}$

× (1) $m_X < m_Y \Rightarrow r_X < r_Y$

✓ (2) $Q_X < Q_Y \Rightarrow r_X > r_Y$

✓ (3) $v_X > v_Y \Rightarrow r_X > r_Y$

33. D

For a long solenoid, $B = \mu_0 n I$

× (1) B is independent of the diameter of the solenoid

✓ (2) B is proportional to the number of turns per unit length n

✓ (3) B is proportional to the current I

34. D

× (1) By Left-hand rule, the magnetic force acting on the electron horizontal.
∴ The path of the electron should be circular on a horizontal plane.

✓ (2) Since magnetic force is always perpendicular to the direction of motion
∴ no work done on the electron by the magnetic force ⇒ constant speed of electron

✓ (3) By $BQv = \dfrac{mv^2}{r}$ $\quad\therefore\ r = \dfrac{mv}{BQ} \propto \dfrac{1}{B}$

35. D

The horizontal component of the magnetic field $B \cos \theta$ is perpendicular to the vertical current.

$F = B \cos \theta \times I L = (10^{-3} \cos 30°) \times (5) \times (0.4) = 1.7 \times 10^{-3}$ N

36. C

For a long solenoid, $B = \mu_o n I$

✓ (1) B is independent of the diameter d of the solenoid

✓ (2) B is proportional to the number of turns per unit length n

× (3) B depends on the material of the core, μ_o represents the permittivity of air

37. A

Two currents in opposite directions have repulsive forces between them.

These two forces are action and reaction that have the same magnitude,

thus two wires have the same change of shape.

38. D

$$F = \frac{\mu_o I_1 I_2 L}{2 \pi r} \propto \frac{I_1 \cdot I_2}{r}$$

$$\therefore F' = \frac{(2)(2)}{(2)} \cdot F = 2F$$

39. D

Since the magnetic field inside the solenoid is uniform, B is constant and thus be a horizontal line.

Near the end of the solenoid, the field then decreases gradually to zero outside the solenoid.

40. D

By Left-hand rule, direction of magnetic force on the particle is downward.

$$B Q v = \frac{m v^2}{r}$$

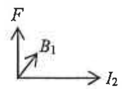
$$\therefore (0.08)(1.6 \times 10^{-19}) = \frac{(3.2 \times 10^{-26})(10^5)}{r} \qquad \therefore r = 0.25 \text{ m}$$

41. C

① When the upper part is at a higher potential,
current flows from left to right along X and flows from right to left along Y
⇒ current flows in opposite direction along the 2 wires ⇒ repulsion

② When the lower part is at a higher potential,
current flows from right to left along X and flows from left to right along Y
⇒ current flows in opposite direction along the 2 wires ⇒ repulsion

42. A



By Right-hand screw rule, B-field produced by current in wire PQ at position RS is B_1 into the paper.

By Left-hand rule, the magnetic force acting on the wire RS is in $+y$ direction.

43. B

By $B Q v = m r \omega^2$ and $v = r \omega$

$$\therefore B Q = m \omega = m \frac{2\pi}{T}$$

$$\therefore T = \frac{2 \pi m}{B Q}$$

44. D

By Left hand rule, magnetic force acting on the upper wire is out of paper and that on the lower wire is into the paper.

Thus the loop would rotate in anticlockwise direction when viewing from right hand side indicated by s.

45. B

Electric force $= q E$

Magnetic force $= B q v$

For undeflected motion of a charged particle : $q E = B q v \qquad \therefore v = \frac{E}{B}$

∴ Only those particles that have the same speed v equal to E/B can have no deflection in the cross-field region.

46. A

✓ (1) Two currents in the same direction ⇒ attraction between the two wires

× (2) $F = \frac{\mu_o I_1 I_2 L}{2 \pi r} \propto \frac{1}{r}$

× (3) There should be a neutral point in mid way between them where the magnetic field is zero.

47. C

✓ (1) From the diagram, the magnetic force is upwards.
By Left hand rule, the current is in the same direction as the motion.
∴ Both P and Q are positively charged.

✓ (2) By $F = B Q v$ and $F = \frac{mv^2}{r}$ $\quad \therefore B Q v = \frac{mv^2}{r} \quad \therefore r = \frac{m v}{B Q} \propto v \quad \therefore r_P < r_Q \Rightarrow v_P < v_Q$

× (3) By $F = B Q v$ and $F = m r \omega^2 \quad \therefore m r \omega \omega = B Q v \quad \therefore m \cdot v \cdot \frac{2\pi}{T} = B Q v$

$\therefore T = \frac{2 \pi m}{B Q}$ which is independent of the speed of the particle

48. D

By Right-hand screw rule :

At X, the B-field by the upper wire is into paper and that by the lower wire is also into paper.

$\therefore$ The resultant B-field is into paper.

$$B = 2 \times \frac{\mu_o I}{2\pi r} = 2 \times \frac{(4\pi \times 10^{-7}) \cdot (1)}{2\pi (0.1)} = 4 \times 10^{-6}\ \text{T}$$

49. C

For two long, straight parallel conducting wires : $F = \dfrac{\mu_o I_1 I_2 L}{2\pi r} = \dfrac{\mu_o I^2 L}{2\pi r} \propto \dfrac{I^2 L}{2\pi r}$

✓ (1) The force is inversely proportional to the distance between the wires r.

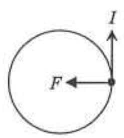
✓ (2) The force is proportional to the length of that section of the wires ℓ.

× (3) The directions of current flow only affect the direction of the force but not the magnitude.

50. B

$$B Q v = \frac{m v^2}{r}$$

$$\therefore\ v = \frac{B Q r}{m} = \frac{0.02 \times 1.6 \times 10^{-19} \times 0.005}{9.1 \times 10^{-31}} = 1.76 \times 10^7\ \text{m s}^{-1}$$



For the direction, consider the point at the rightmost position

By Left hand rule, since current is upwards, velocity of electron is downwards

$\therefore$ the electron moves in clockwise direction

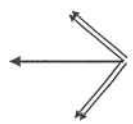
51. A

By $F = B Q v$ and $F = \dfrac{m v^2}{r}$

$$B Q v = \frac{m v^2}{r} \qquad \therefore\ k = \frac{Q}{m} = \frac{v}{B r} \propto \frac{1}{r}$$

$$\therefore\ k' = \frac{r_A}{r_B} \cdot k = \frac{k}{2}$$

52. A



By Right-hand screw rule, the B-field by each wire is given as shown.

Same current carried by the 4 wires $\Rightarrow$ same magnitude of B-field

$\therefore$ The resultant B-field is given by I.

53. C

✓ (1) BC is perpendicular to the magnetic field, thus a magnetic force acts on it.

✓ (2) By Left-hand rule, magnetic force acting on AB is downwards and that on CD is upwards, magnetic force on BC is out of paper and that on AD is into paper.
$\therefore$ The magnetic forces on the four wires tend to reduce the area of the coil.

× (3) As the magnetic forces acting on AB and CD balance each other, and that on BC and AD balance, there is no resultant force acting on the coil..

54. B

By $F = B Q v$ and $F = m r \omega^2$

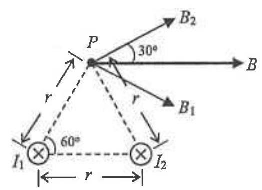
$\therefore\ m r \omega \omega = B Q v$

$\therefore\ m \cdot v \cdot \dfrac{2\pi}{T} = B Q v$

$\therefore\ T = \dfrac{2\pi m}{B Q}$

$\therefore$ T is independent of the speed v and is a constant, thus the graph is a horizontal line.

55. D



By Right-hand screw rule, the B-field by each wire is given as shown.

Current I_1 produces the magnetic field B_1 perpendicular to $P I_1$.

Current I_2 produces the magnetic field B_2 perpendicular to $P I_2$.

The resultant magnetic field B is the sum of the two horizontal components of B_1 and B_2.

$$B = B_1 \cos 30° + B_2 \cos 30°$$
$$= 2B_1 \cos 30° = 2 \cdot \frac{\mu_o I}{2\pi r} \cdot \frac{\sqrt{3}}{2} = \frac{\sqrt{3}\mu_o I}{2\pi r} \text{ (to the right)}$$

56. D

In order to have a B-field along the diagonal RP,

(1) B-field by P and R should be eliminated one another (as B-field produced by P and R at O is along QS),

(2) B-field by Q and S should be from O to P (as B-field produced by Q and S at O is along PR).

To satisfy (1), current of P and R should be in the same direction (either into or out of paper).

To satisfy (2), by Right-hand screw rule, current of S : into paper ; current of Q : out of paper.

57. B

Electric force $= Q E$ Magnetic force $= B Q v$

Crossed E- and B- fields $\Rightarrow$ both forces in opposite directions $\Rightarrow$ no deflection if the 2 forces equal

$\therefore\ QE = BQv \quad \therefore\ v = \dfrac{E}{B}$

$\therefore$ With same E-field and B-field, the ions should have the same velocity.

58. A

Magnetic force between two parallel currents in same direction is attractive.

Magnetic force between two parallel currents in opposite direction is repulsive.

59. B

Inside the magnetic field, the magnetic force provides the centripetal force

$\therefore\ BQv = \dfrac{mv^2}{r} \quad \therefore\ r = \dfrac{mv}{BQ}$

× (1) If the flux density B has decreased gradually, the radius r should be gradually increased.

× (2) If the charged particle has lost its charge q gradually, the radius r should be gradually increased.

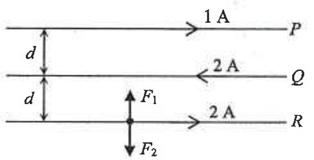
✓ (3) When the charged particle has lost its kinetic energy gradually, its speed v is gradually decreased, thus the radius r would also gradually decrease.

60. D

$B_P = \dfrac{\mu_o I_1}{2\pi(30)} - \dfrac{\mu_o (0.6)}{2\pi(10)} = 0 \qquad \therefore\ I_1 = 1.8\text{ A}$

I_1 is in the opposite direction so that the direction of the magnetic field produced is opposite to that by I_2.

61. D



Force per unit length : $\dfrac{F}{L} = \dfrac{\mu_o \cdot I_1 \cdot I_2}{2\pi \cdot r} \qquad \therefore\ F = \dfrac{\mu_o \cdot (1) \cdot (1)}{2\pi \cdot (d)}$

Force acting on R by P : $F_1 = \dfrac{\mu_o \cdot (1) \cdot (2)}{2\pi \cdot (2d)} = F$ (upwards)

Force acting on R by Q : $F_2 = \dfrac{\mu_o \cdot (2) \cdot (2)}{2\pi \cdot (d)} = 4F$ (downwards)

Net force on $R = 4F - F = 3F$

62. B

In a magnetic field, charged particle performs circular motion with period T.

By $BQv = mr\omega^2 \qquad \therefore\ BQ = m\omega = m\dfrac{2\pi}{T} \qquad (\text{as } v = r\omega)$

$\therefore\ T = \dfrac{2\pi \cdot m}{B \cdot Q}$

For the proton ${}^1_1\text{p}$, it performs half of a cycle $\qquad \therefore\ t_1 = \dfrac{1}{2}T = \dfrac{1}{2} \times \dfrac{2\pi \cdot m}{B \cdot Q} = \dfrac{\pi \cdot m}{B \cdot Q}$

For the alpha ${}^4_2\alpha$, it performs a quarter of a cycle $\qquad \therefore\ t_2 = \dfrac{1}{4}T = \dfrac{1}{4} \times \dfrac{2\pi \cdot (4m)}{B \cdot (2Q)} = \dfrac{\pi \cdot m}{B \cdot Q}$

$\therefore\ t_1 : t_2 = 1 : 1$

63. A

By $BQv = \dfrac{mv^2}{r} \qquad \therefore\ B = \dfrac{mv}{Qr} \propto \dfrac{mv}{Q} \qquad$ (r is the same)

$\therefore\ \dfrac{B_\alpha}{B_e} = \dfrac{m_\alpha}{m_e} \times \dfrac{v_\alpha}{v_e} \times \dfrac{Q_e}{Q_\alpha}$

$\therefore\ \dfrac{B_\alpha}{(1)} = (\dfrac{7200}{1}) \times (\dfrac{1}{4}) \times (\dfrac{1}{2}) \qquad \therefore\ B_\alpha = 900\text{ mT} = 0.9\text{ T}$

64. B

By $B = \dfrac{\mu_o \cdot I}{2\pi \cdot r}$

$\therefore\ \Delta B = \dfrac{\mu_o \cdot \Delta I}{2\pi \cdot r}$

$\therefore\ (5.0 \times 10^{-6}) = \dfrac{(4\pi \times 10^{-7}) \cdot (0.5)}{2\pi \cdot r}$

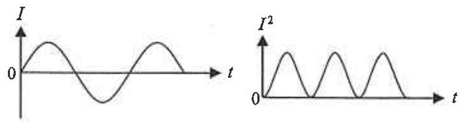
$\therefore\ r = 0.02\text{ m} = 2\text{ cm}$

65. C

Since the current through PQ and the current through RS must be always in opposite direction, force between the two wires must always be repulsive.

$F = \dfrac{\mu_o I_1 I_2 L}{2\pi \cdot r} \propto I^2$

The shape of the graph F should be same as the graph I^2.



66. C

If the charged particles passes crossed field without deflection, then $QE = BQv \qquad \therefore\ v = \dfrac{E}{B}$

The beam of charged particles must have the same velocity v.

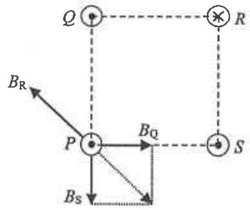
If only the magnetic field is present, $BQv = \dfrac{mv^2}{r} \qquad \therefore\ r = \dfrac{mv}{BQ}$

Different masses m or different charges Q can give different radius of curvature r, and thus they split up.

67. D

If the wire P has no net force, then the resultant magnetic field due to Q, R, S must be zero at P.

The magnetic field due to the three wires is shown in the figure.



Let the separation between QR be r, then the separation between PR is $\sqrt{2}\,r$.

$B_Q = B_S = B$

The resultant of B_Q and B_S is $\sqrt{2}\,B$.

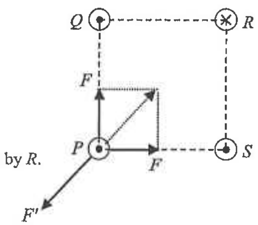
$\therefore\ B_R = \sqrt{2}\,B$

$\therefore\ \dfrac{\mu_o I'}{2\pi(\sqrt{2}\,r)} = \sqrt{2} \times \dfrac{\mu_o I}{2\pi r}$

$\therefore\ I' = 2I$

OR

Let the distance of each side of the square be r.



Magnetic forces between any two currents are given by $\dfrac{F}{L} = \dfrac{\mu_o I_1 I_2}{2\pi r}$

For two currents flowing in the same direction, attractive forces exist.

For two currents flowing in the opposite direction, repulsive forces exist.

Consider P, the resultant of attractive forces by Q and by S balances the repulsive force by R.

$\sqrt{2} \times \dfrac{\mu_o I^2}{2\pi r} = \dfrac{\mu_o I \cdot I'}{2\pi \times \sqrt{2}r}$

$\therefore\ I' = 2I$

68. C

Consider the horizontal component of the Earth's magnetic field that is perpendicular to the current.

Horizontal component of the magnetic field is $B\cos\theta$.

By $F = B\cos\theta \cdot I \cdot L$

$\therefore\ (7.5 \times 10^{-5}) = (B\cos 20°)(8.0)(0.5)$

$\therefore\ B = 2.0 \times 10^{-5}$ T

69. D

✓ (1) $B = \mu_o n_X I_X - \mu_o n_Y I_Y = \mu_o(1200 \times 1 - 2400 \times 0.5) = 0$

✓ (2) The magnetic field at Q is due to solenoid X only, as no magnetic field outside a solenoid.

$B = \mu_o n_X I_X = (4\pi \times 10^{-7}) \times (1200) \times (1) = 1.5$ mT

✓ (3) By right hand grip rule, magnetic field due to solenoid X at Q is towards the left.

70. A

$F = BIL\sin\theta \times N$

$= (0.4)(1.2)(0.15)\sin 30° \times (20) = 0.7$ N

By Left hand rule, the magnetic force is out of paper.

71. D

By $BQv = \dfrac{mv^2}{r}$

$\therefore\ r = \dfrac{mv}{BQ}$

For greater deflection, radius r of the circular path should be **decreased**.

× (1) By increasing the mass m, radius r increases, thus deflection decreases.

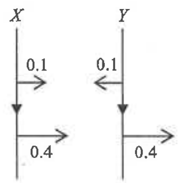
✓ (2) By increasing the charge Q, radius r decreases, thus deflection increases.

✓ (3) By increasing the flux density B, radius r decreases, thus deflection increases.

72. B

The magnetic forces between X and Y are attractive.

Magnetic force on X by Y is 0.1 N rightwards and magnetic force on Y by X is 0.1 N leftwards.



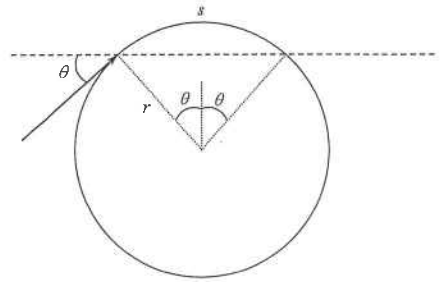
When the magnetic field into the paper is applied, by use of the Left hand rule, the magnetic force is in rightward direction.

Since the resultant magnetic force on X is 0.5 N, the magnetic force due to the applied magnetic field is 0.4 N rightwards.

The same magnetic force of 0.4 N in rightward direction also acts on Y.

The resultant magnetic force on $Y = 0.4 - 0.1 = 0.3$ N rightwards

73. B



Let r be the radius and s be the arc length of transit.

By $BQv = mr\omega^2$ $\quad \therefore\ BQ = m\omega = m\dfrac{2\pi}{T}$ $\quad$ (as $v = r\omega$)

$\therefore\ T = \dfrac{2\pi \cdot m}{B \cdot Q}$

✓ (1) Time of transit along the arc : $t = T \times \dfrac{2\theta}{360°}$ $\quad \therefore\ t \propto \theta$

× (2) Period T and t should be independent of the speed v.

✓ (3) $t \propto T \propto \dfrac{1}{B}$

74. A

Magnetic force per unit length between two parallel currents : $\dfrac{F}{L} = \dfrac{\mu_o I_1 I_2}{2\pi r}$

Magnetic forces between 2 parallel currents :

same direction are attractive ; opposite direction are repulsive.

Magnetic force per length on the middle wire by $I_1 = \dfrac{\mu_o I_1 I}{2\pi(r/2)} = \dfrac{\mu_o I_1 I}{\pi r}$ (to the left)

Magnetic force per length on the middle wire by $I_2 = \dfrac{\mu_o I_2 I}{2\pi(r/2)} = \dfrac{\mu_o I_2 I}{\pi r}$ (to the right)

Since $I_2 > I_1$, the magnetic force per length by I_2 is greater.

Resultant magnetic force per length on the middle wire $= \dfrac{\mu_o I_2 I}{\pi r} - \dfrac{\mu_o I_1 I}{\pi r} = \dfrac{\mu_o I(I_2 - I_1)}{\pi r}$ (to the right)

75. A

✓ (1) B is proportional to I

✓ (2) B is proportional to n, the number of turns per unit length

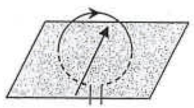
× (3) B is independent of the area A for a long solenoid

76. A

By using Right hand screw rule,

the magnetic field line at the centre of the loop points into the loop

as indicated in A.



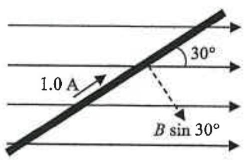
77. A

✓ (1) Using stronger magnet can increase the strength of the magnetic field, thus increasing the turning effect.

✓ (2) Reducing the resistance of the rheostat can increase the current, thus increasing the turning effect.

× (3) Using a coil with smaller number of turns would decrease the turning effect.

78. A



Consider the component of the magnetic field perpendicular to the current, that is, $B \sin 30°$.

The direction of magnetic force is into the paper by use of the Left hand rule.

$F = B \sin 30° \times I \times L$

$= (5 \times 10^{-3}) \sin 30° \times (1.0) \times (0.5) = 1.25 \times 10^{-3}$ N

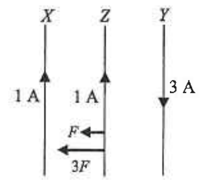
79. D

Magnetic force per unit length between two parallel currents : $F = \dfrac{\mu_o I_1 I_2}{2\pi r}$

Moreover, magnetic forces between 2 parallel currents in the same direction are attractive,

and magnetic forces between 2 parallel currents in the opposite direction are repulsive.

Assume the separation between XZ is r. Separation between YZ is also r.



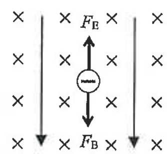
By Newton's third law, the magnetic force per unit length on Z by X is also F.

Magnetic force per unit length on Z by $X = \dfrac{\mu_o (1)(1)}{2\pi(r)} = F$ (to the left)

Magnetic force per unit length on Z by $Y = \dfrac{\mu_o (1)(3)}{2\pi(r)} = 3F$ (to the left)

Resultant force per unit length on Z by X and $Y = F + 3F = 4F$ (to the left)

80. C



When the electron moves towards the right, it represents a current to the left.

Since the magnetic field is pointing into the paper,

by Left hand rule, the magnetic force F_B is downwards.

To make the electron be undeflected, the electric force F_E must be upwards.

As the electron carries negative charge, the electric field should be downwards

so that the electric force is upwards.

81. C

By the use of Right hand screw rule to find the direction of B-field due to a straight wire current :

Direction of B-field at point O due to P : out of paper

Direction of B-field at point O due to Q : out of paper

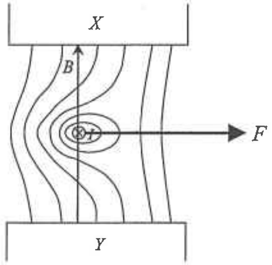
Direction of B-field at point O due to R : into paper

Direction of B-field at point O due to S : out of paper

The B-field given by R is in opposite direction to that of the other wires.

Thus, removing wire R can increase the resultant magnetic field at O.

82. C



From the pattern of catapult field, the magnetic force is towards the right.

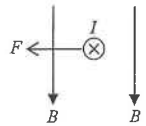
From the figure shown, the direction of current is into the paper.

By using the Left hand rule, the direction of magnetic field is upwards.

As direction of magnetic field is from N-pole to S-pole, the magnetic pole at X is South.

83. C

Direction of current flowing through the rod is from Y to X,
into the paper as seen by the eye.
Direction of magnetic field is downwards.
By using Left hand rule, the magnetic force is towards the left.



84. A

By using Right hand grip rule,

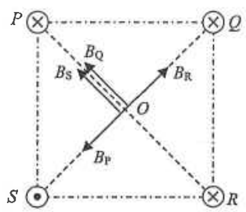
B-field due to P is along OS at O.

B-field due to Q is along OP at O.

B-field due to R is along OQ at O.

B-field due to S is along OP at O.

The B-fields due to P and R are in opposite direction
and they balance each other.



The resultant magnetic field due to Q and S are in the same direction and thus their resultant magnetic field is along OP.

85. D

Magnetic field inside the solenoid is : $B = \dfrac{\mu_o N I}{L}$

The magnetic field is independent of the area A.

× A. The magnetic field is unchanged as both N and L are doubled.

× B. The magnetic field is unchanged as both N and L are unchanged.

× C. The magnetic field is halved as L is doubled.

✓ D. The magnetic field is doubled as N is doubled.

86. A

✓ A. When the coil is vertical, the magnetic forces on the four wires are either directed away from the centre or towards the centre. Thus, the magnetic forces do not have moment to give turning effect.

× B. The magnitude of magnetic force acting on BC is constant at any position of the coil since $F = B I l$, magnetic field B, current I, and length l are all constant.

× C. The direction of magnetic force acting on AB reverses every half cycle since the direction of current through AB reverses every half cycle due to the commutator.

× D. The direction of current in the coil reversed every half cycle due to the commutator.

87. C

The magnetic field produced by current I is anticlockwise around I. At point R, the B is towards the right.

The magnetic field produced by the poles of magnet is towards the left (from North to South).

Thus, at R, the resultant magnetic field can be zero.

88. D

✓ (1) Consider the charged particles entering the magnetic field.
The magnetic field B is out of paper, magnetic force F is towards the right,
by using Left hand rule, the current is upwards.
As current is the flow of positive charge, the charged particles must be positive.

✓ (2) Since magnetic force is always perpendicular to the motion, no work is done,
thus the kinetic energy and speed must remain unchanged after emerging from the magnetic field.

✓ (3) By $B q v = \dfrac{m v^2}{r}$, as B, q, v are the same, mass m is proportional to the radius r.
As the radius of Q is greater, the mass of Q must be greater than that of P.

The following list of formulae may be found useful :

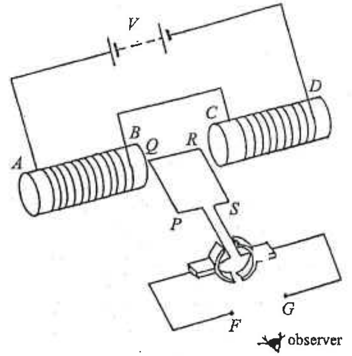
Force on a moving charge in a magnetic field	$F = BQv\sin\theta$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \dfrac{\mu_o I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \dfrac{\mu_o NI}{l}$

Use the following data wherever necessary :

Permeability of free space	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
Charge of electron	$e = 1.60 \times 10^{-19}$ C
Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
Acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)

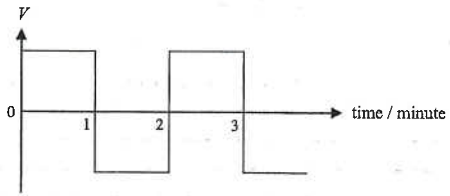
Part A : HKCE examination questions

1. **< HKCE 1984 Paper I - 8 >**



The figure above shows a simple experimental set-up to study the motion of a motor. *AB* and *CD* are solenoids connected to a battery *V*. *F* and *G* are connected to an external voltage supply. Its variation with time is shown in the following figure.

(Positive voltage *V* indicates the current flows from *F* to *G* via the coil.)



1. (a) What is the polarity of the solenoids

(i) at *B*, and

(ii) at *C* ? (2 marks)

(i) ____________________

(ii) ____________________

(b) What is the direction of rotation of the coil *PQRS*

(i) in the first minute,

(ii) in the second minute, and

(iii) in the third minute ? (3 marks)

(i) ____________________

(ii) ____________________

(iii) ____________________

(c) What would happen to the rotation of the coil *PQRS* if the input voltage supply reversed at a high frequency (e.g. 50 Hz) ? (2 marks)

____

____

(d) Suppose that instead of being connected to the battery *V*, the terminal of the solenoid at *A* is connected to *F* and the terminal of the solenoids at *D* is connected to *G*. *F* and *G* remain connected to the external voltage supply as indicated in the above voltage-time graph.

(i) What is the direction of rotation of the coil *PQRS*

(1) in the first minute,

(2) in the second minute, and

(3) in the third minute ? (3 marks)

(1) ____________________

(2) ____________________

(3) ____________________

(ii) What would happen to the rotation of the coil *PQRS* if the input voltage reversed at high frequency (e.g. 50 Hz) ? (2 marks)

____

____

(e) State 3 methods to increase the turning speed of this motor. (3 marks)

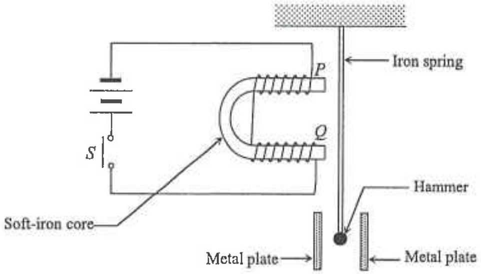
____

____

____

2. < HKCE 1993 Paper I - 5 >

A student designs a simple door bell as shown in the below figure. When switch S is pressed and then released, two notes "ding-ding" are heard.



(a) State the polarities at the two ends of the soft-iron core P and Q. (2 marks)

(b) Explain how the two notes are produced. (4 marks)

(c) Explain why soft iron is used as the core in the above design. (2 marks)

(d) Suggest one way to modify the bell so that two notes of different frequencies "ding-dong" are produced. (2 marks)

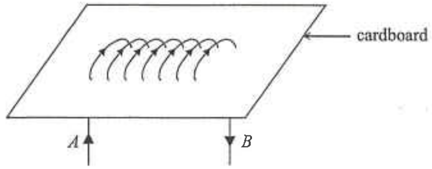
(e) Comment on the following two statements :

Statement 1 : The bell does not work if the spring is made of copper.

Statement 2 : The bell does not work if the polarities of the battery are reversed. (4 marks)

3. < HKCE 1993 Paper I - 5 >

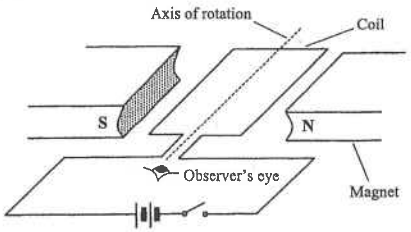
The figure below shows a solenoid passing through a piece of horizontal cardboard. A direct current passes through the solenoid from A to B to produce a magnetic field.



(a) Describe a method to find the magnetic field pattern on the cardboard using iron filings. (3 marks)

(b) Draw a diagram to show the pattern and direction of the magnetic field on the cardboard. (2 marks)

4. < HKCE 2000 Paper I - 6 >



A rectangular coil can rotate in a magnetic field as shown in the above figure. Initially the coil lies horizontally. The switch is now closed.

(a) State the initial direction of rotation of the coil as seen by the observer. (1 mark)

(b) The coil turns, oscillates a few times about the vertical position and then comes to a rest. Explain the motion of the coil. (4 marks)

5. **< HKCE 2005 Paper I - 11 >**

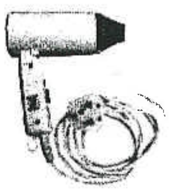


Figure 1

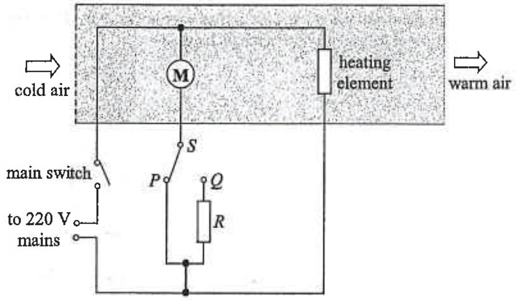


Figure 2

Figure 1 shows a simple hairdryer designed by Joseph. He makes use of a motor-driven fan and a heating element to generate warm air. Figure 2 shows the circuit diagram of the dryer. The motor and the heating element are connected to the 220 V mains. The switch S can be connected to either contact P or Q.

(a) Carmen uses the dryer to dry her wet hair. Explain, in terms of molecular motion, how the dryer can speed up the rate of evaporation of water from wet hair. (2 marks)

(b) Switch S is connected to contact P and the following data are given :

Resistance of the heating element = 50 Ω

Rate of air flowing through the dryer = 0.05 kg s^{-1}

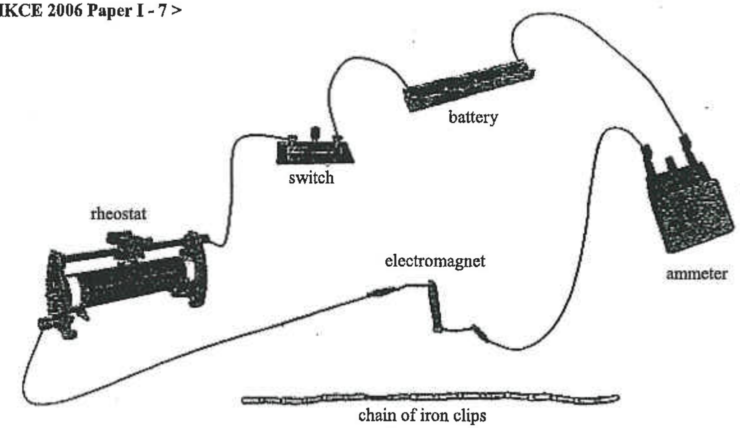
Temperature of air flowing into the dryer = 20°C

Specific heat capacity of air = 1000 J kg^{-1} °C^{-1}

Estimate the temperature of the air flowing out of the dryer, and state one assumption in your calculation. (4 marks)

(c) If switch S is connected to contact Q instead, explain whether the temperature of the air flowing out of the dryer would be higher than when S is connected to contact P. (3 marks)

6. **< HKCE 2006 Paper I - 7 >**

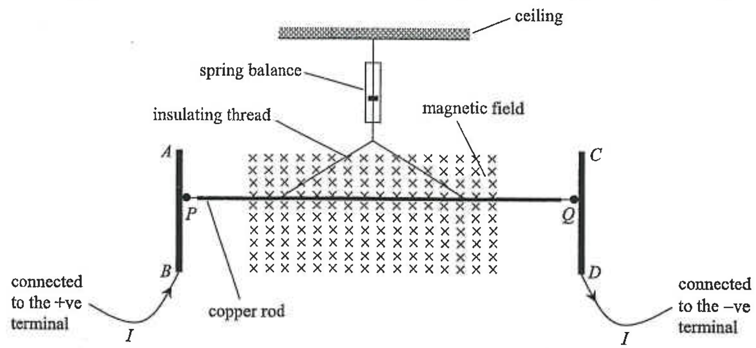


In a physics lesson, you are asked by the teacher to investigate the relationship between the strength of an electromagnet and the number of turns of its coil by using the apparatus shown in the above Figure. Describe the procedure for the experiment you should conduct. State clearly how you can measure the strength of the electromagnet. (5 marks)

7. **< HKCE 2007 Paper I - 11 >**

A copper rod PQ is hung at rest by insulating threads in a uniform magnetic field pointing into the paper as shown in the below Figure. The other ends of the threads are connected to a spring balance fixed on the ceiling. The two contacts P and Q at the ends of the copper rod can slide smoothly along two fixed vertical conducting rails AB and CD. The rails AB and CD are connected to the positive and the negative terminals of a d.c. power supply respectively. As a result, a current I passes through the copper rod.

Assume that the copper rod always remains horizontal and does not leave the magnetic field throughout the experiment.



7. (a) (i) In the above Figure, indicate the direction of the force F acting on the copper rod due to the current passing from P to Q. (1 mark)

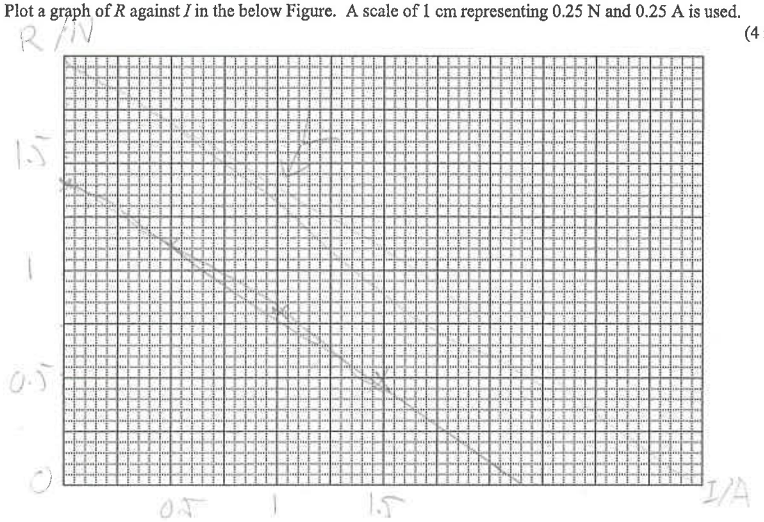
(ii) Suggest THREE methods to increase the force F. (3 marks)

(iii) Express the magnitude of force F in terms of the reading R of the spring balance and the weight W of the copper rod. (1 mark)

(b) A teacher conducts an experiment with the setup in the above Figure to find out how the reading R of the spring balance changes with the current I. The Table below shows the data collected.

R / N	1.4	1.1	0.8	0.5
I / A	0.0	0.5	1.0	1.5

(i) Plot a graph of R against I in the below Figure. A scale of 1 cm representing 0.25 N and 0.25 A is used. (4 marks)



(ii) Find the weight of the copper rod. (1 mark)

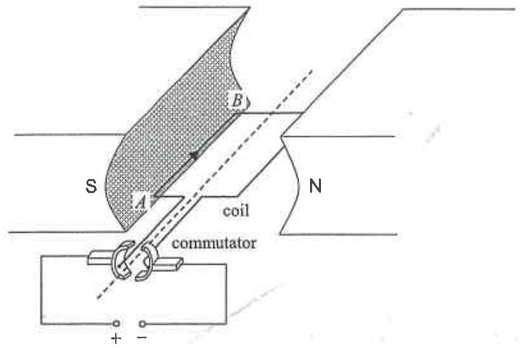
(iii) Find the maximum value of I such that the insulating threads remain taut. (1 mark)

(iv) If the experiment is repeated with a heavier copper rod, sketch a graph of R against I you would expect to obtain in the above Figure, and label it as L. (2 marks)

8. < HKCE 2008 Paper I - 8 >

Figure 1 shows the simplified structure of a motor with the plane of the coil at horizontal position. At this moment, it carries a current in the direction indicated by the arrow.

Figure 1

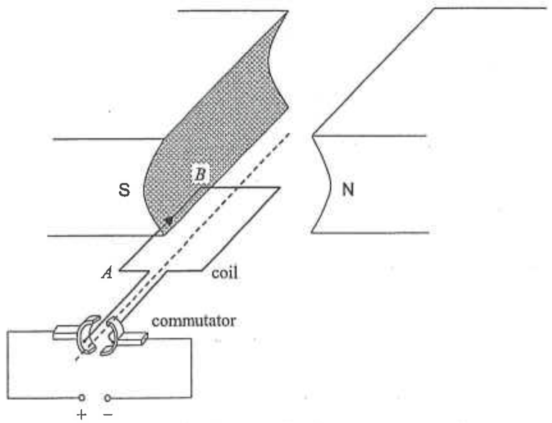


(a) Mark the direction of the magnetic force acting on the side AB in Figure 2. (1 mark)

(b) Explain how the commutator helps to keep the coil rotating in one direction. (2 marks)

(c) When the coil reaches the vertical position, the current is zero. Explain why the coil keeps on turning even no magnetic force is acting on it. (1 mark)

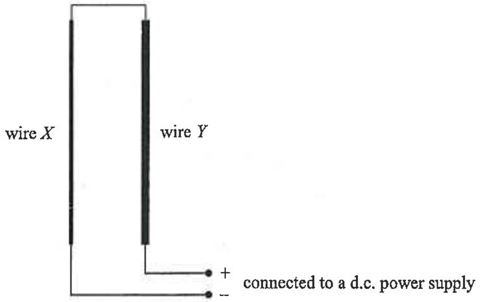
Figure 2



(d) If the coil is not fully inserted between the magnets as shown in Figure 2, describe and explain how this would affect the motion of the coil. Assume the current is the same as before. (3 marks)

9. < **HKCE 2009 Paper I - 8** >

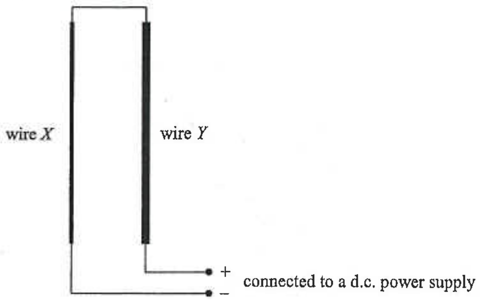
The Figure below shows two long resistance wires X and Y which are connected in series to a d.c. power supply. X and Y are made of the same material but X is thinner than Y.



(a) State the direction of the magnetic field at Y due to the current passing through X. (1 mark)

(b) There are magnetic forces F_X and F_Y acting on X and Y respectively due to the current passing through them.

(i) Indicate the direction of F_Y in the Figure below. (1 mark)



(ii) Compare the magnitudes of F_X and F_Y and explain briefly. (2 marks)

(c) Explain whether X and Y will attract and repel each other alternatively when the d.c. power supply is replaced by an a.c. power supply. (2 marks)

10. < **HKCE 2010 Paper I - 12** >

Figure 1 shows a simple motor that contains two electromagnets.

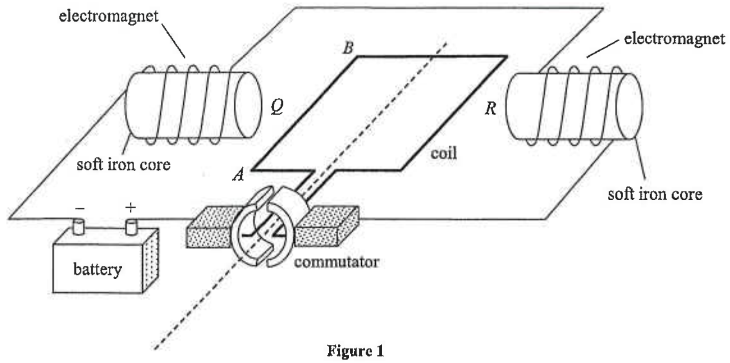


Figure 1

(a) State the polarities (north / south) of the electromagnets at Q and R and the direction (up / down) of the electromagnetic force acting on side AB of the coil at the instant shown. (2 marks)

Q ____________ R ____________

AB ____________

(b) Figure 2 shows the instant when the coil has rotated by 180°. By considering the electromagnetic force acting on side AB, explain why the coil can continue to rotate in the same direction. (4 marks)

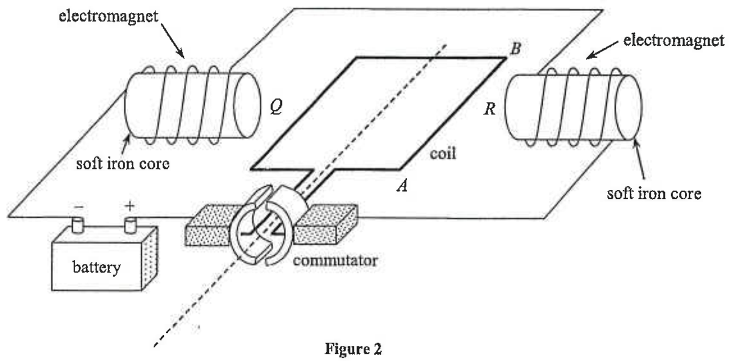
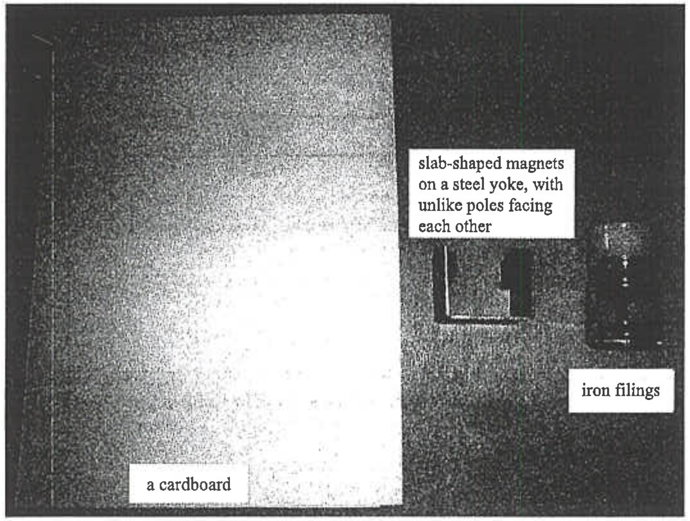


Figure 2

(c) Suggest **two** methods to increase the speed of rotation of the motor. (2 marks)

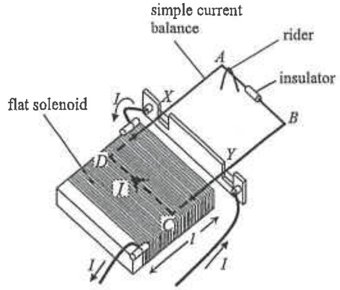
11. < HKCE 2011 Paper I - 6 >

The magnetic field between two slab-shaped magnets with unlike poles facing each other is uniform. Describe how to use the apparatus in the Figure below to illustrate this. (4 marks)



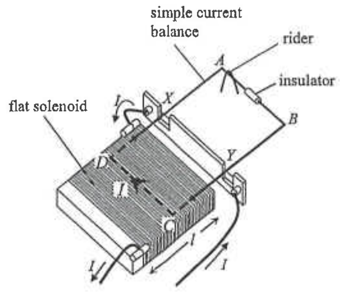
Part B : HKAL examination questions

12. < HKAL 1996 Paper I - 8 >



The above figure shows a simple current balance consisting of a horizontal rectangular metal loop $ABCD$ pivoting on the axis XY which is at the middle between AB and CD. Part of the current balance is inside a flat solenoid such that CD is perpendicular to the axis of the solenoid. The length of CD is 20 cm. When current I flows through the current balance $YCDX$ and then to the solenoid, a rider of mass 0.1 g has to be placed on AB to restore equilibrium. The length, l, and the number of turns, N, of the flat solenoid are 50 cm and 600 respectively.

(a) Indicate on the Figure below the direction of the magnetic field inside the solenoid. (1 mark)

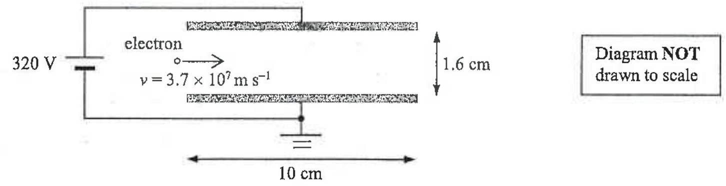


(b) (i) Express, in terms of I, an expression of the magnetic field strength inside the solenoid. Hence, find the magnetic force acting on arm CD in terms of I. (3 marks)

(ii) By considering the equilibrium of the current balance, deduce the value of the current I. (3 marks)

13. < HKAL 2006 Paper I - 4 >

In a vacuum, a beam of electrons with a horizontal velocity 3.7×10^7 m s^{-1} enters midway into a region of electric field between two horizontal square metal plates as shown in the Figure below. The length of the side of the plates is 10 cm. A voltage of 320 V is applied across the plates and the separation between them is 1.6 cm.

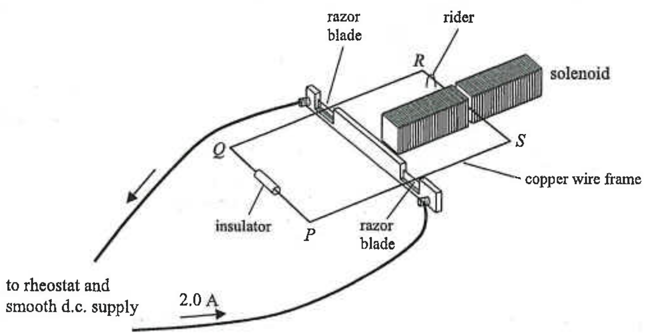


(a) Find the electric field strength between the plates. (2 marks)

(b) A uniform magnetic field normal to the paper is applied between the two plates so as to make the electron beam travel horizontally. Find the magnitude of the magnetic field applied. (Neglect the weight of the electron.) (2 marks)

14. < HKAL 2007 Paper I - 3 >

The Figure below shows a current balance which consists of a copper wire loop *PQRS* balanced on two razor blades. Two identical solenoids, each of 1500 turns, are placed coaxially such that one arm *RS* of the current balance is in the narrow gap between the two solenoids. Each solenoid is 30 cm long and has a square cross-section of 3 cm × 3 cm.



When a current of 2.0 A flows in the arm *RS* of the current balance, and the same current flows in the two solenoids in the same direction (not shown in the figure), placing a rider of mass 72 mg on the arm *RS* can restore the balance.

(a) Indicate in the above Figure the direction of the magnetic force acting on the arm *RS* and the direction of the current in the solenoids. (2 marks)

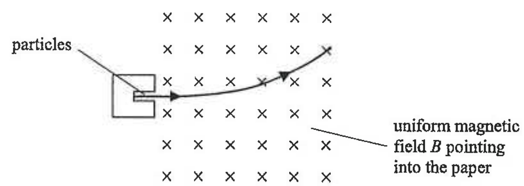
14. (b) (i) By considering the equilibrium of the current balance, find the average magnetic field B in the gap between the two solenoids. (2 marks)

(ii) By considering the current flowing in the two solenoids, calculate the magnitude B' of the magnetic field at the gap produced by the two solenoids. (2 marks)

(iii) State **TWO** possible reasons to account for the discrepancy between the two values of B and B'. (2 marks)

15. < HKAL 2010 Paper I - 4 >

(a) Particles with the speed v of 1.63×10^7 m s^{-1} are directed into an evacuated region with a uniform magnetic field B of 0.5 T perpendicular to the initial velocity of the particles as shown in the Figure below. Given that the charge to mass ratio of a particle is 4.82×10^7 C kg^{-1}, find the radius of the path described by the particles in the field region. (2 marks)

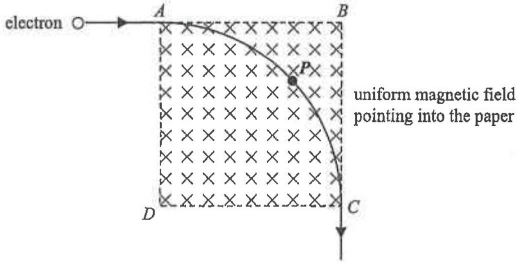


(b) Explain whether the particles would emerge with a greater speed from the region of magnetic field. (2 marks)

Part C : HKDSE examination questions

16. **< HKDSE 2013 Paper IB - 4 >**

An electron moving with speed 1.2×10^7 m s^{-1} enters a square region *ABCD* with a uniform magnetic field of 0.01 T pointing into the paper as shown in the figure below. The electron describes a quarter circle from *A* to *C* and it emerges from *C* with the same speed. Neglect the effects of gravity.



(a) (i) Find the magnitude of the magnetic force acting on the electron at point *P* on its path. (2 marks)

(ii) Indicate in the above Figure the direction of the electron's acceleration at the point *P*. (1 mark)

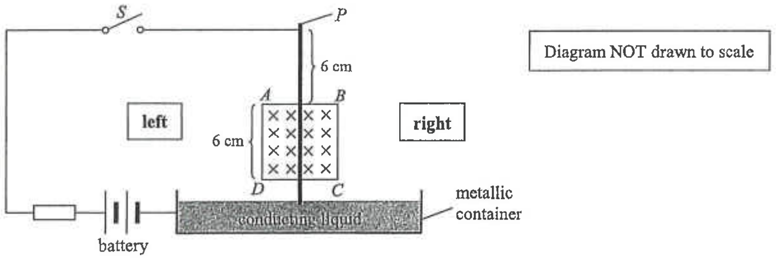
(b) Although the electron accelerates due to the magnetic force, explain why it emerges from the magnetic field with the same speed. (2 marks)

(c) Deduce the speed of the electron when entering the magnetic field such that it would describe a semi-circle from *A* to *D* instead. (2 marks)

17. **< HKDSE 2015 Paper IB - 9 >**

Figure (a) shows a set-up for demonstrating one of Faraday's discoveries. A light metal rod is free to rotate about point *P* while its lower end just touches some conducting liquid in a metallic container.

Figure (a)



17. A uniform magnetic field pointing into the paper is applied over the region *ABCD* containing part of the rod. When switch *S* is closed, the rod 'kicks' out and leaves the liquid surface.

(a) State the direction (to the left / to the right / out of the paper) that the rod 'kicks' and describe the subsequent motion of the rod. (3 marks)

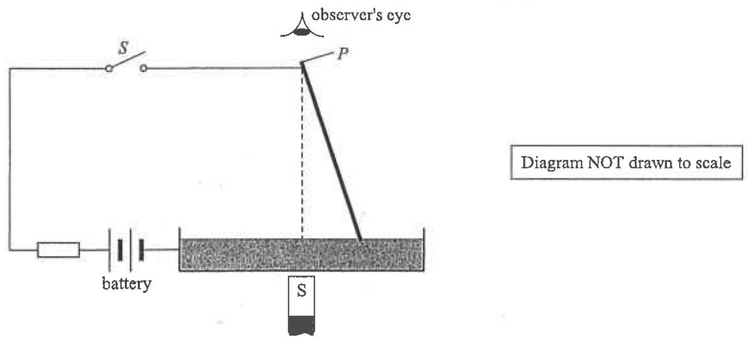
(b) When switch *S* is closed, the initial moment about point *P* that makes the rod 'kick' out is 7.2×10^{-4} N m. Assume that the magnetic force acts at the midpoint of the part of the rod within the magnetic field.

(i) Calculate the magnetic force acting on the rod at that instant. (2 marks)

(ii) Hence, find the strength *B* of the magnetic field if the current flowing through the rod is 3.2 A when the circuit is closed. (2 marks)

(c) Now the uniform magnetic field is removed and a bar magnet is placed underneath the container as shown in Figure (b). The rod is held tilted at an angle to the vertical but with its lower end still in the conducting liquid.

Figure (b)



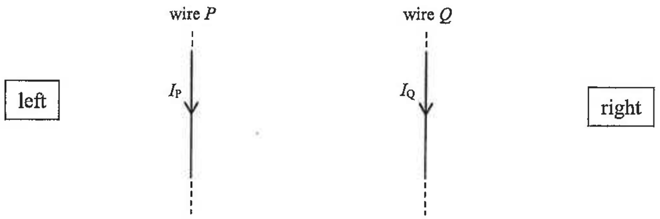
(i) Sketch on Figure (b) the field lines around the rod due to the bar magnet. (1 mark)

(ii) After closing switch *S* and the rod is released from rest, describe its subsequent motion viewed from above. (1 mark)

18. < HKDSE 2017 Paper IB - 9 >

(a) Two long straight current carrying wires, P and Q, are parallel to each other and lie on the plane of the paper as shown in Figure 1. The currents in the wires, I_P and I_Q, flow in the same direction.

Figure 1



(i) State the direction (to the left / to the right / into the paper / out of the paper) of the magnetic field at Q due to P. (1 mark)

(ii) In Figure 1, draw the direction of the magnetic force acting on Q due to P. (1 mark)

(iii) Show that the magnitude of the magnetic force per unit length F_l acting on Q due to P is

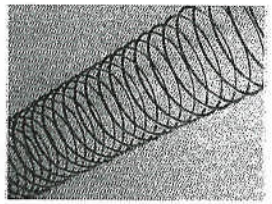
$$F_l = \frac{\mu_o I_P I_Q}{2\pi r}$$

where μ_o is the permeability of free space and r is the separation between the two wires. (3 marks)

(iv) For the magnetic force acting on Q due to P and the magnetic force acting on P due to Q, if $I_P \neq I_Q$, briefly explain whether the two forces are equal in magnitude. (2 marks)

(b) Figure 2 shows a metal slinky spring.

Figure 2



(i) If a direct current passes through the spring, briefly explain whether the spring will be compressed or stretched due to magnetic force. (2 marks)

(ii) A student suggests that the spring will be compressed and stretched alternately due to magnetic force when an alternating current passes through. Briefly explain why he is wrong. (1 mark)

There is question in next page

Question Solution

1. (a) (i) S-pole [1]

(ii) N-pole [1]

(b) (i) clockwise [1]

(ii) anticlockwise [1]

(iii) clockwise [1]

(c) No rotation [2]

(d) (i) (1) clockwise [1]

(2) clockwise [1]

(3) clockwise [1]

(ii) The coil would rotate continuously. [2]

(e) Any **THREE** of the following : [3]

* Increase the voltage supply
* Increase the number of turns in $PQRS$
* Increase the number of turns in the solenoids
* Insert iron rods into the two solenoids

2. (a) P is S-pole [1]

Q is N-pole [1]

(b) When S is pressed, current flows through the coil and the soft iron core is magnetized. [1]

It attracts the iron spring towards the left. [1]

The hammer strikes the left metal plate to produce the first note. [1]

When S is released, the iron core is demagnetized.

The hammer then springs back to strike the right metal plate to produce the second note. [1]

(c) Soft iron is a magnetic material. [1]

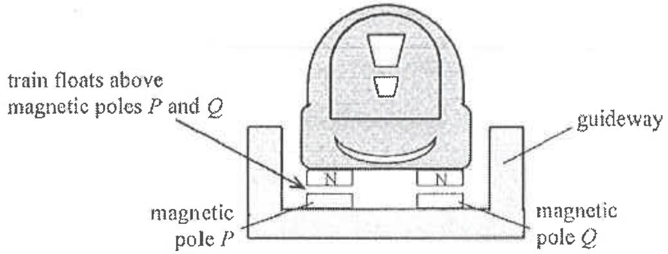
It can increase the strength of the magnetic field. [1]

(d) Any **ONE** of the following : [2]

* Replace one metal plate with another made of a different metal
* Change the length of one of the metal plates
* Change of the thickness of one of the metal plates
* Stick a lump of plasticine to one plate

Read the following passage about a **magnetically levitated (maglev) train** and answer the questions that follow.

'A maglev train car is just a box with magnets on the four corners,' says Jesse Powell, the son of the maglev train inventor. The electromagnets employed have superconducting coils (i.e. coils with extremely low resistance). They therefore can generate magnetic fields 10 times stronger than ordinary electromagnets, enough to levitate and propel a train.



LEVITATION

Two sets of magnetic fields are set up for different functions. One is to make the train float a few centimetres above magnetic poles P and Q as shown while the other is a propulsion system run by an alternating current for moving the train car along the guideway by magnetic attraction and repulsion. This floating design enables a smooth movement of the train. Even when the train travels up to 600 km per hour, passengers inside experience less vibration than travelling on traditional trains.

(a) Explain why electromagnets employing superconducting coils can produce much stronger magnetic fields. (2 marks)

(b) State the polarities of the magnetic poles P and Q and explain how this arrangement enables the train to float. (2 marks)

(c) Referring to the resistive forces experienced by the train, explain why a maglev train ride is (i) smoother and (ii) faster. (2 marks)

2. (e) Statement 1 is correct. [1]

Copper is not a magnetic material, it cannot be attracted by the electromagnet. [1]

Statement 2 is not correct. [1]

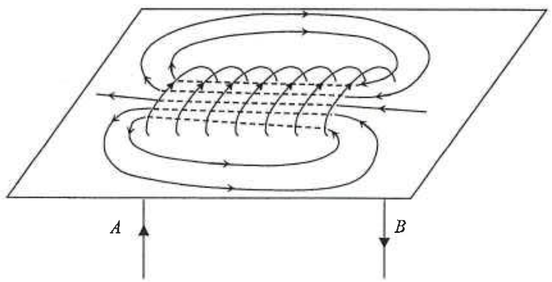
If the polarities of the battery are reversed,
the soft iron core can still be magnetized and attracted by the electromagnet. [1]

3. (a) Sprinkle some iron filings on the board. [1]

Tap the board gently. [1]

The magnetic field pattern is shown by the pattern of the iron filings. [1]

(b)



< Direction magnetic field lines correct > [1]

< Pattern of magnetic field lines correct > [1]

4. (a) The coil rotates in clockwise direction. [1]

(b) When the switch is closed, current flows through the coil. As the coil is placed in a magnetic field, there are magnetic forces acting on the wires to rotate the coil and the coil turns clockwise. [1]

When the coil turns to the vertical position, the turning effect becomes zero.

Due to inertia, the coil shoots through the vertical position to the other side. [1]

The direction of the turning effect acting on the coil reverses
and the coil rotates back in the opposite direction (anticlockwise). This process repeats. [1]

As energy is lost against friction during the motion, the coil will finally stop in the vertical position. [1]

5. (a) More water molecules gain enough energy to escape from the water surface. [1]

The water molecules after escaped from the water surface would be blown away by the wind from the dryer. [1]

5. (b) Power given out by the heating element :

$P = \dfrac{V^2}{R}$

$= \dfrac{(220)^2}{(50)}$

$= 968$ W [1]

Assume no heat lost to the surroundings. [1]

$E = P\,t = m\,c\,\Delta T$ [1]

$\therefore$ $(968)(1) = (0.05)(1000)(\theta - 20)$

$\therefore$ $\theta = 39.4$°C < accept $\theta = 39.36$°C > [1]

(c) If S is connected to contact Q, the current flowing through the motor is reduced. [1]

The speed of the rotation of the fan is decreased. [1]

As the rate of air flowing through the dryer is reduced,

the temperature of air flowing out would be higher. [1]

6. Use the electromagnet to attract the iron clips. [1]

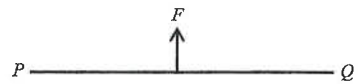
Record the number of iron clips when the chain just falls down. [1]

Change the number of turns of the coil and repeat the above procedure. [1]

Record the change of the number of iron clips when the chain just falls down. [1]

In each trial, the current should be kept constant. [1]

7. (a) (i) [1]



(ii) ① Increase the strength of the magnetic field. [1]

② Increase the current. [1]

③ Widen the magnetic field so that the length of the rod in the magnetic field is increased. [1]

< Do not accept : increase the length of the rod >

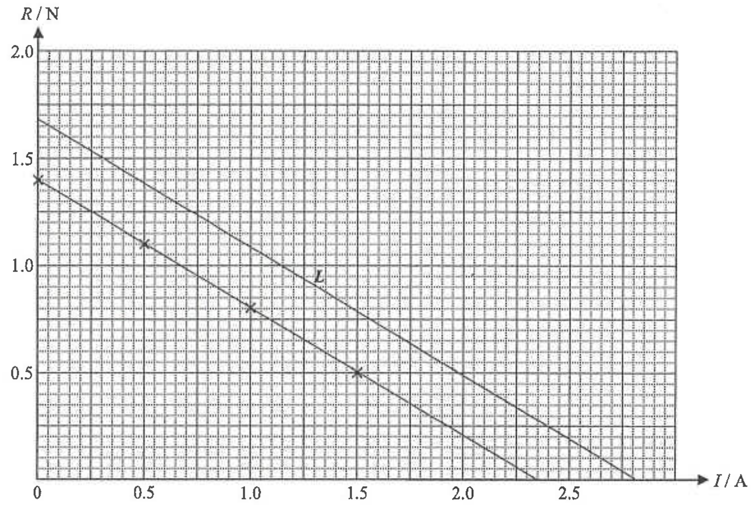
< Do not accept : decrease the resistance of the rod >

< Do not accept : decrease the weight of the rod >

(iii) Balance of forces : $F + R = W$

$\therefore$ $F = W - R$ [1]

7. (b) (i)



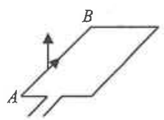
< Correct labelled axes with units > [1]
< Correct scale > [1]
< Correct points plotted > [1]
< Correct straight line through the points > [1]

(ii) W = 1.4 N < accept 1.35 N to 1.45 N > [1]

(iii) When $R = 0$, I = 2.35 A < accept 2.3 A to 2.4 A > [1]

(iv) < The line is above the original line > [1]
< The line is parallel to the original line > [1]

8. (a)



[1]

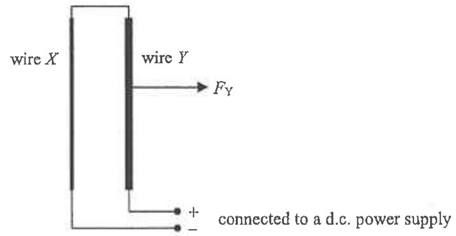
(b) Commutator can reverse the direction of the current through the coil [1]
whenever the coil has rotated half cycle. [1]

(c) due to inertia [1]

(d) Since length of wire inside the magnetic field is decreased, [1]
magnetic force acting on the wire decreases, [1]
thus the rotation speed of the motor decreases. [1]

9. (a) out of paper [1]

(b) (i)



[1]

(ii) The magnitudes of the two forces are equal (**OR** $F_X = F_Y$) [1]
because they are action-reaction pair. [1]

(c) The directions of the current in X and Y are always opposite. [1]
The forces are always repulsive. (**OR** The forces will not attract and repel alternately.) [1]

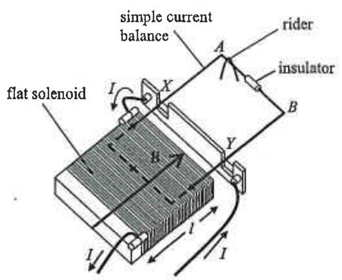
10. (a) Q north < accept N >
R south < accept S > [1]
AB down [1]

(b) The current in the coil is reversed [1]
due to the commutator. [1]
But the direction of magnetic field produced remains unchanged. [1]
So the force acting on side AB points up and the coil continues to rotate. [1]

(c) Any **TWO** of the followings : [2]
* Use a battery of higher voltage. (**OR** Increase the current.)
* Increase the number of turns of the coil.
* Increase the area of coil in the magnetic field.
* Insert a soft iron core in the coil.
* Increase the number of turns of the winding in the solenoid.

11. Put the cardboard on top of the magnets. [1]
Sprinkle some iron filings onto the cardboard. [1]
Tap the cardboard gently to show the magnetic field pattern. [1]
The iron filings will form evenly spaced parallel lines between the magnets. [1]

12. (a)



[1]

(b) (i) $B = \dfrac{4\pi\times10^{-7}\times600\times I}{0.5}$ [1]

$F = B\,I\,L$

$= \dfrac{4\pi\times10^{-7}\times600\times I}{0.5}\times I\times(0.2)$ [1]

$= 3.02\times10^{-4}\,I^2$ <accept $3.0\times10^{-4}\,I^2$> [1]

(ii) $F = m\,g$ [1]

$\therefore$ $(3.02\times10^{-4}\,I^2) = (0.1\times10^{-3})\,(9.81)$ [1]

$\therefore$ $I = 1.80$ A <accept 1.81 A> [1]

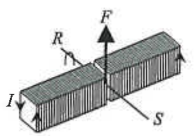
13. (a) $E = \dfrac{V}{d} = \dfrac{320}{0.016}$ [1]

$= 2\times10^4$ V m^{-1} [1]

(b) $B\,Q\,v = Q\,E$ [1]

$\therefore$ $B = \dfrac{E}{v} = \dfrac{2\times10^4}{3.7\times10^7} = 5.41\times10^{-4}$ T [1]

14. (a)



<Magnetic force F is upwards> [1]

<Current I is anticlockwise when viewed from left> [1]

(b) (i) $F = m\,g = B\,I\,L$

$(72\times10^{-6})\,(9.81) = B\,(2)\,(0.03)$ [1]

$\therefore$ $B = 0.0118$ T [1]

14. (b) (ii) $B' = \mu_0\,n\,I$

$= (4\pi\times10^{-7})(\dfrac{1500}{0.3})(2)$ [1]

$= 0.0126$ T [1]

(iii) Any **TWO** of the followings : [2]

* The solenoids are not infinitely long.
* There is air gap between the two solenoids.
* The Earth's magnetic field may affect the result.
* The arm RS may not be exactly perpendicular to the magnetic field.
* Since it is difficult to balance, some error may occur for the mass of rider obtained.

15. (a) $B\,Q\,v = \dfrac{m\,v^2}{r}$ $\therefore$ $\dfrac{Q}{m}B\,r = v$ [1]

$\therefore$ $(4.82\times10^7)\,(0.5)\,r = 1.63\times10^7$

$\therefore$ $r = 0.676$ m [1]

(b) No.

Since the magnetic force acting on the particle is always perpendicular to its velocity, [1]

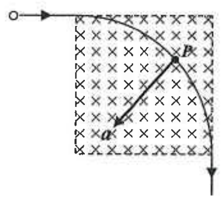
no work is done on the particle by the magnetic force. [1]

16. (a) (i) $F = B\,Q\,v$

$= (0.01)\,(1.6\times10^{-19})\,(1.2\times10^7)$ [1]

$= 1.92\times10^{-14}$ N [1]

(ii)



<direction of a : towards the centre of the circular arc> [1]

(b) F is always perpendicular to the velocity of the electron, [1]

thus, no work is done and the kinetic energy remains unchanged. [1]

OR

Electron only changes direction while speed remains unchanged, [1]

no work is done and the kinetic energy remains unchanged. [1]

16. (c) $F = BQv = \dfrac{mv^2}{r}$ [1]

$\therefore\ v = \dfrac{BQ}{m}r$

As $\dfrac{BQ}{m}$ is constant, if r is halved, v is also halved.

$\therefore\ v = 0.6 \times 10^7\ \text{m s}^{-1}$ < accept $6 \times 10^6\ \text{m s}^{-1}$ > [1]

17. (a) The rod 'kicks' to the right. [1]

The rod then leaves the liquid and the circuit is not complete.

Therefore, current stops flowing and the rod swings back to the original position. [1]

The above process then repeats so the rod continually kicks out and then returns. [1]

(b) (i) Moment $= F \times d$

$\therefore\ (7.2 \times 10^{-4}) = F \times (0.06 + 0.03)$ [1]

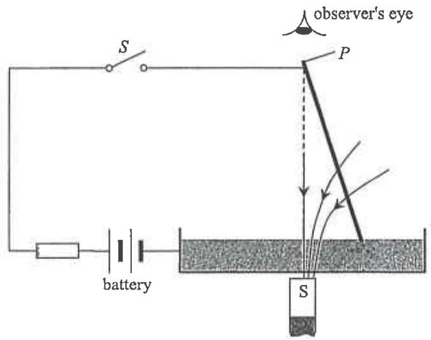
$\therefore\ F = 8 \times 10^{-3}$ N [1]

(ii) By $F = BIL$

$\therefore\ (8 \times 10^{-3}) = B\,(3.2) \times (0.06)$ [1]

$\therefore\ B = 0.0417$ T < accept 0.042 T > [1]

(c) (i)



[1]

(ii) The rod rotates in anticlockwise direction. [1]

18. (a) (i) The magnetic field at Q due to P points out of the paper. [1]

(ii) [1]

18. (a) (iii) The magnetic field at Q due to P :

$$B_Q = \frac{\mu_o I_P}{2\pi r}$$ [1]

Magnetic force on Q with length l :

$$F = B_Q I_Q l$$ [1]

$$= \frac{\mu_o I_P}{2\pi r} \cdot I_Q l$$

Magnetic force per length :

$$F_l = \frac{F}{l} = \frac{\mu_o I_P I_Q}{2\pi r}$$ [1]

(iv) The two forces form an action and reaction pair, [1]

thus they are equal in magnitude. [1]

(b) (i) As current passes in the same direction between two adjacent wires, [1]

the wires attract each other, thus the solenoid is compressed. [1]

(ii) Currents between two adjacent wires always flows in the same direction at any instant, [1]

thus, the solenoid will always be compressed.

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part（必修部分）

Section A – Heat and Gases（熱和氣體）
1. Temperature, Heat and Internal energy（溫度、熱和內能）
2. Transfer Processes（熱轉移過程）
3. Change of State（形態的改變）
4. General Gas Law（普適氣體定律）
5. Kinetic Theory（分子運動論）

Section B – Force and Motion（力和運動）
1. Position and Movement（位置和移動）
2. Newton's Laws（牛頓定律）
3. Moment of Force（力矩）
4. Work, Energy and Power（作功、能量和功率）
5. Momentum（動量）
6. Projectile Motion（拋體運動）
7. Circular Motion（圓周運動）
8. Gravitation（引力）

Section C – Wave Motion（波動）
1. Wave Propagation（波的推進）
2. Wave Phenomena（波動現象）
3. Reflection and Refraction of Light（光的反射及折射）
4. Lenses（透鏡）
5. Wave Nature of Light（光的波動特性）
6. Sound（聲音）

Section D – Electricity and Magnetism（電和磁）
1. Electrostatics（靜電學）
2. Electric Circuits（電路）
3. Domestic Electricity（家居用電）
4. Magnetic Field（磁場）
5. Electromagnetic Induction（電磁感應）
6. Alternating Current（交流電）

Section E – Radioactivity and Nuclear Energy（放射現象和核能）
1. Radiation and Radioactivity（輻射和放射現象）
2. Atomic Model（原子模型）
3. Nuclear Energy（核能）

Physics – Elective part（選修部分）

Elective 1 – Astronomy and Space Science（天文學和航天科學）
1. The universe seen in different scales（不同空間標度下的宇宙面貌）
2. Astronomy through history（天文學的發展史）
3. Orbital motions under gravity（重力下的軌道運動）
4. Stars and the universe（恆星和宇宙）

Elective 2 – Atomic World（原子世界）
1. Rutherford's atomic model（盧瑟福原子模型）
2. Photoelectric effect（光電效應）
3. Bohr's atomic model of hydrogen（玻爾的氫原子模型）
4. Particles or waves（粒子或波）
5. Probing into nano scale（窺探納米世界）

Elective 3 – Energy and Use of Energy（能量和能源的使用）
1. Electricity at home（家居用電）
2. Energy efficiency in building（建築的能源效率）
3. Energy efficiency in transportation（運輸業的能源效率）
4. Non-renewable energy sources（不可再生能源）
5. Renewable energy sources（可再生能源）

Elective 4 – Medical Physics（醫學物理學）
1. Making sense of the eye（眼的感官）
2. Making sense of the ear（耳的感官）
3. Medical imaging using non-ionizing radiation（非電離輻射醫學影像學）
4. Medical imaging using ionizing radiation（電離輻射醫學影像學）

The following list of formulae may be found useful :

Induced e.m.f.	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \dfrac{\mu_o I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \dfrac{\mu_o NI}{l}$

Use the following data wherever necessary :

Permeability of free space	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
Charge of electron	$e = 1.60 \times 10^{-19}$ C
Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
Acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)

Part A : HKCE examination questions

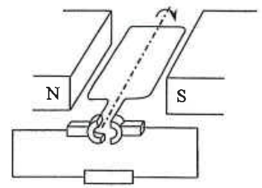
1. **< HKCE 1981 Paper II - 34 >**

Which of the following statements concerning the generator shown in the figure is/are correct ?

(1) The direction of the current through the load reverses periodically.

(2) The maximum magnitude of the current depends on the speed of rotation of the coil.

(3) The maximum magnitude of the current depends on the resistance of the load.



A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

2. **< HKCE 1983 Paper II - 33 >**

The figure shows a bar magnet moving along the diameter of a metal ring. Which of the following will happen ?

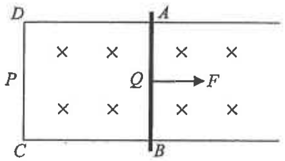
A. An induced current will flow in a clockwise direction in the ring.
B. An induced current will flow in an anticlockwise direction in the ring.
C. An alternating current will be produced in the ring.
D. No induced current will be produced.

3. **< HKCE 1984 Paper II - 25 >**

Which of the following devices is designed to convert mechanical energy into electrical energy ?
A. dynamo
B. transformer
C. motor
D. electric cell

4. **< HKCE 1985 Paper II - 42 >**

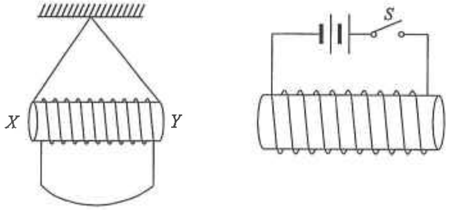
A copper rod AB is free to move on two parallel conducting wires. It is pulled by a force F and moves in the direction shown in the figure. The direction of the magnetic field points into the paper. Which of the following statements is/are true ?



(1) A current will flow from C to D through P.
(2) A current will flow from B to A through Q.
(3) An induced voltage will be set up across AB.

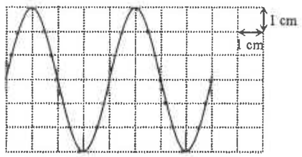
A. (2) only
B. (3) only
C. (1) & (3) only
D. (2) & (3) only

5. **< HKCE 1987 Paper II - 34 >**



A light coil of wire XY is suspended by insulating string such that it can swing freely. A solenoid connected to a cell with a switch S is placed near to the end Y of the coil as shown. What would happen to the coil XY just when the switch S is closed ?
A. The coil moves towards the solenoid.
B. The coil moves away from the solenoid.
C. The coil would move down.
D. The coil would move up.

6. **< HKCE 1989 Paper II - 42 >**



The figure shows the display on a CRO with the time base set at 1 ms cm^{-1} and Y-gain at 0.5 V cm^{-1}. The peak voltage and frequency of the a.c. voltage applied across the Y-plates are

	peak voltage	frequency
A.	1.5 V	500 Hz
B.	1.5 V	250 Hz
C.	3.0 V	50 Hz
D.	3.0 V	250 Hz

7. **< HKCE 1989 Paper II - 35 >**

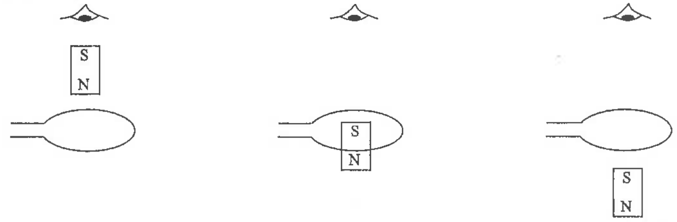


Figure (1) **Figure (2)** **Figure (3)**

A magnet is allowed to fall through a copper ring. What is the direction of the induced current (if any) on the ring observed by the eye when the magnet is in the position as shown in Figure (1), (2) and (3) ?

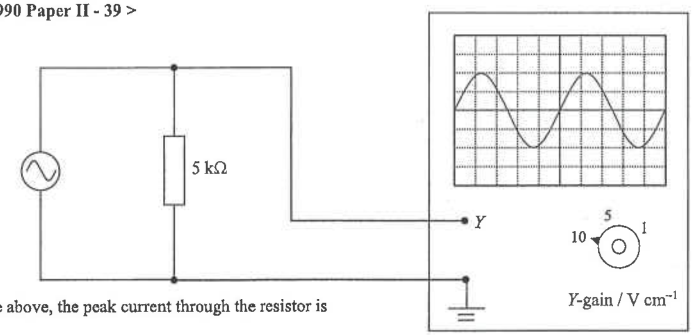
	Figure (1)	Figure (2)	Figure (3)
A.	Clockwise	No current	Anticlockwise
B.	Anticlockwise	No current	Clockwise
C.	Anticlockwise	No current	Anticlockwise
D.	Anticlockwise	Anticlockwise	Clockwise

8. **< HKCE 1990 Paper II - 36 >**

Figure 1 **Figure 2**

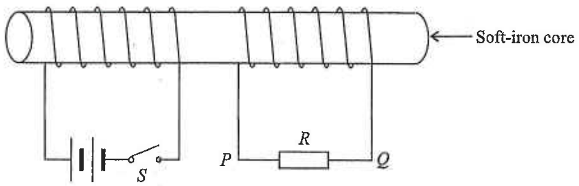
In Figure 1, the galvanometer deflects to the left with a reading of 10 μA. The north pole of the same magnet is now pushed towards the coil from the other side at a faster rate as shown in Figure 2. The deflection on the galvanometer will be
A. more than 10 μA to the right.
B. less than 10 μA to the left.
C. more than 10 μA to the left.
D. less than 10 μA to the right.

9. **< HKCE 1990 Paper II - 39 >**



In the figure above, the peak current through the resistor is
A. 2 mA
B. 4 mA
C. 8 mA
D. 4 A

10. **< HKCE 1993 Paper II - 34 >**

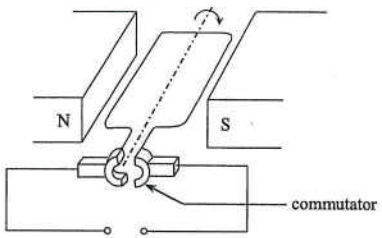


Two coils of conducting wires are wrapped on a soft-iron core as shown in the above figure. Switch S is closed and after a while re-opened. Which of the following statements is/are true ?

(1) At the moment when S is closed, a current flows through R from P to Q.
(2) When S remains closed, there is no current flowing through R.
(3) At the moment when S is re-opened, a current flows through R from P to Q.

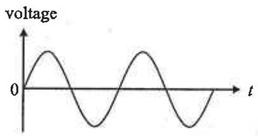
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

11. **< HKCE 1993 Paper II - 37 >**

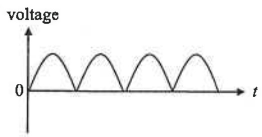


The above diagram shows a simple generator. Which of the following graphs below shows the time variation of the voltage produced by the generator ?

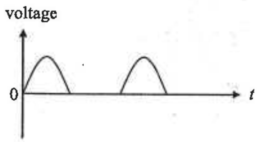
A.



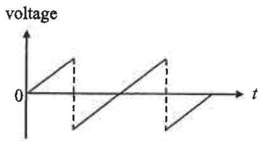
B.



C.



D.



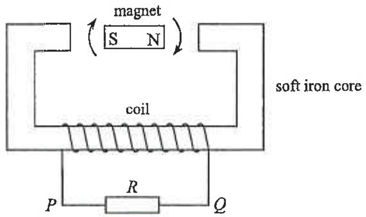
12. **< HKCE 1994 Paper II - 31 >**

Which of the following statements about direct current (d.c.) and alternating current (a.c.) is/are correct ?

(1) All d.c. sources produce constant voltages.
(2) The direction of current in an a.c. circuit changes with time.
(3) Both d.c. and a.c. produce a heating effect in a resistor.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

13. **< HKCE 1994 Paper II - 36 >**



A magnet is initially placed between the ends of a soft iron core as shown above. The magnet is then quickly rotated clockwise through one complete revolution. Which of the following statements correctly describes the induced current flowing through the resistor R ?

A. The current flows through R from P to Q, and then reverses its direction.
B. The current flows through R from Q to P, and then reverses its direction.
C. The current flows through R from P to Q.
D. The current flows through R from Q to P.

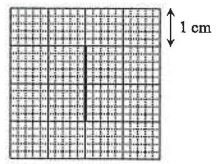
14. **< HKCE 1994 Paper II - 32 >**

Which of the following correctly shows the major energy change in the device when it is working ?

	Device	From	To
A.	A microphone	electrical	sound
B.	A loudspeaker	sound	electrical
C.	A dynamo	electrical	electrical
D.	A motor	electrical	mechanical

15. **< HKCE 1994 Paper II - 37 >**

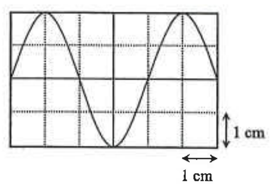
The diagram shows the trace of a signal on a CRO with the time base switched off. The Y-gain is set at 1 V cm^{-1}. Which of the following statements correctly describes the input signal ?



A. It is an a.c. of peak voltage 1 V.
B. It is an a.c. of peak voltage 2 V.
C. It is a d.c. of constant voltage 1 V.
D. It is a d.c. of constant voltage 2 V.

16. **< HKCE 1995 Paper II - 37 >**

The diagram shows the display on a CRO with the time base at 10 ms cm^{-1} and Y-gain at 0.5 V cm^{-1}. Find the peak voltage and frequency of the signal applied across the Y-plates.



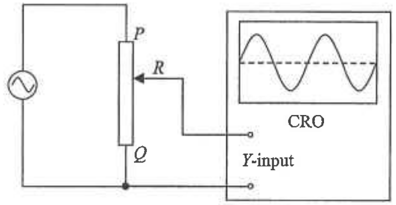
	Peak voltage / V	Frequency / Hz
A.	1	16.7
B.	1	25
C.	1	50
D.	2	25

17. **< HKCE 1996 Paper II - 31 >**

Which of the following devices is **not** an application of electromagnetic induction ?

A. a bicycle dynamo
B. a magnetic tape playback head
C. a moving coil microphone
D. a moving coil loudspeaker

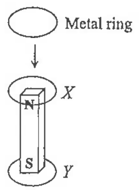
18. < HKCE 1997 Paper II - 36 >



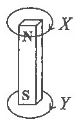
In the above circuit, the terminal Q and the sliding contact R of the variable resistor are connected to the Y-input of a CRO. If R is moved towards P, how would the amplitude and period of the trace displayed on the CRO be affected ?

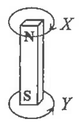
	Amplitude of the trace	Period of the trace
A.	increases	remains unchanged
B.	increases	increases
C.	decreases	remains unchanged
D.	decreases	decreases

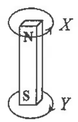
19. < HKCE 1997 Paper II - 34 >

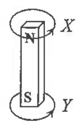


A metal ring is released and falls vertically around a magnet as shown in the above diagram. Which of the following diagrams correctly describes the directions of the induced current, if any, in the ring at positions X and Y ?

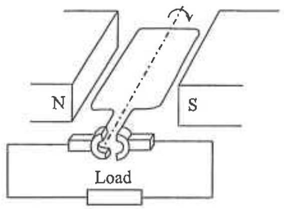
A.


B.


C.


D.


20. < HKCE 1997 Paper II - 37 >

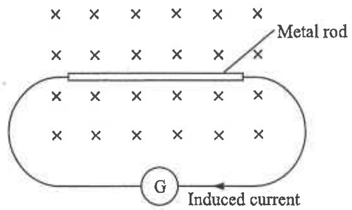


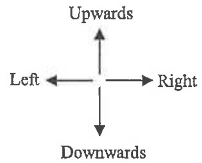
The diagram shows an electricity generator connected to a load. Which of the following can increase the voltage produced by the generator ?

(1) Rotating the coil at a greater speed
(2) Reducing the resistance of the load
(3) Replacing the coil with one of larger area

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

21. < HKCE 1998 Paper II - 34 >



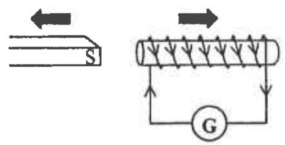


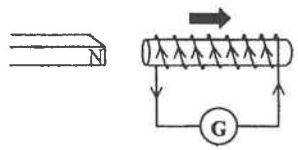
In the above diagram, a metal rod is placed inside a magnetic field pointing into the paper. In which direction should the rod be moved in order to produce an induced current as shown in the diagram ?

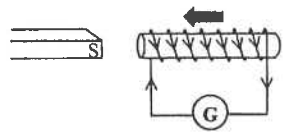
A. into the paper
B. out of the paper
C. upwards
D. downwards

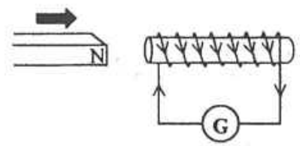
22. < HKCE 2000 Paper II - 38 >

A bar magnet is placed near a solenoid. Which of the following correctly shows the direction of the induced current in the solenoid ? (Note : The arrow " ➔ " indicates the direction of motion of the magnet or solenoid.)

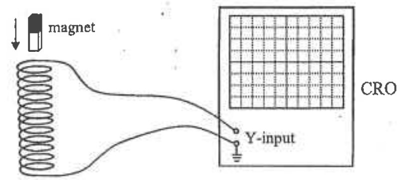
A.


B.


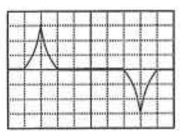
C.


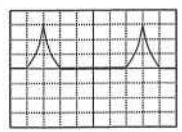
D.


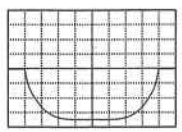
23. < HKCE 2001 Paper II - 35 >

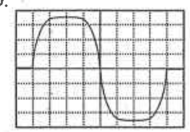


A long solenoid is placed in a vertical position and its two ends are connected to the Y-input of a CRO (with the time base switched on). A bar magnet is released above the solenoid so that it falls through the solenoid. Which of the following figures best represents the trace shown on the CRO ?

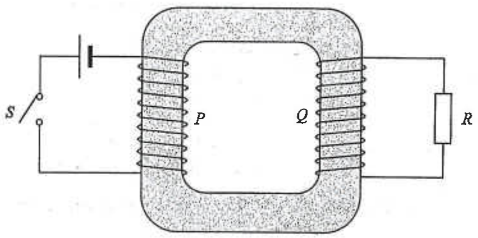
A.


B.


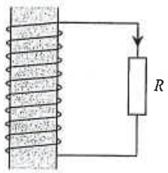
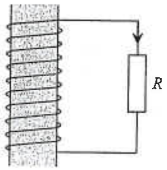
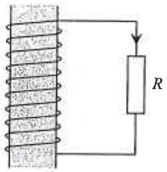
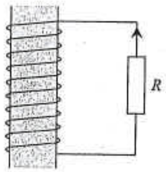
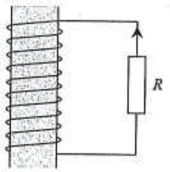
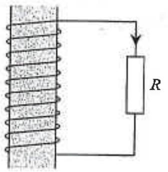
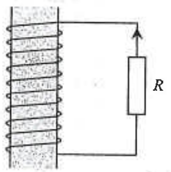
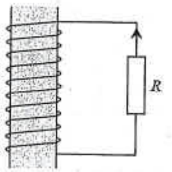
C.


D.


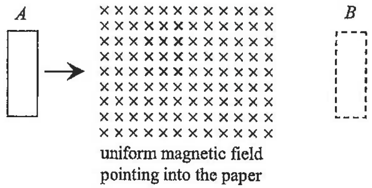
24. **< HKCE 2003 Paper II - 37 >**



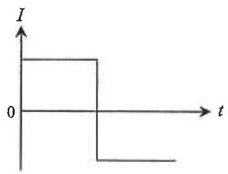
Two coils P and Q are wound on a soft-iron core as shown above. Switches S is closed and then opened again. Which of the following shows the directions of the induced current flowing through the resistor R ?

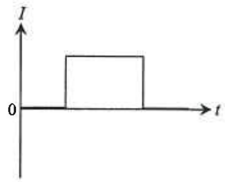
	At the instant S is closed	At the instant S is opened again
A.		
B.		
C.		
D.		

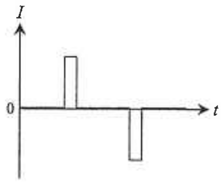
25. **< HKCE 2004 Paper II - 35 >**

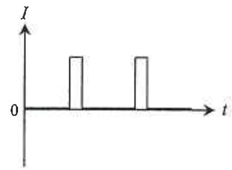


A rectangular coil is moved with a uniform speed from position A to position B as shown above. Which of the following graphs represents the variation of the current induced in the coil with time ?

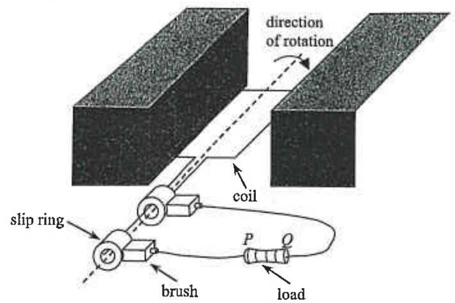
A.


B.


C.


D.


26. **< HKCE 2004 Paper II - 36 >**



The diagram shows a generator connected to a load. Which of the following statements is/are correct ?

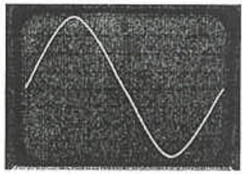
(1) The generator produces an alternating current through the load.

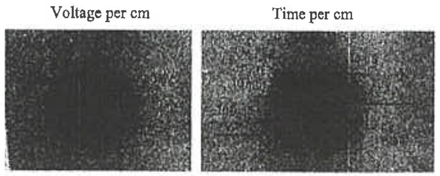
(2) At the instant shown, a current is flowing through the load from P to Q.

(3) The current produced reaches a maximum when the coil is vertical.

A. (1) only
B. (3) only
C. (1) and (2) only
D. (2) and (3) only

27. **< HKCE 2004 Paper II - 38 >**

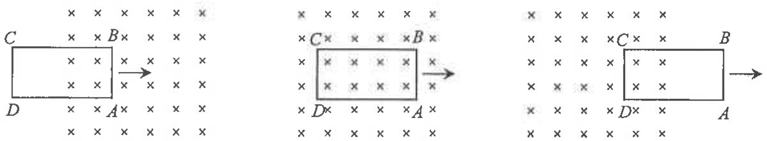




The photographs show the trace of a signal on a CRO and some settings of the CRO. The voltage gain is set at 0.5 V per cm and the time-base is set at 10 ms per cm. Find the frequency and peak voltage of the input signal.

	Frequency / Hz	Peak Voltage / V
A.	10	2
B.	10	4
C.	20	2
D.	20	4

28. **< HKCE 2005 Paper II - 42 >**



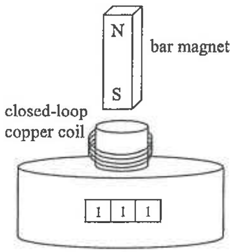
position P position Q position R

A conducting rectangular coil $ABCD$ is moved across a uniform magnetic field pointing into the paper as shown above. Which of the following statements is/are correct ?

(1) The induced current flows from A to C through B when the coil is at P.
(2) The magnitude of the induced current is the largest when the coil is at Q.
(3) The direction of the induced current when the coil is at R is the same as that when it is at P.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

29. **< HKCE 2007 Paper II - 43 >**

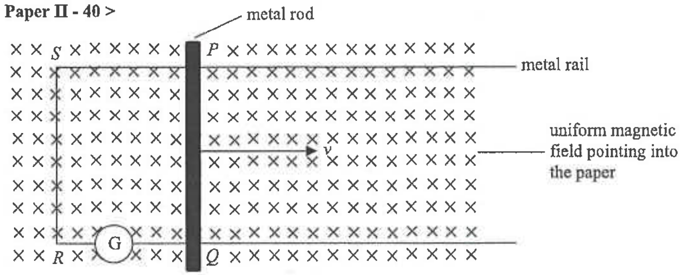


electronic balance

An electronic balance reads X when a closed-loop copper coil is placed on it as shown above. A bar magnet drops from certain height vertically above. Just before the magnet reaches the coil, the reading of the electronic balance is

A. the same as X.
B. first smaller than X and then greater than X.
C. smaller than X.
D. greater than X.

30. **< HKCE 2007 Paper II - 40 >**

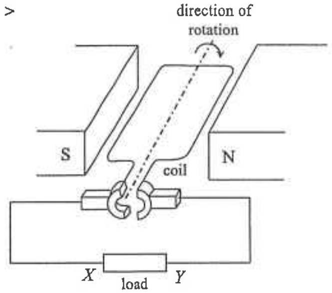


Under an external force, a metal rod PQ is moving with a uniform speed v on a metal rail placed in a uniform magnetic field as shown above. Which of the following descriptions is/are correct ?

(1) Current flows through the galvanometer from Q to R.
(2) The metal rod will accelerate to right if the direction of the magnetic field is reversed.
(3) The pointer of the galvanometer will deflect to opposite direction if the direction of the magnetic field is reversed.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

31. **< HKCE 2007 Paper II - 42 >**

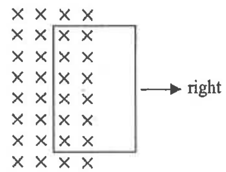


The above figure shows a simple structure of a d.c. generator. Which of the following statements is/are correct ?

(1) The current delivered to the load is constant.
(2) The current generated in the coil is alternating, but the current delivered to the load is unidirectional.
(3) The current flows through the load from X to Y.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

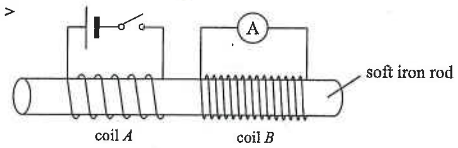
32. **< HKCE 2008 Paper II - 40 >**



In the figure, a rectangular coil is pulled to the right with uniform speed in a uniform magnetic field pointing into the paper. Which of the following descriptions about the current induced in the coil and the magnetic force acting on the coil is correct ?

A. No current is induced in the coil and no magnetic force is acting on the coil.
B. A current is induced in the coil but the resultant magnetic force acting on the coil is zero.
C. A current is induced in the coil and a resultant magnetic force is acting on the coil to the left.
D. A current is induced in the coil and a resultant magnetic force is acting on the coil to the right.

33. **< HKCE 2008 Paper II - 39 >**

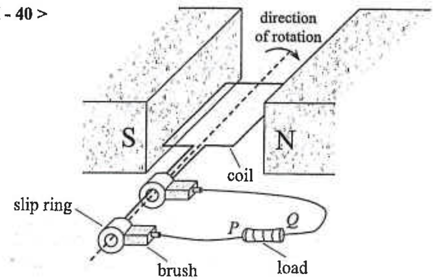


An experiment about electromagnetism is designed as shown above. Coil B has a greater number of turns than coil A. Coil B is connected to a sensitive ammeter. Which of the following statements is/are correct ?

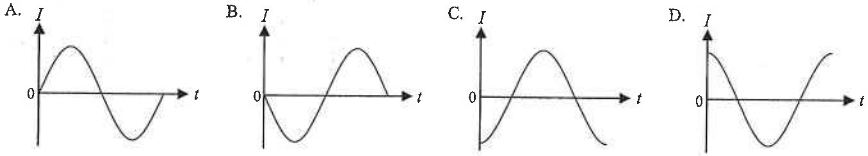
(1) When the switch is closed, a steady current flows through the ammeter.
(2) At the moment the switch is opened, a current flows through the ammeter momentarily.
(3) If the soft iron rod is replaced by a glass rod, the ammeter will have a greater deflection at the moment the switch is opened.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

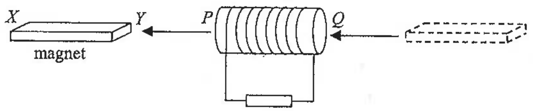
34. **< HKCE 2009 Paper II - 40 >**



The figure above shows the position of the coil in a generator at time $t = 0$. The current is taken to be positive when it flows from P to Q through the load. Which of the following graphs best represents the variation of current I with time t as the coil rotates ?



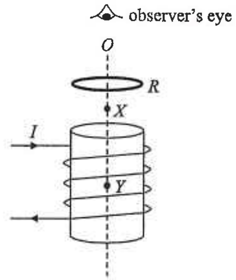
35. **< HKCE 2009 Paper II - 39 >**



When a magnet is moving towards end Q for a solenoid, it is found that a north pole is induced at end Q. As shown in the figure above, the magnet passes through and moves away from the solenoid, what are the polarities of end P of the solenoid and end X of the magnet ?

	polarity of end P	polarity of end X
A.	S	S
B.	S	N
C.	N	S
D.	N	N

36. **< HKCE 2010 Paper II - 42 >**



A copper ring R is falling through a solenoid along the axis as shown. The plane of the ring is kept horizontal throughout. The solenoid is carrying a steady current I. Y is the centre of the solenoid.

Which of the following combinations about the directions of the induced current in the ring (if any) at X and at Y as observed from O is correct ?

	at X	at Y
A.	clockwise	clockwise
B.	clockwise	no current
C.	anticlockwise	anticlockwise
D.	anticlockwise	no current

37. **< HKCE 2011 Paper II - 44 >**

A metal rod PQ is moving with a uniform speed v on a metal rail placed in a uniform magnetic field as shown in the figure above. A resistor is connected across RS. Which of the following descriptions is/are correct ?

(1) Kinetic energy of the rod is converted into electrical energy.
(2) Current flows through the resistor from S to R.
(3) The induced current will be reversed if the rod moves in the opposite direction.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

Part B : HKAL examination questions

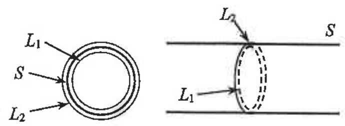
38. **< HKAL 1980 Paper I - 23 >**

The magnetic flux through a coil of N turns increases at a uniform rate from zero to Φ in time t. What is the magnitude of the e.m.f. induced in the coil ?

A. $N\Phi t$
B. $\Phi t / N$
C. $N\Phi / t$
D. $N t / \Phi$

$\frac{N\Phi}{t}$

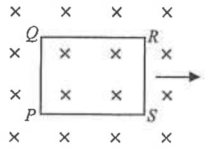
39. **< HKAL 1982 Paper I - 25 >**



S is a long solenoid. L_1 is a wire loop just inside the solenoid, and L_2 is a wire loop just outside the solenoid. The current in the solenoid is increased at a steady rate, such that the e.m.f. induced in L_1 is 1.2 V. Find the e.m.f. induced in L_2.

A. 0 V.
B. 0.6 V.
C. 1.2 V.
D. 2.4 V.

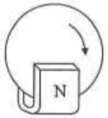
40. **< HKAL 1983 Paper I - 21 >**



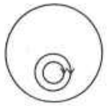
Rectangular coil $PQRS$ is driven with constant velocity towards the right in a uniform magnetic field directed perpendicular into paper as shown in the figure. Which of the following statements is correct at the instant shown in the figure ?

A. The magnitude of the magnetic flux through the coil changes with time.
B. An induced current is flowing in the coil in the anticlockwise direction.
C. An electromagnetic force acts on the side PQ in a direction opposing its motion.
D. There is no induced current flowing in the coil.

41. **< HKAL 1984 Paper I - 27 >**



A large copper disc mounted on a horizontal axle is spun in the clockwise direction between the poles of a horseshoe magnet. Which of the following diagrams correctly shows the eddy currents flowing in the disc ?

A. 
B. 
C. 
D. 

42. **< HKAL 1984 Paper I - 22 >**

A solenoid has a length of 0.30 m and cross-sectional area of 3.2×10^{-4} m^2. There are 1000 turns of wire wound on it. When the solenoid carries a current of 1.5 A, the magnetic flux through the solenoid is

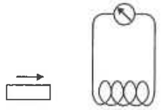
A. 6.0×10^{-7} Wb.
B. 2.0×10^{-6} Wb.
C. 5.7×10^{-4} Wb.
D. 2.0×10^{-3} Wb.

43. **< HKAL 1984 Paper I - 23 >**

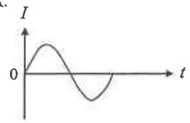
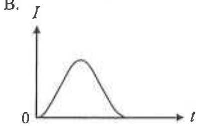
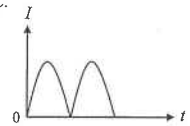
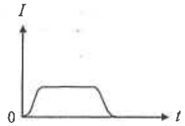
A sinusoidal voltage is generated by an a.c. generator. If the speed of rotation of the coil is increased, what will happen to the frequency and the peak voltage generated ?

	frequency	**peak voltage**
A.	increase	no change
B.	no change	increase
C.	increase	decrease
D.	increase	increase

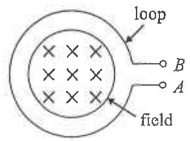
44. **< HKAL 1986 Paper I - 37 >**



A short bar magnet moving with uniform velocity passes through an air-cored solenoid of connected to a galvanometer as shown. Which of the following graphs best represents the variation of the current I in the solenoid with time t ?

A. 
B. 
C. 
D. 

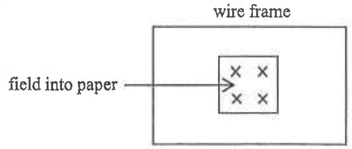
45. **< HKAL 1987 Paper I - 38 >**



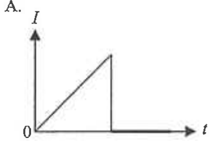
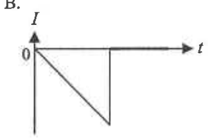
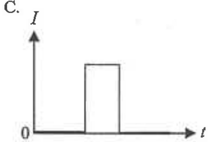
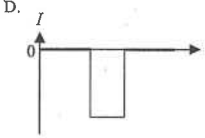
A uniform magnetic field acting perpendicular into paper is inside a circular region of radius 8 cm. A circular loop of radius 10 cm is placed outside the field region as shown in the figure. If the magnetic field is now decreasing at a constant rate of 0.01 T s^{-1}, what will be the magnitude and direction of the induced e.m.f. in the loop ?

	Magnitude	**Direction**
A.	2.0×10^{-4} V	from A to B via the loop
B.	2.0×10^{-4} V	from B to A via the loop
C.	3.1×10^{-4} V	from A to B via the loop
D.	3.1×10^{-4} V	from B to A via the loop

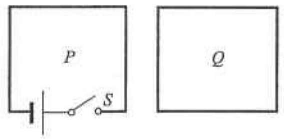
46. **< HKAL 1988 Paper I - 42 >**



A rectangular wire frame is placed outside a uniform magnetic field which is confined to a square region as shown in the figure. The direction of the magnetic field is perpendicular into paper. If the wire frame moves to the right with a uniform velocity, which of the graphs below best represents the variation of the induced current I with time t ?
(The anti-clockwise direction of the current is taken as positive.)

A. 
B. 
C. 
D. 

47. **< HKAL 1989 Paper I - 36 >**



Two rectangular wire loops P and Q are placed in the same plane side by side. Loop P includes a battery and a switch S, which is initially open. If S is suddenly closed, what is the direction of the induced current in loop Q ? Are the magnetic forces between the two loops attractive or repulsive ?

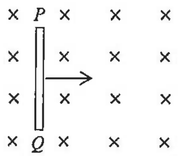
	Direction of induced current	**Nature of force**
A.	clockwise	attractive
B.	clockwise	repulsive
C.	anticlockwise	attractive
D.	anticlockwise	repulsive

48. **< HKAL 1989 Paper I - 35 >**

A certain length of a copper wire is bent to form a circular coil of one turn. The coil is then placed in a uniform magnetic field with its plane normal to the direction of the magnetic field. The flux linkage through the coil is Φ. The same length of wire is now bent to form a double loop of smaller radius. The flux linkage through the coil would become

A. $\Phi/4$.
B. $\Phi/2$.
C. Φ.
D. 2Φ.

49. **< HKAL 1992 Paper I - 38 >**

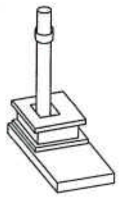


A metal rod PQ moves with constant velocity across a uniform magnetic field directed perpendicularly into paper as shown in the above figure. A voltage is induced across the rod. Which of the following statements is/are correct ?

(1) The magnitude of the voltage depends on the length of the rod.
(2) Point P is at a lower potential than Q.
(3) A magnetic force is acting on the rod to oppose its motion.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

50. **< HKAL 1992 Paper I - 40 >**



An aluminium ring floats above a coil carrying alternating current. Which of the following will affect the height of the ring ?

(1) the resistivity of the ring
(2) the density of the ring
(3) the frequency of the alternating current

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

51. **< HKAL 1994 Paper IIA - 37 >**

The magnetic flux linkage for a coil placed in a uniform magnetic field depends on

(1) the resistance of the coil
(2) the number of turns of the coil
(3) the angle between the normal of the coil and the direction of the magnetic field

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

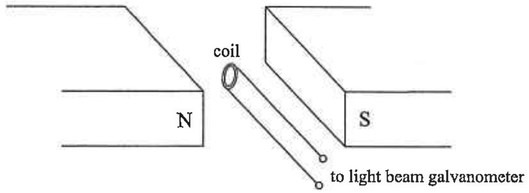
52. **< HKAL 1995 Paper IIA - 35 >**

A bar magnet is moved perpendicularly towards a copper disc. Which of the following statements are correct ?

(1) Eddy current is induced in the copper disc.
(2) Temperature of the copper disc increases.
(3) A repulsive force is experienced by the magnet.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

53. **< HKAL 1997 Paper IIA - 23 >**

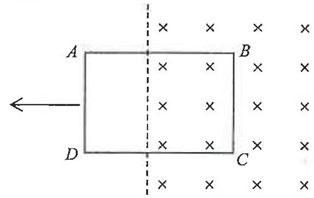


The above figure shows a small coil, connected to a light beam galvanometer, placed in a region of uniform magnetic field between the poles of a magnet. The plane of the coil is parallel to the pole faces. Which of the following actions would produce a deflection of the galvanometer ?

(1) Moving the coil to and fro between the poles.
(2) Moving the coil away from the region between the pole faces.
(3) Rotating the coil about a diameter through an angle of 180°.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

54. **< HKAL 1997 Paper IIA - 31 >**



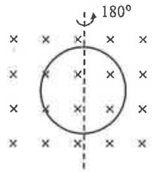
A rectangular metal wire frame $ABCD$ moves to the left with a uniform speed across a region of uniform magnetic field acting perpendicularly into paper. Which of the following is/are true at the instant shown in the figure ?

(1) A current is flowing in the clockwise direction.
(2) The electric potential at B is higher than that at C.
(3) The side AD experiences a magnetic force acting to the right.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

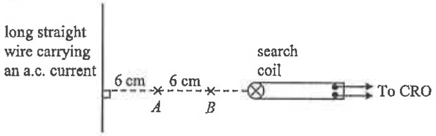
55. **< HKAL 1999 Paper IIA - 36 >**

A coil of metal wire is placed on a plane perpendicular to a uniform magnetic field. The coil is rotated through 180° about a diameter as shown. The induced e.m.f. in the coil is **independent** of



A. the area of the coil.
B. the flux density of the magnetic field.
C. the number of turns of the coil.
D. the resistance of the coil.

56. **< HKAL 1999 Paper IIA - 30 >**

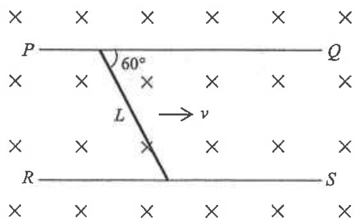


A long straight wire carrying an a.c. current lies on the plane of the paper as shown. A search coil connected to a CRO with the time-base off is used to measure the peak value of the magnetic field produced by the a.c. current. When the search coil is placed at B, the length of the trace on the CRO is 2 cm. If the search coil is placed at A, the length of the trace would be

A. 0.5 cm.
B. 1 cm.
C. 2 cm.
D. 4 cm.

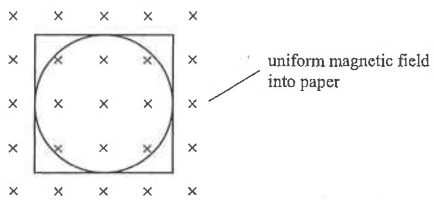
57. **< HKAL 2002 Paper IIA - 27 >**

A metal wire of length L is inclined at angle 60° to rail PQ as shown. It is moved rightwards with a uniform velocity v across a uniform magnetic field directed into paper along the two horizontal rails PQ and RS. The strength of the magnetic field is B. What is the e.m.f. induced in the rod ?



A. $\dfrac{BvL}{2}$
B. BvL
C. $\dfrac{2BvL}{\sqrt{3}}$
D. $\dfrac{\sqrt{3}BvL}{2}$

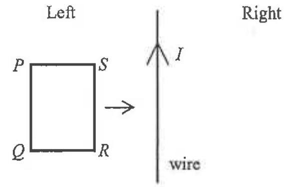
58. **< HKAL 2002 Paper IIA - 28 >**



A circular frame and a square frame, made from the same type of metal wires, are placed in a uniform magnetic field as shown. The length of each side of the square is equal to the diameter of the circle. When the flux density of the magnetic field is increased at a steady rate, find the ratio of the induced current in the circular frame to that in square frame.

A. 1 : 1
B. 1 : π
C. π : 4
D. 2 : π

59. **< HKAL 2003 Paper IIA - 34 >**

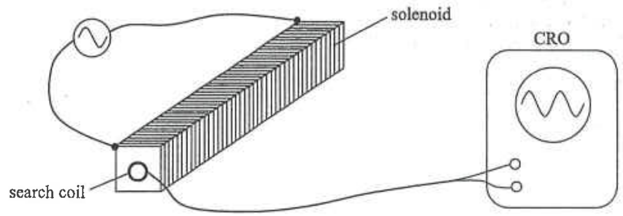


The figure shows a rectangular metal coil $PQRS$ moving from left to right with a uniform speed across an insulated metal wire carrying a steady current I. Which of the following gives the correct sequence for the direction of the current induced in the coil $PQRS$?

A. Clockwise and then anticlockwise
B. Anticlockwise and then clockwise
C. Clockwise, then anticlockwise and finally clockwise again
D. Anticlockwise, then clockwise and finally anticlockwise again

60. **< HKAL 2004 Paper IIA - 28 >**

A search coil is placed at one end of a solenoid as shown in the figure. The solenoid is connected to an a.c. source so that an a.c. current is flowing in the solenoid. The induced voltage on the search coil is shown on the CRO connected to the search coil.

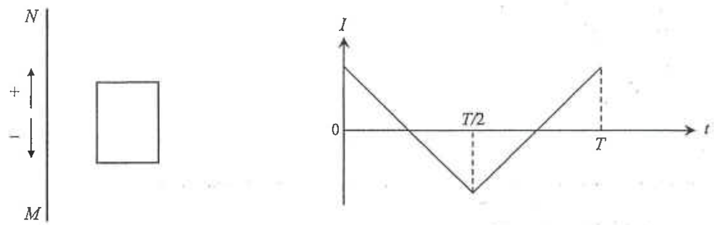


Which of the following changes will **NOT** affect the amplitude of the induced voltage in the search coil ?

A. Increase the frequency of the a.c. current in the solenoid.
B. Increase the number of turns on the search coil.
C. Place the search coil in the middle of solenoid, without changing its orientation.
D. Replace the solenoid with one of greater cross-sectional area while keeping the same magnitude of a.c. current.

61. **< HKAL 2005 Paper IIA - 19 >**

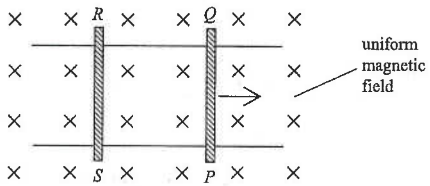
A rectangular coil is placed adjacent to a straight wire MN carrying a current I which varies with time t as shown in the graph. The wire MN is in the plane of the coil and the current I is positive (+) when it is in the direction from M to N.



Starting from $t = 0$, how does the direction of the current induced in the coil vary in one period ?

A. Clockwise first and then anticlockwise
B. Anticlockwise first and then clockwise
C. Clockwise → anticlockwise → clockwise → anticlockwise
D. Anticlockwise → clockwise → anticlockwise → clockwise

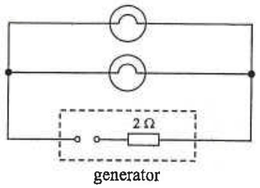
62. **< HKAL 2005 Paper IIA - 16 >**



Two conducting rods PQ and RS are placed on two smooth, parallel, horizontal conducting rails. A uniform magnetic field is directed into the plane of the paper as shown. If now rod PQ is given an initial velocity to the right, which of the following statements is **NOT** correct ?

A. The induced current is in the direction of $PQRS$.
B. The magnetic force acting on the rod PQ is towards the left.
C. Rod RS starts moving towards the right.
D. Rod PQ would keep on moving with a uniform speed.

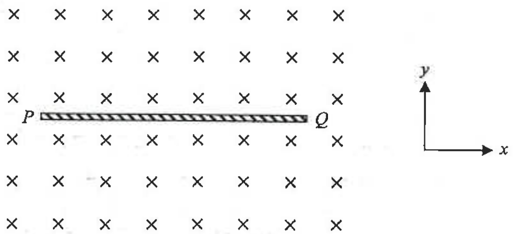
63. **< HKAL 2005 Paper IIA - 17 >**



Two '12 V, 6 W' lamps are operating at their rated values. The internal resistance of the generator is 2 Ω. What is the percentage of the electrical power generated by the generator dissipated by the two lamps ?

A. 75%
B. 86%
C. 92%
D. 100%

64. **< HKAL 2006 Paper IIA - 19 >**

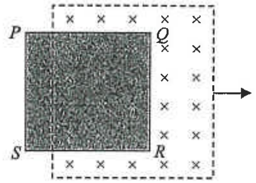


In the figure, a thin metal rod PQ is placed along the x-direction and it is at right angles to a uniform magnetic field pointing into the plane of the paper. In which of the following cases will there be an e.m.f. induced along the length of the metal rod ?

(1) Rotating the rod about an axis through its centre along the y-direction
(2) Moving the rod in the x-direction
(3) Moving the rod in the y-direction

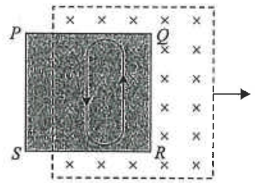
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

65. **< HKAL 2008 Paper IIA - 18 >**

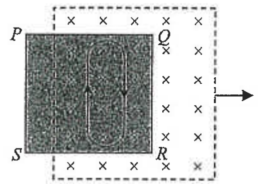


In the figure, $PQRS$ is a metal plate placed perpendicularly to a uniform magnetic field directed into the paper. At the instant shown, the magnetic field is moving to the right and eddy current is induced in the metal plate. Which of the following diagrams best represents a possible path of the eddy current induced in the plate ?

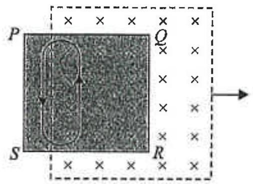
A.



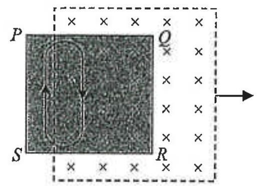
B.



C.

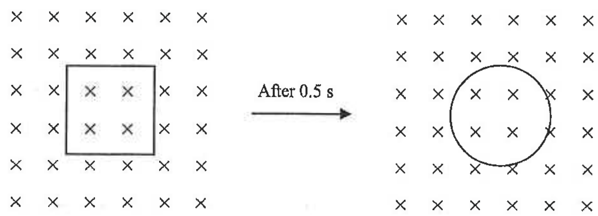


D.



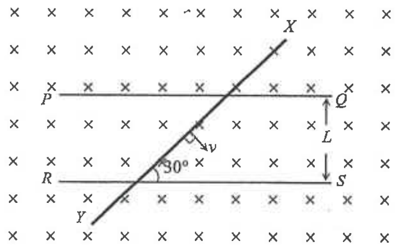
66. **< HKAL 2009 Paper IIA - 32 >**

A metal wire in shape of a square with each side 15.7 cm is placed in a uniform magnetic field of 0.6 T directed into the paper as shown. Suppose its shape is now changed into a circle within a time of 0.5 s. Find the average induced e.m.f. and the direction of the induced current in the frame during this period.



	average induced e.m.f. / mV	direction of the induced current
A.	8.1	clockwise
B.	8.1	anticlockwise
C.	4.0	clockwise
D.	4.0	anticlockwise

67. **< HKAL 2010 Paper IIA - 26 >**



In the figure, PQ and RS are two parallel metal rails with separation L. A metal rod XY resting on the rails moves with velocity v perpendicular to its length across a uniform magnetic field B pointing into the paper. If the rod makes an angle of 30° with the rails, what is the potential difference across Q and S ?

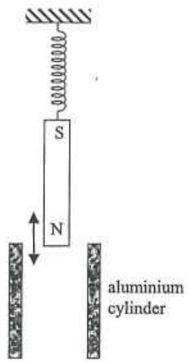
A. $\dfrac{BLv}{\cos 30°}$

B. $BLv \cos 30°$

C. $\dfrac{BLv}{\sin 30°}$

D. $BLv \sin 30°$

68. **< HKAL 2009 Paper IIA - 12 >**



A bar magnet is suspended by a spring from a rigid support. It is oscillating above a hollow aluminium cylinder placed below its lower end. Which of the following statements is/are correct ?
(Neglect air resistance.)

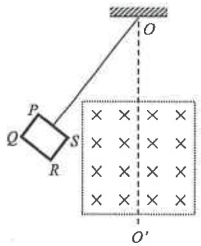
(1) The amplitude of oscillation of the magnet remains unchanged.

(2) The force between the bar magnet and the aluminium cylinder is always attractive.

(3) Eddy currents are induced in the aluminium cylinder.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

69. **< HKAL 2010 Paper IIA - 30 >**

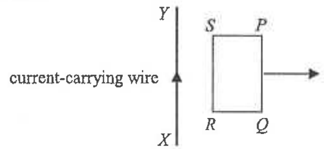


In the above figure, $PQRS$ is a small rectangular metal frame suspended from a fixed point O by a plastic string. The frame is released from the position shown and it swings across a uniform magnetic field pointing into the paper within the dotted rectangle. Neglect air resistance and friction. Which of the following is/are correct ?

(1) A current is induced in the frame in the direction $PQRSP$ when it is entering the field.
(2) The current induced in the frame is at a maximum when it passes OO'.
(3) The direction of the magnetic force experienced by the frame is opposite to its motion when it passes OO'.

A. (1) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

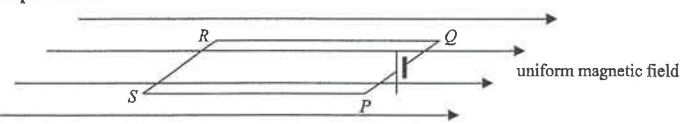
70. **< HKAL 2011 Paper IIA - 27 >**



A long straight wire XY carrying a steady current lies in the plane of the coil. A rectangular coil $PQRS$ is moving to the right with constant speed. Which of the following gives the correct direction of the induced current in the coil and the resultant magnetic force acting on the coil at the instant shown in the above figure ?

	direction of induced current in the coil	resultant magnetic force acting on the coil
A.	anti-clockwise	to left
B.	anti-clockwise	zero
C.	clockwise	to left
D.	clockwise	zero

71. **< HKAL 2011 Paper IIA - 31 >**



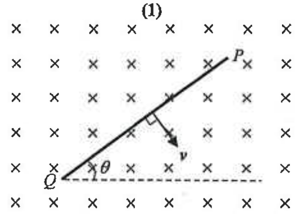
A rigid rectangular conducting loop $PQRS$ is connected to a cell as shown. It is held at rest horizontally within a uniform magnetic field which is parallel to the plane of the loop and perpendicular to its side RS. Which of the following statements is/are correct ?

(1) The side RS of the loop experiences an upward magnetic force.
(2) The loop experiences a turning moment due to the magnetic field.
(3) The magnetic flux linkage through the loop is zero.

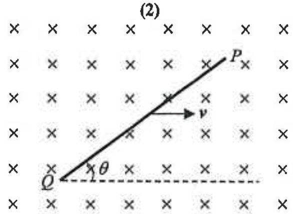
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

72. **< HKAL 2012 Paper IIA - 24 >**

(1)



(2)



In the above figures, a metal rod PQ making an angle θ with the horizontal moves with speed v across a uniform magnetic field pointing into the paper in two different directions shown. What is the ratio of the e.m.f. induced across the rod in Figure (1) to that in Figure (2) ?

A. $1 : \sin\theta$

B. $1 : \sin^2\theta$

C. $\sin\theta : 1$

D. $\sin^2\theta : 1$

Part C : Supplemental exercise

73. A solenoid has a length of 0.30 m and cross-sectional area of 3.2×10^{-4} m^2. There are 1000 turns of wire wound on it. When the solenoid carries a current of 1.5 A, the magnetic flux linkage through the solenoid is

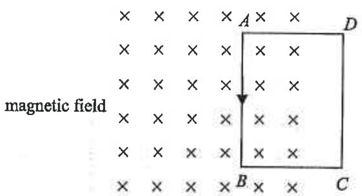
A. 6.0×10^{-7} Wb.

B. 2.0×10^{-6} Wb.

C. 5.7×10^{-4} Wb.

D. 2.0×10^{-3} Wb.

74.



A rectangular coil $ABCD$ is placed in a uniform magnetic field directed perpendicular into paper. When the coil is set into motion, an induced current flows from A to B as shown. Which of the following statements are correct ?

(1) The coil is moving towards the left.

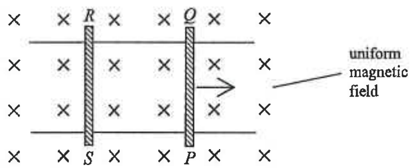
(2) The electric potential at A is higher than that at B.

(3) There is a magnetic force acting on AB towards the right.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

Part D : HKDSE examination questions

75. **< HKDSE Sample Paper IA - 31 >**



The figure shows conducting rods PQ and RS are placed on two smooth, parallel, horizontal conducting rails. A uniform magnetic field is directed into the plane of the paper as shown. PQ is given an initial velocity to the right and left to roll. Which statement is **INCORRECT** ?

A. The induced current is in the direction $PQRS$.

B. The magnetic force acting on the rod PQ is towards the left.

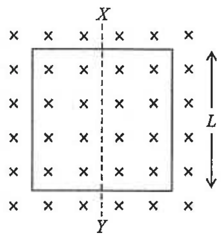
C. Rod RS starts moving towards the right.

D. Rod PQ moves with a uniform speed.

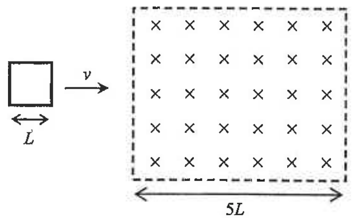
76. **< HKDSE Practice Paper IA - 33 >**

A square metal frame of side length L is placed inside a uniform magnetic field B as shown. What is the change in magnetic flux through the frame when it is rotated about the axis XY by 90° and 180° respectively ?

	90°	**180°**
A.	0	0
B.	0	$2BL^2$
C.	BL^2	0
D.	BL^2	$2BL^2$



77. **< HKDSE 2012 Paper IA - 31 >**



A square metal frame of length of side L moving with constant velocity v passes through a region of uniform magnetic field of width $5L$ as shown. What is the total time period during which a current is induced in the frame ?

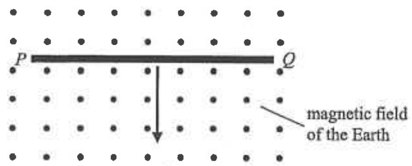
A. $\frac{L}{v}$

B. $\frac{2L}{v}$

C. $\frac{3L}{v}$

D. $\frac{4L}{v}$

78. < HKDSE 2012 Paper IA - 32 >



A copper rod PQ is placed horizontally as shown below. It is released and then falls vertically, cutting across the magnetic field of the Earth pointing out of the paper. Neglect air resistance. Which of the following statements is/are correct ?

(1) A voltage is induced across PQ.

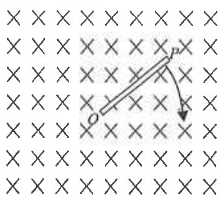
(2) A steady induced current is generated in the rod.

(3) Due to the effect of the Earth's magnetic field, the copper rod falls with an acceleration less than the acceleration due to gravity.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

79. < HKDSE 2013 Paper IA - 29 >

A metal rod OP is rotated about O in a clockwise direction in the plane of the paper with a uniform magnetic field pointing into the paper. Which statement is correct ?



A. An induced current flows in the rod from O to P.

B. An induced current flows in the rod from P to O.

C. E.m.f. is induced in the rod with end O at a higher electric potential.

D. E.m.f. is induced in the rod with end P at a higher electric potential.

80. < HKDSE 2014 Paper IA - 27 >

Figure (a)

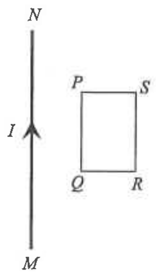
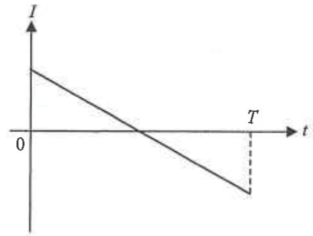


Figure (b)



A long straight current-carrying wire MN and a rectangular coil $PQRS$ are fixed in the same plane as shown in Figure (a). The current I is taken as positive when it flows from M to N and it varies with time t as shown in Figure (b). The direction of the induced current in the coil during the time interval $0 - T$ is

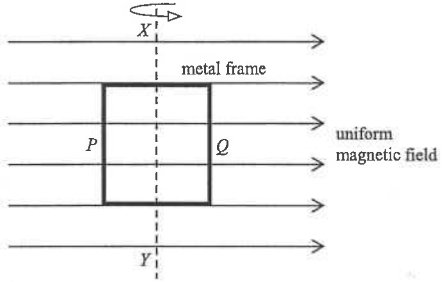
A. first anti-clockwise and then clockwise.

B. first clockwise and then anti-clockwise.

C. anti-clockwise throughout.

D. clockwise throughout.

81. < HKDSE 2015 Paper IA - 24 >



A rectangular metal frame is made to rotate steadily about its axis XY in a uniform magnetic field. At the instant shown, the frame is in the plane of the paper and side P is moving out of the paper while side Q is moving into the paper. Which statement is **INCORRECT** at this instant ?

A. The induced e.m.f. in the frame is at a maximum.

B. The induced current produced in the frame is flowing in anti-clockwise direction.

C. The magnetic force acting on side P is in a direction pointing into the paper.

D. The magnetic forces acting on the frame produce a moment opposing the frame's rotation.

82. < HKDSE 2016 Paper IA - 29 >

A student uses a search coil to study the strength of the magnetic field inside a long solenoid which is connected to an a.c. signal generator set at a certain frequency. The search coil is connected to a CRO with time-base switched off. When the magnetic field is detected, a vertical trace on the CRO is displayed. Which of the following can improve the accuracy of this experiment ?

(1) Rotate the plane of the search coil until the length of the vertical trace on the CRO is the maximum.

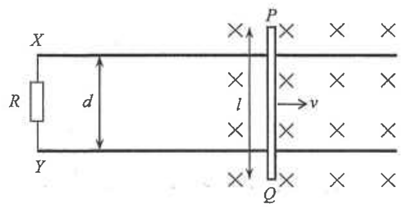
(2) Increase the signal generator's frequency and use the same current as before.

(3) Set the axis of the solenoid along an east-west direction to avoid the effects of the Earth's magnetic field.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

83. < HKDSE 2017 Paper IA - 28 >

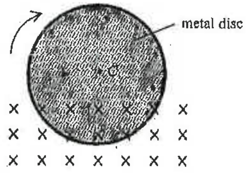
A metal rod PQ of length l is moving along smooth horizontal metal rails X and Y with constant speed v in a uniform magnetic field of magnetic field strength B pointing into the paper. The metal rails X and Y are separated by a distance of d and are connected to a resistor of resistance R as shown. Which of the following descriptions about the induced current is correct ?



	magnitude	direction
A.	$\frac{Blv}{R}$	from X to Y through R
B.	$\frac{Blv}{R}$	from Y to X through R
C.	$\frac{Bdv}{R}$	from X to Y through R
D.	$\frac{Bdv}{R}$	from Y to X through R

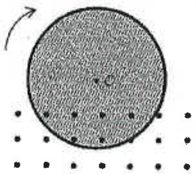
84. **< HKDSE 2017 Paper IA - 27 >**

A metal disc is rotating about its centre *C* with constant speed. Part of the metal disc is inside a uniform magnetic field pointing into the paper as shown. An eddy current flows in the metal disc.

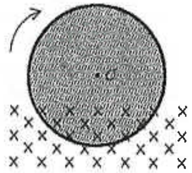


After which of the following changes will the eddy current increase ?

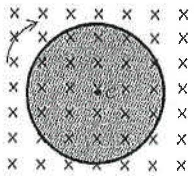
A. Reverse the direction of the magnetic field



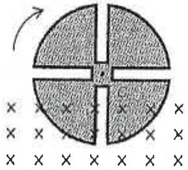
B. Increase the strength of the magnetic field



C. Apply the magnetic field over the whole metal disc

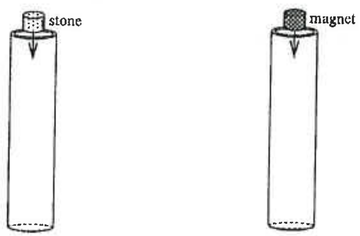


D. Cut several slits from the metal disc



85. **< HKDSE 2018 Paper IA - 29 >**

A stone and a strong magnet of the same size and shape are released from rest into a hollow aluminium tubing respectively. Which of the following is correct ? Neglect air resistance.



	drops slower	reason
A.	stone	the stone is more massive
B.	magnet	the stone is more massive
C.	stone	the magnet induces eddy current in the aluminium tubing
D.	magnet	the magnet induces eddy current in the aluminium tubing

There is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. D	11. B	21. D	31. D	41. D	51. D
2. D	12. D	22. C	32. C	42. B	52. D
3. A	13. A	23. A	33. B	43. D	53. D
4. D	14. D	24. C	34. D	44. A	54. A
5. B	15. A	25. C	35. D	45. A	55. D
6. B	16. B	26. A	36. D	46. D	56. D
7. B	17. D	27. A	37. D	47. D	57. D
8. C	18. A	28. A	38. C	48. B	58. A
9. B	19. B	29. D	39. C	49. A	59. C
10. C	20. C	30. B	40. D	50. D	60. D

61. A	71. D	81. B
62. D	72. A	82. A
63. B	73. D	83. C
64. B	74. B	84. B
65. D	75. D	85. D
66. B	76. D	**86. D**
67. C	77. B	**87. D**
68. B	78. A	
69. A	79. D	
70. C	80. D	

M.C. Solution

1. D

× (1) Since commutator is used, it is a d.c. generator, thus the current always flows in the same direction.

✓ (2) The maximum current depends on the induced voltage which depends on the rotational speed of the coil.

✓ (3) By $I = \frac{V}{R}$, maximum magnitude of current depends on the resistance of *R*.

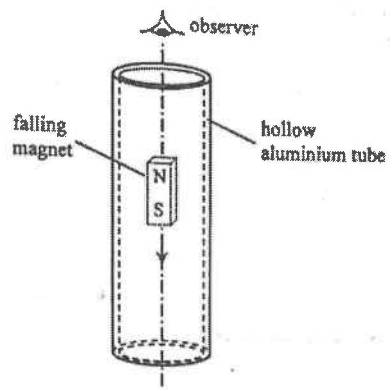
2. D

There is no magnetic flux passing through the coil,

thus there is no induced current in the coil.

86. <HKDSE 2019 Paper IA-28>

87. <HKDSE 2020 Paper IA-28>



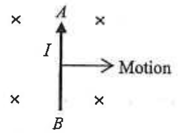
When a small strong magnet falls through a hollow aluminium tube as shown, eddy currents are induced. Which of the following correctly describes the direction of current induced in the tube when viewed by an observer from above ?

A. clockwise both above and below the magnet
B. anti-clockwise both above and below the magnet
C. clockwise above the magnet and anti-clockwise below the magnet
D. anti-clockwise above the magnet and clockwise below the magnet

3. A

Dynamo (generator) changes the mechanical energy of the rotating coil into electrical energy of induced current.

4. D



× (1) By Right-hand rule, current should flow from D to C through P.

✓ (2) By Right-hand rule, induced current flows from B to A through Q.

✓ (3) By Faraday's Law, induced voltage (e.m.f.) is set up across AB where $\varepsilon = B\,v\,l$.

5. B

When the switch S is closed, current starts to flow in the solenoid
which produces a magnetic field with N-pole at the left hand side.

An induced current would then flow in coil XY to oppose the change such that the pole at Y is North.

The two solenoids thus experience opposing magnetic forces so the coil would move away from the solenoid.

6. B

Peak voltage : $V_p = 0.5\ \text{V cm}^{-1} \times 3\ \text{cm} = 1.5\ \text{V}$

Period : $T = 1\ \text{ms cm}^{-1} \times 4\ \text{cm} = 4\ \text{ms}$

Frequency : $f = \dfrac{1}{T} = \dfrac{1}{4\times10^{-3}} = 250\ \text{Hz}$

7. B

Figure (1) : As the N-pole of magnet moves towards the ring, N-pole is induced at the upper end of the ring, thus the induced current is in anticlockwise direction observed by the eye.

Figure (2) : As the magnet is inside the ring, there is no change of magnetic field, thus there is no induced current.

Figure (3) : As the S-pole of magnet moves away from the ring, N-pole is induced at the lower end of the ring, thus the induced current is in clockwise direction.

8. C

In Figure 1, as the S-pole of magnet moves towards the coil (solenoid) from the left,
the left side of the coil is induced to be S-pole,
and the induced current flows through the galvanometer and deflects to the left.

In Figure 2, as the N-pole of magnet moves towards the coil (solenoid) from the right,
the right side of the coil is induced to be N-pole, that means the left side of the coil is induced to be S-pole,
thus the induced current flows in the same direction as Figure 1,
and as the magnet moves at a faster rate, the induced current is greater and is more than 10 μA.

9. B

Peak voltage : $V_o = 2\ \text{cm} \times 10\ \text{V cm}^{-1} = 20\ \text{V}$

Peak current : $I_o = \dfrac{V_o}{R} = \dfrac{20}{5\times10^3} = 4\ \text{mA}$

10. C

✓ (1) When S is closed, current flows in primary coil to give magnetic field lines directed towards the right.
Current is induced in secondary coil from P to Q through R
to give magnetic field lines directed towards the left to oppose the change.

✓ (2) When S remains closed, there is no change of current, thus there is no change of magnetic field,
therefore, no current is induced in the secondary coil.

× (3) When S is opened, current stops flowing in the primary coil and the magnetic field decreases to zero.
Current is induced in the secondary coil from Q to P through R
to give magnetic field lines directed towards the right to oppose the change.

11. B

As commutator is used, it is a d.c. generator,

d.c. generator gives a varying d.c. voltage (unsteady voltage) as shown in option B.

12. D

× (1) A d.c. generator is a d.c. source but it produces varying d.c. voltages.

✓ (2) All a.c. sources would give out current with changing directions.

✓ (3) Both d.c. and a.c. give heating effect by $P = I^2 R$.

13. A

At the time shown, when N-pole of the magnet moves away from the right hand side of the core,
S-pole is induced on the right hand side of the core, thus induced current flows from P to Q through R.

After half of a cycle, when N-pole of the magnet moves away from the left hand side of the core,
S-pole is induced on the left hand side of the core, thus induced current flows from Q to P through R in reverse direction.

14. D

× A. microphone : sound energy → electrical energy

× B. loudspeaker : electrical energy → sound energy

× C. dynamo : mechanical energy → electrical energy

✓ D. motor : electrical energy → mechanical energy

15. A

As the trace of the signal is a line, it is an a.c. voltage.

Peak voltage : $V_o = 1\ \text{cm} \times 1\ \text{V cm}^{-1} = 1\ \text{V}$

16. B

Peak voltage = 2 cm × 0.5 V cm^{-1} = 1 V

Period : T = 4 cm × 10 ms cm^{-1} = 40 ms

Frequency : $f = \frac{1}{T} = \frac{1}{40\times10^{-3}}$ = 25 Hz

17. D

✓ A. A bicycle dynamo gives induced voltage, which is an application of electromagnetic induction.

✓ B. When a magnetic tape moves across a playback head, a.c. current is induced.

✓ C. When sound wave is incident onto a microphone, the coil is set into vibration inside a magnetic field, thus a.c. current is induced.

× D. Loudspeaker makes use of the magnetic force produced by the current inside a magnetic field.

18. A

When R moves towards P, the resistance of RQ increases,

thus voltage increases, amplitude of the trace increases.

Period (or frequency) depends on the a.c. source, thus it remains unchanged.

19. B

When the ring moves towards the magnet at X, current is induced so that the lower side of the ring is N-pole.

When the ring moves away from the magnet at Y, current is induced so that the upper side of the ring is N-pole.

By using Right hand grip rule, the induced current in both cases can be determined.

20. C

✓ (1) Rotating the coil at a greater speed can increase the rate of change of magnetic flux, thus induced voltage by the generator increases.

× (2) Reducing the resistance can increase the induced current, but the resistance would not affect the induced voltage.

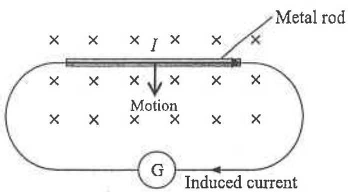
✓ (3) A coil of greater area contains more magnetic flux, thus the induced voltage increases.

21. D

The induced current in the metal rod flows from left to right.

In order to give this induced current,

the rod should move downwards, by using Right-hand rule.



22. C

× A. As they move away from each other, the left side of the solenoid should be induced in N-pole, thus induced current should flow from left to right through the galvanometer.

× B. As the solenoid moves away from the magnet, the left side of the solenoid should be induced in S-pole, thus induced current should flow from right to left through the galvanometer.

✓ C. As the solenoid moves towards the magnet, the left side of the solenoid should be induced with S-pole, thus induced current flows from right to left through the galvanometer.

× D. As the magnet moves towards the solenoid, the left side of the solenoid should be induced with N-pole, thus induced current should flow from left to right through the galvanometer.

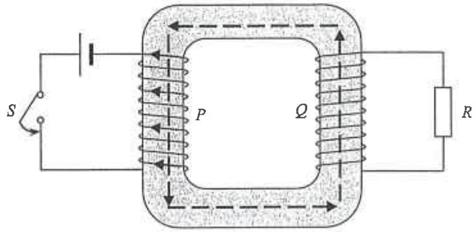
23. A

① When the magnet is approaching, an induced voltage is set up in the solenoid.

② When the magnet is inside the solenoid, no induced voltage is set up.

③ When the magnet is leaving, an induced voltage is set up in the solenoid but in the opposite direction.

24. C



When S is just closed, the current through coil P produces a magnetic field downwards and upwards through Q.

In order to oppose the change of magnetic field, coil Q induces a current which produces a magnetic field in opposite direction (downwards), thus by Right hand grip rule, the current through R is in upward direction.

When S is just opened, current through coil P suddenly stops flowing, thus the magnetic field through Q decreases.

In order to oppose the change of magnetic field, coil Q induces a current which produces a magnetic field in the same direction, thus the induced current should be opposite to that when S is closed.

25. C

When the coil just enters the field region, an induced current flows in anticlockwise direction (+).

When the coil moves inside the field region, there is no induced current.

When the coil just leaves the field region, an induced current flows in clockwise direction (–).

26. A

✓ (1) Since slip rings are used, alternating current is produced.

× (2) By Right-hand-rule, a current is induced in the coil and flows through the resistor from Q to P.

× (3) The current is maximum at the instant shown, but becomes zero when the coil is vertical.

27. A

Since the time base is 10 ms per cm and the time for one cycle is 10 cm

$\therefore$ period $T = 10 \text{ cm} \times 10 \text{ ms cm}^{-1} = 100 \text{ ms}$

$\therefore$ Frequency : $f = \dfrac{1}{T} = \dfrac{1}{100 \times 10^{-3}} = 10 \text{ Hz}$

The amplitude of the trace is 4 cm and the voltage gain is 0.5 V per cm

$\therefore$ Peak voltage $= 4 \text{ cm} \times 0.5 \text{ V cm}^{-1} = 2 \text{ V}$

28. A

✓ (1) By using Right hand rule, induced current flows along AB in anticlockwise direction.

× (2) There is no induced current in this position.

× (3) By using Right hand rule, induced current flows along DC in clockwise direction.

29. D

Since the bar magnet is moving towards the coil, induced current flows to oppose the change.
The top of the coil becomes South-pole due to the induced current.
Action and reaction pair then exists between the magnet and the coil.
For the magnet, an upward force acts on it by the coil.
For the coil, a downward force acts on it by the magnet.
The reading of the balance is then greater due to the downward force on the coil.

30. B

× (1) By Right hand rule, the induced current in the rod is from Q to P, thus current through the galvanometer is from R to Q.

× (2) If the magnetic field is reversed, the direction of the induced current would reverse. However, the opposing force is still towards the left, and the rod should still move in uniform speed.

✓ (3) Since the direction of the induced current is reversed, the pointer of the galvanometer should deflect to the opposite direction.

31. D

× (1) The current delivered to the load by a d.c. generator is an unsteady d.c., thus the current is not constant.

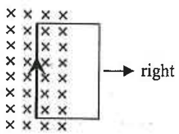
✓ (2) Due to the commutator, current delivered to the load is a d.c., i.e. the current flows in one direction only.

✓ (3) By use of the Right hand rule, the induced current in the coil is in anticlockwise direction, and thus the current flows from X to Y through the load.

32. C

By Right hand rule :
induced current flows upwards in the left wire.

By Left hand rule :
this current gives a magnetic force towards the left.



33. B

× (1) When the switch is closed, only a pulse of induced current flows momentarily through the ammeter.

✓ (2) At the moment the switch is opened, an induced current flows through the ammeter momentarily.

× (3) Since glass rod is not a magnetic material, the magnetic field will become weaker, thus the induced current should be smaller.

34. D

At this position, the magnetic field is pointing towards the left from N-pole to S-pole.

The left arm of the coil is moving upwards.

By using Right hand rule, the induced current in the left arm of the coil is flowing out of paper, and then from P to Q through the load, thus the current is positive and maximum at $t = 0$.

35. D

When the magnet is at the right side and moving towards the solenoid,
as N-pole is induced at Q, thus end X should be N-pole, as opposing forces should exist between them.
When the magnet is at the left side and moving away from the solenoid,
as end Y is S-pole which is leaving, end P should become N-pole as attraction forces should exist between them.

36. D

The top of the solenoid is S-pole and the bottom is N-pole, by Right hand screw rule.

As the ring moves towards the solenoid at X, by Lenz's law, to oppose the change,
a current is induced so that the bottom of the ring is S-pole, and by Right hand screw rule,
the induced current is in anticlockwise direction observed by the eye.

When the ring is at Y, as there is no change of magnetic field, thus no current is induced at Y.

37. D

× (1) Since the rod is moving with uniform speed, its kinetic energy remains unchanged.

✓ (2) By Right hand rule, the induced current flows from Q to P, then flows from S to R through the resistor.

✓ (3) If the rod moves to left, by Right hand rule, the induced current flows from P to Q through the rod.

38. C

$$\varepsilon = \frac{\Delta(N\Phi)}{\Delta t}$$

$$= \frac{N\Phi - 0}{t} = \frac{N\Phi}{t}$$

39. C

The magnetic flux through the coil L_2 is equal to the magnetic flux through the coil L_1,
as both of the contains the same number of magnetic field lines inside the solenoid.

Thus, both of them induce the same e.m.f. of 1.2 V.

40. D

An e.m.f. is induced from P to Q as PQ cuts the magnetic field lines.

Similarly, an e.m.f. is also induced from S to R as SR cut the magnetic field lines.

Since there is no net e.m.f. in the circuit, thus no induced current flows in the loop.

41. D

The magnetic field due to the magnet is perpendicularly into paper.

At the right hand side of the magnet, the disc moves from a region without field to a region with magnetic field, to oppose the change, eddy current is induced in anticlockwise direction to produce magnetic field out of paper.

At the left hand side of the magnet, the disc moves from a region with magnetic field out to a region without field, to oppose the change, eddy current is induced in clockwise direction to produce magnetic field into paper.

42. B

For a solenoid : $B = \dfrac{\mu_o N I}{\ell}$

Magnetic flux through the solenoid : $\Phi = B A$

$\therefore \ \Phi = B A = \dfrac{\mu_o N I}{\ell} \cdot A$

$= \dfrac{(4\pi \times 10^{-7})(1000)(1.5)}{(0.3)} \cdot (3.2 \times 10^{-4})$

$= 2.0 \times 10^{-6}$ Wb

43. D

① Frequency of the voltage is equal to the rotational frequency of the coil, thus the frequency increases.

② Peak voltage is proportional to the rotational speed of the coil, thus the amplitude increases.

44. A

When the bar magnet moves towards the solenoid, induced current in the coil is in one direction.

When the bar magnet moves away from the solenoid, induced current is in the opposite direction.

Only the graph in option A shows that the induced currents are in two directions, thus it is the answer.

45. A

Note that only the small loop contains magnetic field.

Thus, in calculating the magnetic flux : $\Phi = B A$, the area A should be the smaller loop.

By $\varepsilon = \dfrac{\Delta\Phi}{\Delta t} = A\dfrac{\Delta B}{\Delta t}$

$\therefore \ \varepsilon = [\, \pi \times (0.08)^2 \,] \times (0.01)$

$= 2.0 \times 10^{-4}$ V

As the magnetic field is decreasing, to oppose the change,

the induced current would produce a magnetic field in the same direction, that is, into paper,

thus, the induced current is in clockwise direction.

46. D

In the position shown, there is no cutting of magnetic field lines, thus no induced current.

As the frame moves, during the time interval that the left wire of the frame cuts across the magnetic field, current is induced upwards and flows in the frame in clockwise direction, which is negative, and since the frame moves with uniform velocity, the induced current is constant.

47. D

When the switch S is suddenly closed, current flows in loop P in anticlockwise direction.

As the current in the right wire of loop P is upwards, it then produces a magnetic field into paper at loop Q.

When loop Q suddenly experiences a magnetic field into paper, a current is induced in anticlockwise direction so as to produce a magnetic field out of paper to oppose the change.

As the current in the right wire of loop P is upwards and the current in the left wire of loop Q is downwards, repulsive force occurs between them as currents in opposite directions repel each other.

48. B

For the same length of wire forming the double loop : $2\pi r = 2(2\pi r')$ $\therefore \ r' = r/2$

The radius of the new loop is halved, thus the area of the new loop becomes one-quarter.

Flux linkage = $NBA \propto NA$

$\therefore$ As $N \to 2N$ and $A \to \frac{1}{4}A$, the flux linkage becomes $\frac{1}{2}\Phi$

49. A

✓ (1) $\varepsilon = \dfrac{\Delta\Phi}{\Delta t} = B \cdot \dfrac{\Delta A}{\Delta t} = B v L \propto L$

× (2) By Right-hand rule, induced e.m.f. is from Q to P, thus P is at a higher potential.

× (3) As the circuit is not complete, there is induced e.m.f. but no induced current, thus no magnetic force acts on the rod to oppose its motion.

50. D

✓ (1) If the resistivity of the ring is smaller, then the resistance of the ring is smaller, thus greater eddy current can be induced in the ring and the ring would float at a greater height.

✓ (2) If the density of the ring is smaller, then the mass or weight of the ring would be smaller, thus the same upward magnetic force due to eddy current would make the ring float at a greater height

✓ (3) If the frequency of the a.c. increases, then the rate of change of magnetic flux in the coil increases, thus greater eddy current is induced, and the ring would float at a greater height.

51. D

× (1) Resistance would not affect the flux linkage of a coil.

✓ (2) Flux linkage is proportional to the number of turns of the coil.

✓ (3) Since the magnetic flux through a coil depends on the component of the magnetic field through the coil, the angle would affect the flux linkage of the coil.

52. D

✓ (1) When the magnet moves towards copper, the copper experiences a change in magnetic field, thus eddy current is induced in the copper disc.

✓ (2) As eddy current is induced, the current produces a heating effect, thus temperature increases.

✓ (3) The eddy current flows in the direction to give a repulsive force to oppose the motion of the magnet.

53. D

× (1) It gives no change of magnetic flux through the coil, thus no e.m.f. is induced.

✓ (2) The flux through the coil changes to zero, thus e.m.f. is induced.

✓ (3) The flux through the coil changes, thus e.m.f. is induced.

54. A

✓ (1) By Right-hand rule, induced current flows from B to C, and then to D and A in clockwise direction.

× (2) The induced e.m.f. is from B to C, thus C is at a higher potential.

× (3) Side AD is not in the magnetic field, it experiences no magnetic force.

55. D

$$\varepsilon = N\frac{\Delta\Phi}{\Delta t} = \frac{NBA}{t}$$

$\therefore$ ε depends on N, B, A, t only

$\therefore$ ε is independent of the resistance of the coil.

56. D

For a search coil, the length L of the trace on the CRO is proportional to the peak induced voltage in the coil, which is proportional to the peak value of the varying magnetic field.

For a straight wire carrying current, magnetic field produced is :

$$B = \frac{\mu_o I}{2\pi r} \propto \frac{1}{r}$$

As the distance at A is halved that of B, the magnetic field at A is doubled that of B, thus the length of trace is doubled.

$$\therefore \quad L' = \left(\frac{12}{6}\right) \times 2 = 4 \text{ cm}$$

57. D

Since the component of v perpendicular to the wire is $v \sin 60°$

Induced e.m.f. :

$$\varepsilon = B\,(v \sin 60°)\,L = \frac{\sqrt{3}B\,v\,L}{2}$$

58. A

① $\varepsilon = A\dfrac{\Delta B}{\Delta t} \propto A$ ② $R = \dfrac{\rho \ell}{A} \propto \ell$

$$\therefore \quad I = \frac{\varepsilon}{R} \propto \frac{A}{\ell}$$

$$\therefore \quad \frac{I_C}{I_S} = \frac{A_C}{A_S}\cdot\frac{\ell_S}{\ell_C} = \frac{(\pi r^2)}{(2r)^2}\cdot\frac{(4\times 2r)}{(2\pi r)} = 1$$

59. C

① When the coil is at the left and moves to the right, the coil experiences an increase of magnetic flux out of paper. In order to oppose the change, a clockwise current is induced to produce a magnetic field into paper.

② When the coil is just above the wire, the coil experiences a change of magnetic flux from out of paper to into paper. In order to oppose the change, an anticlockwise current is induced to produce a magnetic field out of paper.

③ When the coil is at the right and moves to the right, the coil experiences an decrease of magnetic flux into paper. In order to oppose the change, a clockwise current is induced to produce a magnetic field into paper.

60. D

The secondary coil is a search coil which gives the peak voltage by $V_o = 2\pi f N B_o A$

✓ A. $f\uparrow \Rightarrow V_o\uparrow$

✓ B. $N\uparrow \Rightarrow V_o\uparrow$

✓ C. B-field in the middle of the solenoid is greater than B-field at the end. $\therefore$ $B_o\uparrow \Rightarrow V_o\uparrow$

× D. By $B = \mu_o n I$, B is independent of the area A $\therefore$ same $B \Rightarrow$ same V_o

61. A

From $t = 0$ to $T/4$, current flows from M to N and is decreasing, magnetic field through the loop is into paper and is decreasing. Thus, the induced current in the loop flows in clockwise direction to oppose the change.

From $t = T/4$ to $T/2$, current flows from N to M and is increasing, magnetic field through the loop is out of paper and is increasing. Thus, the induced current in the loop flows in clockwise direction to oppose the change.

From $t = T/2$ to $3T/4$, current flows from N to M and is decreasing, magnetic field through the loop is out of paper and is decreasing. Thus, the induced current in the loop flows in anticlockwise direction to oppose the change.

From $t = 3T/4$ to T, current flows from M to N and is increasing, magnetic field through the loop is into paper and is increasing. Thus, the induced current in the loop flows in anticlockwise direction to oppose the change.

62. D

✓ A. By Right-hand rule, induced current flows along PQ and in the anticlockwise direction.

✓ B. By Left-hand rule, magnetic force acting on PQ is towards the left.

✓ C. By Left-hand rule, there is magnetic force acting on RS towards the right.

× D. Due to the opposing magnetic force acting on PQ, the rod PQ would decelerate.

63. B

Total power consumed by the two lamps = 6 + 6 = 12 W

Current passing through each lamp = $\frac{6}{12}$ = 0.5 A

Power dissipated by the internal resistance of the generator = $I^2 r = (0.5+0.5)^2 (2) = 2$ W

Percentage of power dissipated by the lamps = $\frac{12}{12+2} \times 100\% = 85.7\% \approx 86\%$

64. B

× (1) There is no cutting of magnetic flux when the rod rotates about the axis along y.

× (2) By right-hand-rule, the induced e.m.f. is between the top and the bottom of the rod, not along the rod.

✓ (3) By right-hand-rule, there is an induced e.m.f. along the length of the rod.

65. D

When the field moves away, at the left hand side of the field, the metal there experiences the loss of the field.

To oppose the change, current is induced in clockwise direction to produce a magnetic field into paper.

The eddy current should be at the edge of the field, since the change occurs there.

66. B

The circumference of the square and the circle must be equal.

$\therefore$ $15.7 \times 4 = 2\pi r$ $\therefore$ $r = 10$ cm

Area of the square = $15.7 \times 15.7 = 246.5$ cm^2

Area of the circle = $\pi (10)^2 = 314$ cm^2

$$\varepsilon = \frac{\Delta\Phi}{\Delta t} = B\frac{\Delta A}{\Delta t} = (0.6)\frac{(314-246.5)\times 10^{-4}}{(0.5)} = 8.1\,\text{mV}$$

As the area is increased, the coil experiences an increase of flux into paper.

By Lenz's law, to oppose the change, the induced current acts to give a magnetic field out of paper.

Thus the induced current flows in anticlockwise direction.

67. C

Potential difference across Q and S = induced e.m.f. along the rod between QS

$= B\,v\,l = \frac{B\,v\,L}{\sin 30°}$ (l is the length of the rod)

68. B

× (1) As eddy current is induced in the aluminium cylinder,
the amplitude of oscillation of the magnet gradually decreases
due to the opposing force of the eddy current.

× (2) The force should act always to oppose motion, thus the force may be attractive or repulsive.

✓ (3) The change of magnetic flux experienced by the cylinder induces eddy current in it.

69. A

✓ (1) When the frame enters the field, to oppose the change,
the frame induces a current in anticlockwise direction to produce a magnetic field out of paper,
thus the induced current is in the direction $PQRSP$.

× (2) There is no induced current when it passes OO' as there is no change of magnetic flux.

× (3) As there is no induced current when it passes OO', there is no magnetic force acting on the frame.

70. C

Direction of magnetic field due to the current along XY is into the paper by Right hand grip rule.

As the coil moves away, the strength of B gradually decreases and thus the flux also decreases.

To oppose the change, the coil induces a current in **clockwise** direction to produce a flux into the paper.

Since the induced current along RS is upwards, the magnetic force between XY and RS is attractive,

thus the magnetic force on the coil is **to left**.

71. D

× (1) The current is from S to R, by Left hand rule, the magnetic force should be downwards.

✓ (2) Magnetic force on RS is downwards and force on PQ is upwards, they form a couple to give a moment.

✓ (3) There is no magnetic field lines passing perpendicularly through the loop, thus the flux is zero.

72. A

Figure 1 : $\varepsilon = B\,v\,L$ Figure 2 : $\varepsilon = B\,(v \sin\theta)\,L$

$\therefore$ Ratio = 1 : $\sin\theta$

73. D

$$N\Phi = NBA = N\frac{\mu_o N I}{\ell}\cdot A = (1000)\times\frac{(4\pi\times10^{-7})(1000)(1.5)}{(0.3)}\cdot(3.2\times10^{-4}) = 2.0\times10^{-3}\text{ Wb}$$

74. B

✓ (1) By Right hand rule, B is into paper, I is downwards, thus, motion is leftwards.

× (2) By Right hand rule, induced e.m.f. is downwards from low to high potential.
Thus, potential of B is higher than that of A.

✓ (3) By Left hand rule, B is into paper, I is downwards, thus, magnetic force F is rightwards.
OR
For induced current, magnetic force must oppose motion, thus magnetic force is rightwards.

75. D

✓ A. By Right hand rule, induced current along rod PQ is upwards, thus the current is in the direction $PQRS$.

✓ B. The magnetic force must be oppose the motion, thus it is towards the left.

✓ C. Current along rod RS is from R to S. By Left hand rule, the magnetic force on RS is towards the right.

× D. Due to the opposing magnetic force, the rod PQ should decelerate to rest, not uniform speed.

76. D

The flux through the metal frame : $\Phi = BA = BL^2$

When the frame is rotated by 90°, the flux changes from BL^2 to zero, thus the change is BL^2.

When the frame is rotated by 180°, the flux changes from BL^2 to $-BL^2$, thus the change is $2BL^2$.

77. B

When the square metal frame moves the distance L into the field region, current is induced.

When the square metal frame moves inside the field region, no current is induced.

When the square metal frame moves the distance L away from the field region, current is induced.

Thus the total time that current is induced $= \dfrac{d}{v} = \dfrac{2L}{v}$

78. A

✓ (1) By Right hand rule, an e.m.f. or voltage is induced across PQ.

× (2) As the rod is not a complete circuit, there is no current.

× (3) Since there is no current, there is no opposing magnetic force, thus the rod falls with acceleration g.

79. D

Since the rod is isolated, there is no complete circuit, thus there is no induced current.

By Right hand rule, the induced e.m.f. is from O to P, thus the end P is at a higher electric potential, as induced e.m.f. points from low to high potential.

80. D

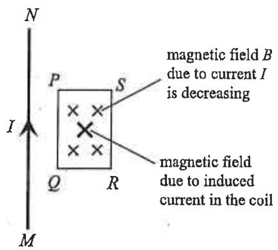
From $t = 0$ to $T/2$, the current is positive and flows from M to N.

By Right hand grip rule, the magnetic field in the coil $PQRS$ due to I is directed into paper.

As current is decreasing, magnetic field B in the coil is decreasing.

By Lenz's law, to oppose the change of magnetic field, the coil induces a current to give a B-field in same direction, thus, the B-field by the induced current is also into the paper.

By Right hand grip rule, the induced current in the coil is in clockwise direction of $PSRQ$.



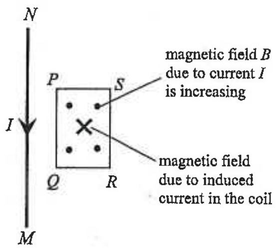
From $t = T/2$ to T, the current is negative and flows from N to M.

The magnetic field in the coil $PQRS$ due to I is directed out of paper.

As current is increasing, magnetic field B in the coil is increasing.

By Lenz's law, to oppose the change, the coil induces a current to give a B-field in opposite direction thus, the B-field due to the induced current is into the paper.

By Right hand grip rule, the induced current in the coil is in clockwise direction of $PSRQ$.



In conclusion, the induced current in the coil is in **clockwise** direction throughout the time interval.

81. B

✓ A. The two sides of the frame P and Q are moving perpendicularly to cut the magnetic field lines, thus the induced e.m.f. is at a maximum at this instant.

× B. Consider the side P, it is moving out of paper. The direction of magnetic field is towards the left. By Right hand rule, the induced current in P is in upward direction. The induced current in Q is in downward direction. Therefore, the induced current in the frame should be in clockwise direction.

✓ C. Whenever there is induced current, there must be a magnetic force opposite to the motion. As P is moving out of paper, the magnetic force on P is into the paper.

✓ D. The magnetic force on P is into the paper and that on Q is out of the paper. These two magnetic forces form a moment to oppose the rotation of the frame.

82. A

✓ (1) Rotate the search coil so that the search coil has different orientation angle with the magnetic field. When the vertical trace on the CRO is maximum, the plane of the search coil is perpendicular to the field. If the vertical trace is not the maximum, the search coil only measures a component of the field.

✓ (2) Since the induced voltage is proportional to the frequency of the a.c., higher frequency gives longer trace, thus, percentage error of the length of the trace is reduced, and accuracy is improved.

× (3) The Earth's magnetic field would not affect the experiment, as search coil cannot detect steady magnetic field such as that of the Earth.

83. C

By using Right hand rule, induced current flows upwards along the rod, thus it flows from X to Y through R.

Since only the length d of the rod can have current flow, induced current is $B\,d\,v\,/\,R$.

84. B

× A. Reverse the direction of magnetic field can only reverse the direction of eddy current, but cannot increase the magnitude of eddy current.

✓ B. Increase the strength of the magnetic field can increase the rate of change of magnetic flux, thus, the induced eddy current increases.

× C. When the whole disc is inside the magnetic field, there is no change of magnetic flux, thus, no eddy current is induced.

× D. Cut several slits give lamination that will reduce the induced eddy current.

85. D

As the magnet moves down along the aluminium tubing, the aluminium experiences a change of magnetic flux of the magnet, thus, eddy current is induced in the aluminium tubing.

As eddy current is induced, there is an opposing magnetic force acting on the magnet.

Thus the net downward force acting on the magnet is less than mg, its downward acceleration is less than g, therefore, the magnet drops slower.

The following list of formulae may be found useful :

Induced e.m.f.	$\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$
Force on a current-carrying conductor in a magnetic field	$F = BIl\sin\theta$
Magnetic field due to a long straight wire	$B = \dfrac{\mu_o I}{2\pi r}$
Magnetic field inside a long solenoid	$B = \dfrac{\mu_o NI}{l}$

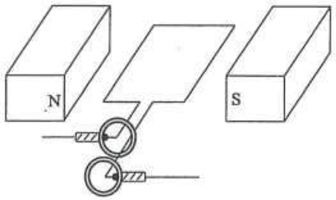
Use the following data wherever necessary :

Permeability of free space	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
Charge of electron	$e = 1.60 \times 10^{-19}$ C
Electron rest mass	$m_e = 9.11 \times 10^{-31}$ kg
Acceleration due to gravity	$g = 9.81$ m s^{-2} (close to the Earth)

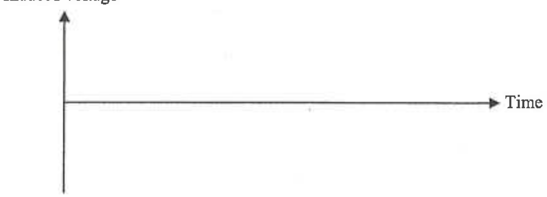
Part A : HKCE examination questions

1. **< HKCE 1980 Paper I - 9 >**

The figure below shows a simple current generator.



(a) In the figure shown below, sketch a graph to show how the induced voltage varies with time when the coil is turned through one revolution, starting with the plane of the coil lying parallel to the field. (2 marks)



(b) The generator is used to deliver a d.c. current. What modification to the generator is necessary to enable this to be done ? (2 marks)

____

____

2. **< HKCE 1981 Paper I - 7 >**

A light rectangular conducting loop *EFGH* moves from left to right with uniform velocity across a uniform magnetic field pointing into paper. Figure 1, 2 and 3 show three subsequent positions of the loop during its motion.

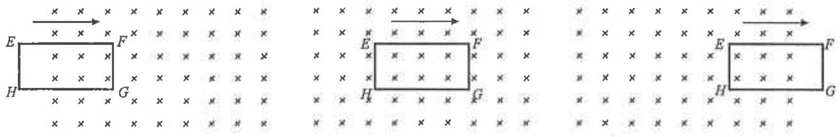


Figure 1 **Figure 2** **Figure 3**

(a) What can you say about the induced current in each of the three cases shown in Figure 1, 2 and 3 ? (3 marks)

____

____

____

(b) State whether an external force is required to maintain the motion of the loop with uniform velocity in each of the above three cases. Explain briefly. (6 marks)

____

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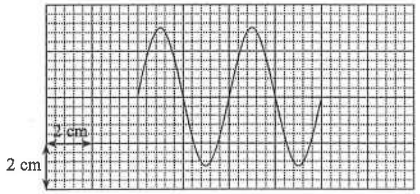
3. **< HKCE 1982 Paper I - 7 >**

If an a.c. signal is inputted to the CRO with the time-base set at 1 ms cm^{-1} and the voltage sensitivity set at 2.5 V cm^{-1}, the wave pattern displayed is shown in the below figure.



(a) From the wave pattern obtained, estimate the peak voltage of the input signal. (1 mark)

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(b) Estimate the time taken for the spot on the screen to produce a complete cycle. (1 mark)

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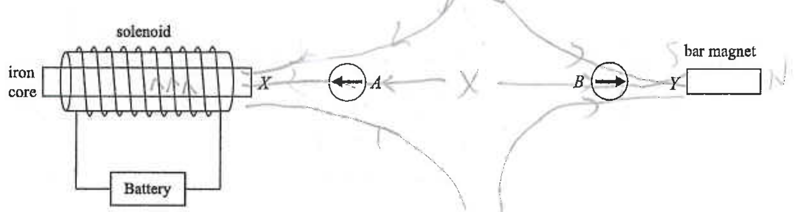
(c) What is the frequency of the input signal ? (2 marks)

____

____

4. < HKCE 1982 Paper I - 9 >

The diagram below shows a solenoid with an iron core, a bar magnet and compasses A and B with needles pointing in the directions indicated. Neglect the effect of the Earth's magnetic field.



(a) Sketch on the diagram above, the magnetic field pattern near end X and end Y.

Indicate

(i) the polarities of X and Y

(ii) the neutral point, and

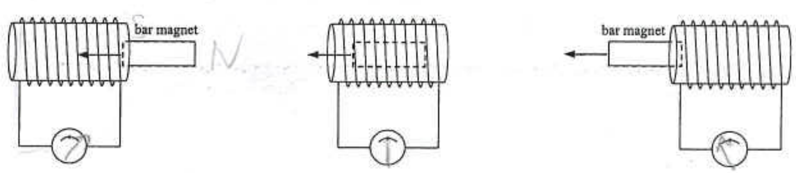
(iii) the direction of the current in the solenoid. (8 marks)

(b) What happens to the neutral point in each of the following cases :

(i) the iron core is taken out of the solenoid at the left hand, and, (1 mark)

(ii) the battery is replaced by a centre-zero galvanometer ? (2 marks)

(c)



After the two changes described in (b) have been made, the bar magnet is moved towards the solenoid and passes through it. Indicate on the given diagrams above the positions of the galvanometer pointer when

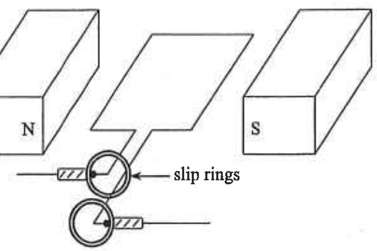
(i) the magnet is just entering the solenoid,

(ii) the magnet is inside the solenoid, and

(iii) the magnet is just leaving the solenoid. (3 marks)

5. < HKCE 1983 Paper I - 8 >

The below figure shows an alternating current generator.



NBVL

(a) Describe briefly with the aid of a diagram how the alternating current generator can be converted into a direct current generator. (4 marks)

(b) Sketch a graph of the output voltage of the a.c. generator against time. Indicate on the time axis of your graph the times at which

(i) the plane of the coil is parallel to the magnetic field (using the letter H), and

(ii) the plane of the coil is perpendicular to the magnetic field (using the letter V). (5 marks)

(c) Describe what happens to the output voltage if (6 marks)

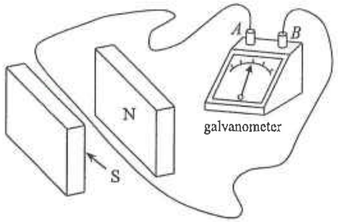
(i) the generator rotates at double its original speed.

(ii) the generator rotates in the opposite direction.

(iii) the number of turns of the coil is doubled.

6. < HKCE 1985 Paper I - 7 >

The below figure shows a simple experimental set-up to study the induced current in a wire moving in a magnetic field. The wire is connected to a galvanometer. If current flows through the galvanometer from A to B, the pointer will deflect to the right.



(a) Draw a diagram to indicate the directions of motion of the wire, of the magnetic field and of the induced current (if any)

(i) if the wire is moving quickly upwards.

(ii) if the wire is moving quickly sideways towards the north pole.

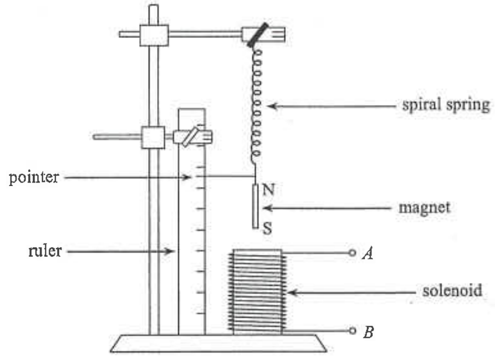
Describe briefly what happens to the galvanometer pointer in each case. (6 marks)

(i)

(ii)

(b) State THREE methods of increasing the induced current in the experiment. (3 marks)

7. < HKCE 1988 Paper I - 9 >



A student sets up an apparatus as shown in the above figure and claims that it can be used to measure a current flowing from terminal A to B through the solenoid.

(a) (i) Explain why this set-up can be used to measure current. (3 marks)

(ii) Suggest TWO methods to increase the sensitivity of the set-up. (2 marks)

(iii) Can this set-up still measure current if the magnet is replaced by a soft iron bar ? Explain briefly. (3 marks)

(b) A and B are now connected to a centre-zero galvanometer. The magnet is set to vibrate up and down. It is kept out of the solenoid. Is there any current passing through the solenoid when the magnet

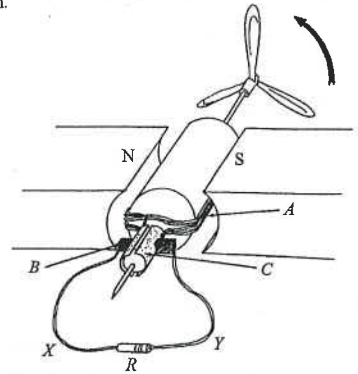
(i) moves towards the solenoid ?

(ii) is at its lowest point ?

If there is a current, state its direction. Explain briefly in each case. (5 marks)

8. < HKCE 1989 Paper I - 7 >

A student uses the set-up as shown in the figure to investigate the generation of electrical energy from wind. The blades are turning in the direction shown.



(a) What is the name of the parts labelled

(i) *A*,

(ii) *B*, and

(iii) *C* ? (3 marks)

(b) Sketch the variation of the output current against time and determine the direction of the current passing through the resistor *R* at the moment shown in the figure. (3 marks)

(c) You are given a voltmeter and an ammeter. Draw a circuit diagram to show how they can be used to measure the power output by the generator. (3 marks)

(d) The current output is 0.7 A when the voltage between *XY* is 12 V. Determine the power output by the generator at that moment. (2 marks)

(e) State TWO advantages and TWO disadvantages of using wind to generate electrical energy. (4 marks)

9. < HKCE 1996 Paper I - 7 >

(a)

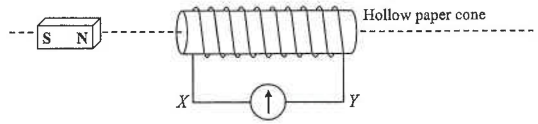


Figure 1

A bar magnet is pushed with constant speed from left to right through a solenoid as shown in Figure 1. Describe the change in the direction of the current passing through the galvanometer during the motion of the magnet. (3 marks)

(b)

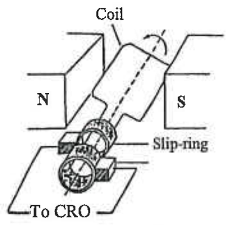


Figure 2

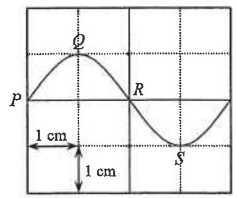


Figure 3

Figure 2 shows the structure of a simple a.c. generator. A voltage is induced when the coil is set into rotation. The output of the generator is displayed on a CRO as shown in Figure 3. The time base of the CRO is set at 20 ms cm^{-1} and *Y*-gain at 50 mV cm^{-1}.

(i) Which points (*P*, *Q*, *R* and *S*) shown in Figure 3 correspond to instants at which the plane of the coil is parallel to the magnetic field ? (2 marks)

(ii) Find the peak voltage and frequency of the output of the generator. (3 marks)

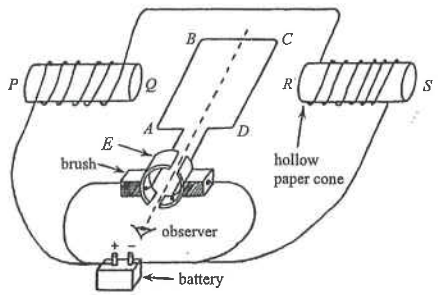
(iii) Describe what happens to the peak voltage and frequency of the output of the generator in each of the following cases :

(1) Increasing the speed of rotation of the coil.

(2) Winding the coil on a soft-iron core. (4 marks)

(iv) Steam is commonly used to drive generators in power stations to generate electricity. Suggest two other practical means of driving generators. (2 marks)

10. < HKCE 1998 Paper I - 5 >



The Figure above shows a type of motor. *PQ* and *RS* are solenoids. The solenoids and the coil *ABCD* are connected in parallel to a battery.

(a) State

(i) the polarity at end *Q* of the solenoid *PQ*,

(ii) the direction of rotation of the coil as seen by the observer. (2 marks)

(b) Name the component *E* and explain its function. (3 marks)

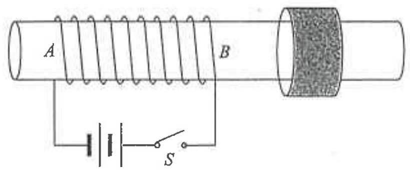
(c) Suggest **two** ways of increasing the rotating speed of the coil. (2 marks)

(d) A student says "If the battery in the above Figure is replaced by a 50 Hz a.c. supply, the coil will only oscillate to and fro. Hence the motor will not function properly."

Explain why the student is incorrect. (4 marks)

(e) Describe, with the help of a diagram, how the motor in the above Figure can be converted to a direct current generator. (3 marks)

11. < HKCE 2002 Paper I - 6 >



A soft-iron rod is inserted into a solenoid *AB*, which is connected to a battery and a switch *S* as shown in the above figure. Initially *S* is open. An aluminium ring is also inserted into the rod and placed beside the solenoid. *S* is now closed.

(a) State the polarity at end *B* of the solenoid. (1 mark)

(b) Explain why the aluminium ring will move away from the solenoid. (3 marks)

12. < HKCE 2003 Paper I - 6 >

Figure 1 shows a battery-powered electric fan. Mary wants to construct a simple generator from the fan. She removes the motor of the fan and connects it to a light bulb (see Figure 2). When the blades of the fan are turned rapidly, the bulb lights up.

Figure 1

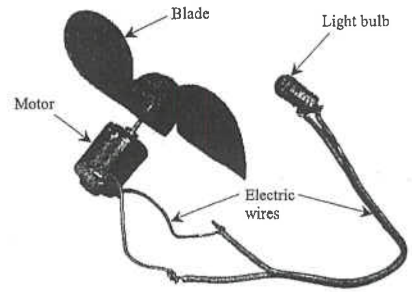


Figure 2

(a) Name two essential components of a motor. (2 marks)

(b) Explain why the bulb lights up when the blades are turning. (3 marks)

13. **< HKCE 2008 Paper I - 11 >**

A student uses the setup in Figure 1 to study the current induced in a solenoid when a magnet is falling through it. When a current is passing through the current sensor from A to B, a positive reading is obtained. Figure 2 shows the result after the magnet is released at a certain height.

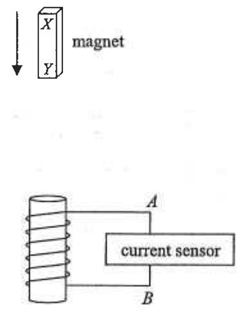


Figure 1

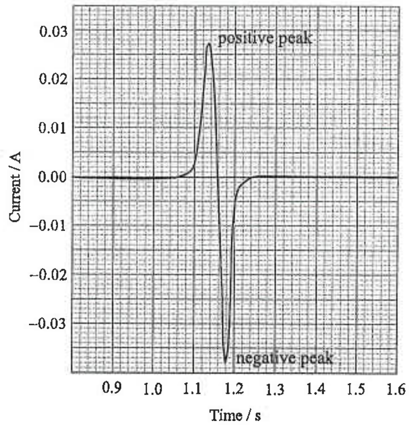


Figure 2

(a) State the polarity of end Y of the magnet. (1 mark)

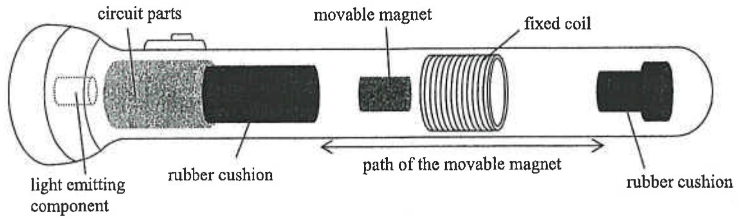
(b) Explain why the reading of the induced current is negative when the magnet leaves the solenoid. (3 marks)

(c) Explain why the magnitude of "negative peak" is greater than that of "positive peak". (2 marks)

14. **< HKCE 2010 Paper I - 13 >**

A hand-shaken torch does not require any battery. Shaking it for a short while will produce a current and give out bright light. Figure 1 shows the structure of the torch.

Figure 1



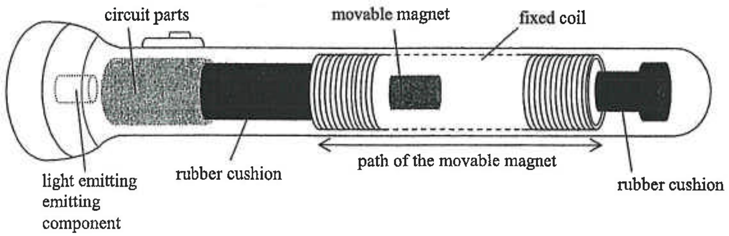
(a) Describe how current is produced in the fixed coil when the torch is shaken. (2 marks)

(b) State **one** method to increase the current without modifying the torch. (1 mark)

(c) Describe the energy conversion when this torch is in operation. (2 marks)

(d) In another design as shown in Figure 2, the fixed coil covers the whole length of the path of the movable magnet. It is found that the torch becomes dimmer than the original design when operating it in the same way. Explain briefly. (The resistance of the fixed coil can be neglected.) (2 marks)

Figure 2



Part B : HKAL examination questions

15. **< HKAL 1996 Paper I - 7 >**

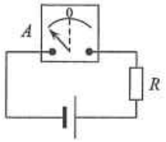


Figure 1

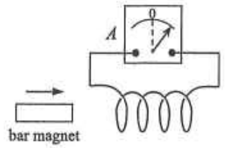


Figure 2

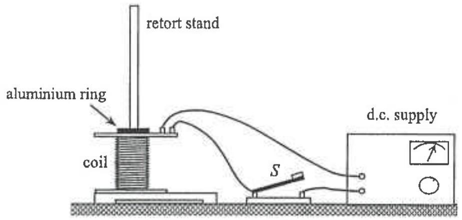
A centre-zero galvanometer A is connected in series with a resistor, R, and a 1.5 V cell as shown in Figure 1. The pointer of A deflects to the left. The galvanometer is now connected to a coil as shown in Figure 2. When a bar magnet is moved with uniform speed by a student towards the coil, the pointer of A deflects to the right.

(a) On Figure 2, indicate the direction of the induced current in the coil and also the poles of the bar magnet. (2 marks)

(b) Where does the electrical energy in the circuit come from ? (1 mark)

(c) Suggest THREE ways to increase the deflection of A. (2 marks)

16. **< HKAL 1996 Paper I - 7 >**



A coil and a retort stand made of iron are arranged as shown. The coil is connected to a d.c. supply via a switch S. When the switch is pressed on, the aluminium ring placed on top of the coil jumps up momentarily and then falls back to the top of the coil.

(a) Briefly explain this observation. (3 marks)

16. (b) If now the d.c. supply is replaced by an a.c. supply.

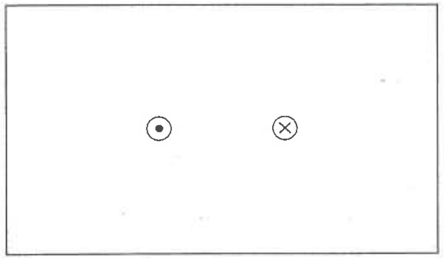
(i) What would be observed if the switch is closed ? (1 mark)

(ii) Suggest a practical use of this experimental result. (1 mark)

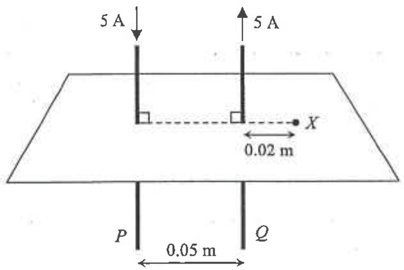
(iii) The heat capacity of the ring is 7.8 J K^{-1} and its temperature is found to rise from 25°C to 40°C during the first 50 s when the a.c. supply is on. Find the average rate of increase in internal energy of the ring. (2 marks)

17. **< HKAL 2000 Paper I - 7 >**

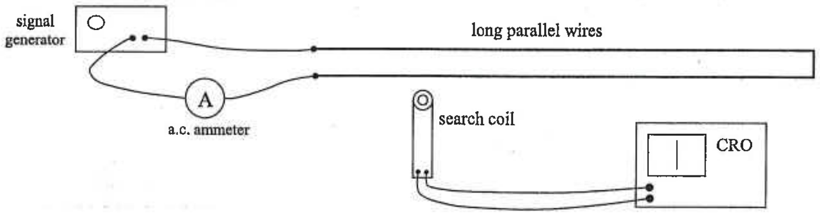
(a) In the figure below, there are two parallel wires carrying currents in opposite directions. The current in the left wire is perpendicularly out of paper while the current in the right wire is perpendicularly into paper. Sketch in the space below the magnetic field pattern around the two wires. (2 marks)



(b) In the figure below, if the current flowing through both wires is 5 A and the separation between them is 0.05 m, find the magnitude of the resultant magnetic field due to these two wires at point X, which is 0.02 m from wire Q. (2 marks)



17. (c) Two long parallel current-carrying wires are now connected to a signal generator giving out a.c. current. A search coil connected to a CRO is used to investigate the magnetic field around the two wires. With the time base of the CRO switched off, a vertical trace is observed on the screen of the CRO.

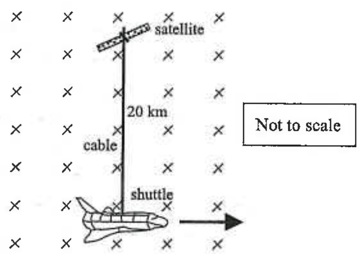


(i) Explain what is represented by the length of the trace observed on the CRO. (2 marks)

(ii) Explain whether the measurement of the magnetic field by the search coil would be affected by the Earth's magnetic field. (2 marks)

18. **< HKAL 2000 Paper I - 8 >**

In the figure below, a space shuttle carries a satellite attached to it by a 20 km long conducting cable. The two move together around the Earth above the equator in orbital motion. In the orbital motion, the cable sweeps through the magnetic field of the Earth.



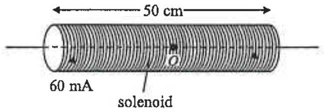
Given : Magnetic field strength in the orbital region $= 30 \times 10^{-6}$ T
Orbital position of the shuttle $= 6.8 \times 10^{6}$ m from the centre of the Earth
Mean radius of the Earth $= 6.4 \times 10^{6}$ m

(a) Calculate the orbital speed of the shuttle at this position. (3 marks)

(b) Find the e.m.f. induced across the cable. State one assumption that you have made in the calculation. (3 marks)

19. **< HKAL 2001 Paper I - 4 >**

The figure below shows a solenoid of diameter 5.0 cm and length 50 cm. The solenoid has 1000 turns and it carries a steady current of 60 mA.

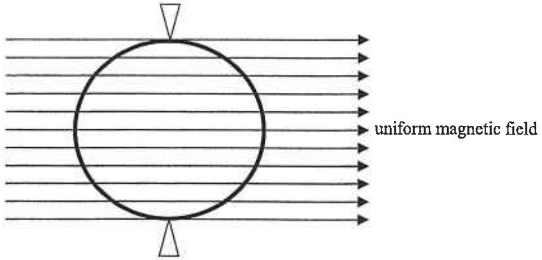


(a) Calculate the magnetic field strength at the centre O of the solenoid. (2 marks)

(b) Calculate the magnetic flux linkage through the solenoid. (2 marks)

20. **< HKAL 2003 Paper I - 4 >**

The figure below shows a circular coil of 100 turns and radius 5 cm pivoted by two smooth vertical supports. It is placed in a region with a uniform magnetic field of 0.1 T towards the right. The ends of the coil are joined together and the resistance of the coil is 10 Ω.



The coil is turned through 90° by an external force until its plane is perpendicular to the magnetic field.

(a) Would the coil resist being turned ? Explain briefly. (2 marks)

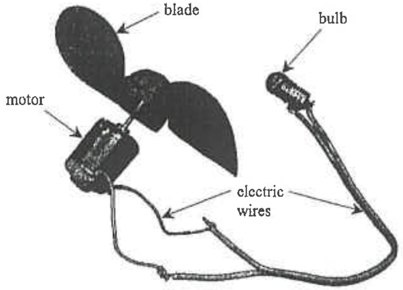
(b) If the coil is released from rest at the new position described above, would it move back to its original position ? Explain briefly. (2 marks)

(c) The coil is now fixed with its plane perpendicular to the magnetic field. The flux density of the field is increased at a uniform rate of 0.3 T s^{-1}. Find the magnitude of the current induced in the coil. (3 marks)

Part C : HKDSE examination questions

21. < HKDSE Sample Paper IB - 7 >

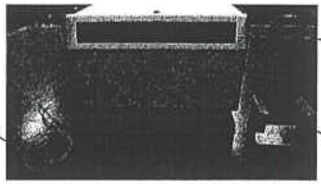
Amy uses the motor of a toy fan as a simple generator. She connects a bulb to the two terminals of the motor. This is shown in the Figure below.



The bulb lights up when the blades are turned rapidly. Explain why and state the energy conversion taking place in this process. (4 marks)

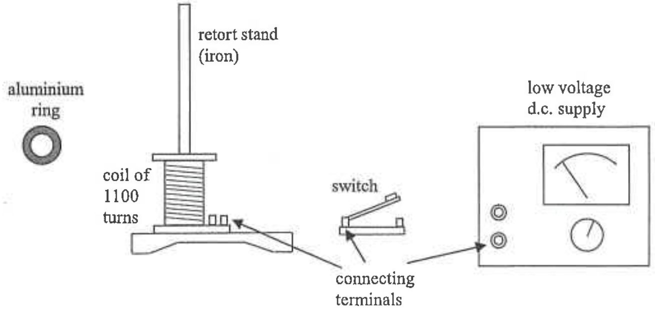
22. < HKDSE 2012 Paper IB - 10 >

You are given a long conducting wire, a pair of slab-shaped magnets on steel yoke and a light-beam galvanometer for detecting small currents. With the aid of a diagram, describe an experiment to investigate TWO factors affecting the e.m.f. induced in a conductor when it moves in a magnetic field. (7 marks)



23. < HKDSE 2014 Paper IB - 9 >

(a) You are given a low voltage d.c. supply, an aluminium ring, a switch, a coil of 1100 turns and a retort stand arranged as shown. Use three connecting leads to complete the connections among the apparatus in the figure and describe how to demonstrate Lenz's law in electromagnetic induction. State and explain the observation. (6 marks)



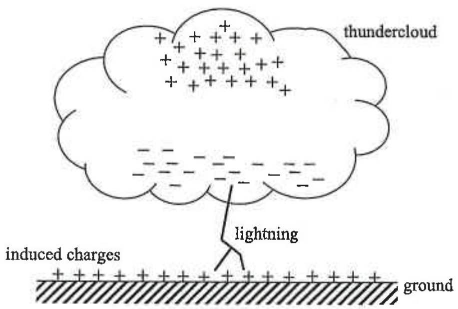
(b) Describe what would be observed if the experiment in part (a) is repeated with

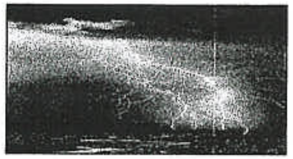
(i) a low voltage a.c. supply ; (1 mark)

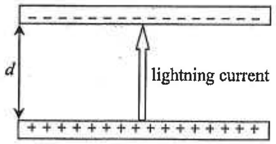
(ii) a low voltage a.c. supply and an aluminium ring with a slit cut through it as shown []. (1 mark)

24. < **HKDSE 2016 Paper IB - 8** >

Read the following passage about **lightning** and answer the question that follow.







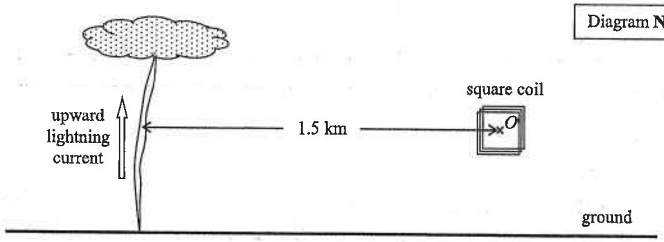
Lightning occurs when charges accumulate in the clouds to such an extent that the electric field in the atmosphere is strong enough to cause the air to lose its insulating properties. The threshold electric field for 'breakdown' to occur is about 3×10^5 V m^{-1} above which electrons or ions in the atmosphere can pass through the air between clouds and the ground or between clouds and clouds. The peak current of a typical lightning bolt can reach about 30 000 A. How the charges are separated and accumulated in the clouds is not fully understood yet. In most cases, negative charges are at the base of the cloud and positive charges are induced on the ground.

(a) (i) What is the meaning of 'breakdown' in the passage ? (1 mark)

(ii) The thundercloud's base and the ground can be modeled as two parallel plates with opposite charges. If the negative charges distributed at the cloud's base are about d = 2 km from the ground, find the potential difference between the cloud and the ground when the electric field in the atmosphere just reaches the threshold of 'breakdown'. (2 marks)

A lightning detector having a small square coil inside is placed at point O which is 1.5 km from the lightning bolt. The coil and the lightning's direction are in the same vertical plane as shown. Assume that the lightning current flows vertically upwards to the thundercloud from the ground.

Diagram **NOT** drawn to scale



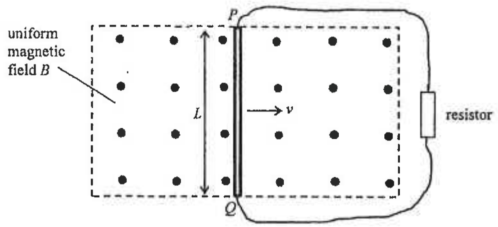
24. (b) (i) State the direction of the magnetic field (to the left / to the right / into paper / out of paper) produced at point O by the lightning current. Estimate the magnetic field strength's peak value at O. (3 marks)

(ii) Explain why within the very short duration of lightning, an induced current first flows in the coil in a certain direction and then reverses. Your answer should include the directions of the induced current in the coil. (3 marks)

(iii) Among the physical quantities related to lightning, **electric field in the atmosphere, lightning current** and **magnetic field due to lightning**, suggest which one can be monitored so as to give fore-warning of lightning. Explain your choice. (2 marks)

25. < **HKDSE 2018 Paper IB - 9** >

(a)



The Figure above shows a metal rod PQ of length L moving with constant velocity v across a uniform magnetic field B pointing out of the paper. An e.m.f. ξ is induced across rod PQ as it cuts the field lines. When the rod is connected to a resistor outside the field, a current I flows in the circuit.

(i) Indicate the direction of I in the above Figure. (1 mark)

(ii) Explain why an external force F is required to maintain the uniform motion of rod PQ. Find F in terms of the physical quantities given. (3 marks)

(iii) This set-up works as a generator. By considering the mechanical power input by external force F to the set-up, show that $\xi = B L v$. (2 marks)

25. (b) At a certain place the Earth's magnetic field runs along the S-N direction such that the field lines make an angle θ with the horizontal as shown in Figure (a).

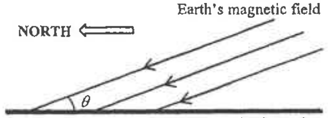


Figure (a)

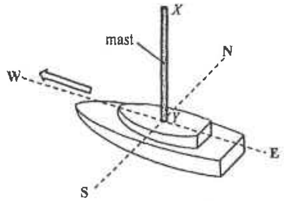


Figure (b)

A ship with a vertical aluminium mast sails at sea along a straight course to the west as shown in Figure (b). As a result, an e.m.f. is induced across the mast XY.

(i) Explain why it is **only the horizontal component** of the Earth's magnetic field that is cut by the mast which gives rise to this induced e.m.f. (1 mark)

____

____

(ii) Given : length of mast XY = 20 m

speed of the ship = 6 m s^{-1}

Earth's magnetic field = 50 μT

θ = 30°

Referring to (a)(iii), calculate the e.m.f. induced across XY and state whether the distribution of free electrons along the mast is more at end X, more at end Y or uniform along XY. (3 marks)

____

____

____

____

____

(iii) Suppose X and Y are connected by a cable running side-by-side with the mast so that they form a complete circuit. Explain whether there will be a current passing through it. (2 marks)

____

____

____

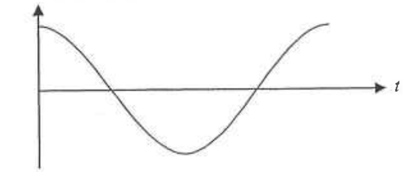
____

There is question in next page

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a)



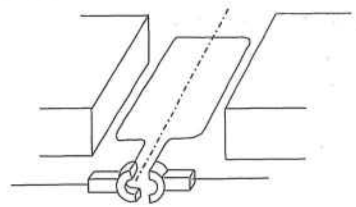
< the induced voltage is maximum at $t = 0$ > [1]

< a complete cycle shown above is drawn > [1]

(b) Change the slip rings [1]

to a commutator. [1]

< accept the use of diagram to show the commutator >



2. (a) In figure 1, induced current flows in direction of $GFEH$. [1]

OR

In figure 1, induced current flows in anticlockwise direction. [1]

In figure 2, no induced current flows. [1]

In figure 3, induced current flows in the direction of $HEFG$. [1]

OR

In figure 3, induced current flows in clockwise direction. [1]

(b) In figure 1, an applied force along the direction of motion is required to maintain the motion of the loop [1]

since there is an opposite magnetic force acts on the wire GF when current flows in magnetic field. [1]

In figure 2, no force is required [1]

since there is no current flowing in the loop. [1]

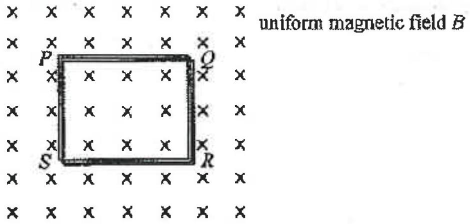
In figure 3, an applied force also along the direction of motion is required to maintain the motion of the loop [1]

since there is an opposite magnetic force acts on the wire HE when current flows in magnetic field. [1]

26. <HKDSE 2019 Ppaper-IB-9>

A rectangular coil $PQRS$ of 20 turns, each having an area of 0.005 m^2, is placed in a uniform magnetic field B of strength 0.3 T pointing into the paper as shown in Figure 9.1.

ure 9.1



(a) The strength of the magnetic field decreases uniformly to zero within 0.5 s.

(i) Explain why a current would be induced in the coil. (2 marks)

*(ii) Calculate the change in total magnetic flux linkage through the coil and the value of the induced e.m.f. ξ in the coil. (3 marks)

(b) Now the coil is rotated uniformly about an axis through 180° as shown in Figures 9.2(a) and 9.2(b) within 0.5 s.

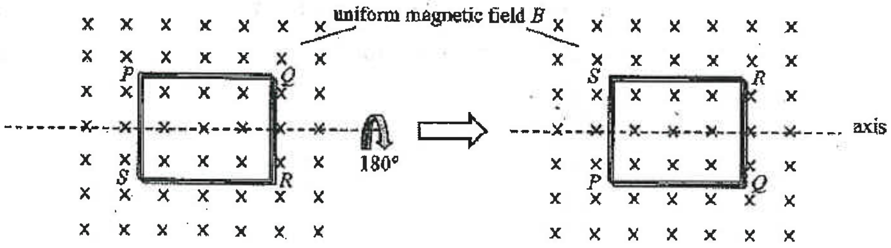


Figure 9.2(a)

Figure 9.2(b)

(i) State the value of the change in total magnetic flux linkage through the coil in this case (1 mark)

(ii) At the moment when the coil rotated through 90°, would the induced current flow in the direction $PQRS$, $PSRQ$ or is there no induced current in the coil ? (1 mark)

(c) Figure 9.3 shows a thin rectangular aluminium plate suspended by a long string. The plate is partly inside a uniform magnetic field provided by a strong magnet.

ure 9.3

The magnet, which is not in contact with the plate, is suddenly shifted to the right.

(i) On Figure 9.3, draw a small circle at the location where eddy currents are induced on the aluminium plate. Use an arrow to indicate the direction of current. (2 marks)

(ii) Describe the subsequent motion of the aluminium plate, if any. (1 mark)

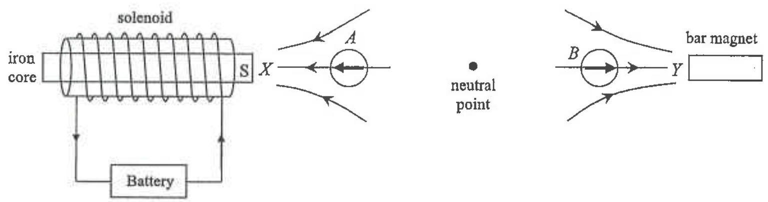
3. (a) Peak voltage = $3\text{ cm} \times 2.5\text{ V cm}^{-1} = 7.5\text{ V}$ [1]

(b) Time taken = $4\text{ cm} \times 1\text{ ms cm}^{-1} = 4\text{ ms}$ [1]

(c) Frequency = $\dfrac{1}{4\times10^{-3}}$ [1]

$= 250\text{ Hz}$ [1]

4. (a)



< Correct pattern > [2]

< Indication of direction of magnetic field > [2]

< Both of the poles are South > [2]

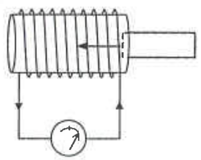
< Neutral point between two compasses > [1]

< Correct direction of current > [1]

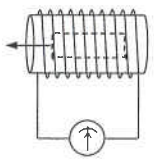
(b) (i) The neutral point moves towards X [1]

(ii) The neutral point disappears [2]

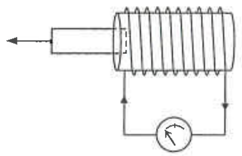
(c)



[1]



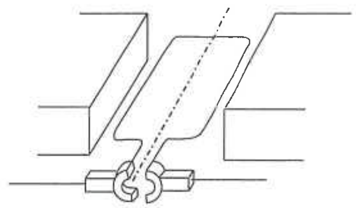
[1]



[1]

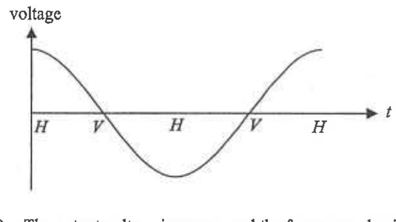
5. (a) Replace the slip rings by a commutator. [2]

Connect the coil to the commutator via 2 carbon brushes. [1]



[1]

(b)



< Voltage is maximum at $t = 0$ > [1]

< Both positive and negative voltage shown > [1]

< Shape correct > [1]

< Correct H > [1]

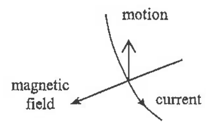
< Correct V > [1]

(c) (i) The output voltage increases and the frequency also increases (**OR** double) [2]

(ii) The amplitude of the voltage is unchanged but the phase is reverse. [2]

(iii) The output voltage increases (**OR** double). [2]

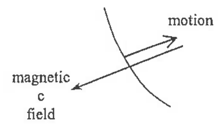
6. (a) (i)



[2]

The pointer deflects to the left. [1]

(ii)



[2]

The pointer does not have any deflection. [1]

(b) Any **THREE** of the following : [3]

* Move the wire with a greater speed
* Use a stronger magnet
* Replace the wire with a coil of more number of turns
* Replace the wire with one of lower resistance

7. (a) (i) Current flowing through the solenoid will give a magnetic field to attract the magnet. [1]
The magnet will be pulled down [1]
and the spring will extend. [1]

(ii) Any **TWO** of the following : [2]
* Increase the number of turns in the solenoid
* Use a stronger magnet
* Use a weaker spring

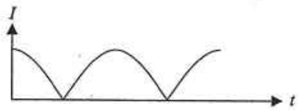
(iii) The set-up can still work. [1]
Since the soft iron will be magnetized by the magnetic field of the solenoid, [1]
attraction always exists. [1]

(b) (i) Yes ! [1]
From B to A [1]
There is a change of magnetic field and thus has an induced current. [1]

(ii) No ! [1]
There is no change in magnetic field at the lowest point as the magnet is momentarily at rest. [1]

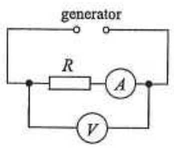
8. (a) (i) A is coils. [1]
(ii) B is carbon brush [1]
(iii) C is commutator (**OR** two split rings) (**OR** two half-rings) [1]

(b) [2]

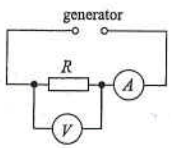


Current flows from X to Y. [1]

(c) [3]



OR



(d) Power $= VI = (12) \times (0.7)$ [1]
$= 8.4$ W [1]

8. (e) **Advantages** : (Any TWO) [2]
* Wind is cheaper
* Wind is of unlimited supply
* Wind has no pollution

Disadvantages : (Any TWO) [2]
* Unsteady output (no output when no wind)
* Low power output
* Suitable only for windy places
* Direction of wind always changes

9. (a) When the magnet moves towards the solenoid, a current passes through G from X to Y. [1]
When the magnet is inside the solenoid, there is no current. [1]
When the magnet moves away from the solenoid, a current passes through G from Y to X. [1]

(b) (i) The plane of the coil is parallel to the magnetic field at points Q and S. [2]

(ii) Peak voltage $= 1 \times 50 = 50$ mV (OR 0.05 V) [1]
Period : $T = 4 \times 20 \times 10^{-3} = 0.08$ s [1]
Frequency : $f = \dfrac{1}{T} = \dfrac{1}{0.08} = 12.5$ Hz [1]

(iii) (1) Peak voltage increases [1]
Frequency increases [1]
(2) Peak voltage increases [1]
Frequency remains unchanged. [1]

(iv) Any **TWO** of the following : [2]
* Wind (**OR** moving air)
* Running water
* Sea wave

10. (a) (i) End Q is a south pole. [1]
(ii) The coil rotates in a clockwise direction. [1]

(b) E is a commutator (**OR** 2 half-rings) (**OR** 2 split-rings) [1]
It is used to reverse the direction of current flowing through the coil when the coil has rotated half cycle. [1]
Hence the coil will continue to rotate in the same direction. [1]

10. (c) Any **TWO** of the following : [2]

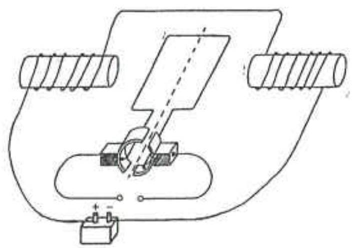
* Increase the voltage of the battery (OR Increase the current passing through the coil)
* Increase the number of turns of the coil
* Increase the area of the coil
* Increase the number of turns of the solenoid
* Insert a soft iron core inside the paper cone
* Wind the coil on a soft-iron core

(d) If the direction of current is reversed, the polarities of the solenoids [1]
and the current flowing through the coil are reversed at the same time. [1]
So the direction of rotation of the coil will remain unchanged. [1]
Hence the motor will still function properly for a.c. supply. [1]

OR

If the direction of current is reversed, the direction of current flowing through the solenoid [1]
and the current flowing through the coil are reversed at the same time. [1]
So the direction of the forces acting on the coil will remain unchanged. [1]
Hence the motor will still function properly for a.c. supply. [1]

(e)



[1]

The wires connecting the commutator are disconnected from the battery. [1]
The other arrangements remain unchanged. [1]

11. (a) B is South pole. [1]

(b) When S is closed, a magnetic field will be built up in the solenoid.
There will be an induced current flowing in the aluminium ring. [1]
By Lenz's Law, the induced current flows in a direction such that it produces an effect to oppose the change. [1]
So the end of the ring near the solenoid becomes a south pole.
The aluminium ring will move away from the solenoid under the action of the repulsive force acting on it. [1]

12. (a) Any **TWO** of the following : [2]

* coil
* magnet
* commutator
* soft iron core

(b) When the blades are turning, the coil inside the motor will rotate [1]
in the magnetic field of the magnet. [1]
A voltage is induced in the coil [1]
and thus current passes through the light bulb to light it up.

13. (a) North (**OR** N-pole) [1]

(b) By Lenz's law, the induced current flows in a direction to oppose the change of magnetic field. [1]
When the south pole leaves, current is induced so that the lower end of the solenoid becomes north. [1]
By Right hand grip rule, the induced current then flows in an opposite direction through the sensor. [1]

(c) The magnet is accelerating. (**OR** The speed of the magnet is increasing.) [1]
Thus the rate of change of magnetic field is greater. [1]

14. (a) When the torch is shaken, the movable magnet moves across the fixed coil.
The magnetic field through the fixed coil changes (**OR** the coil cuts the magnetic field lines) [1]
and a current is induced. (**OR** by Lenz's law, a current is produced.) [1]

(b) Any **ONE** of the following : [1]

* Shake the torch with a greater speed.
* Shake the torch more times.

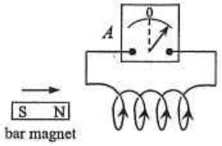
(c) Kinetic energy (**OR** *K.E.*) changes to electrical energy, [1]
and then changes to light (**OR** light and heat) [1]

(d) Because the magnet cannot leave the coil, (**OR** the magnet is always inside the coil) [1]
the coil experiences weaker (**OR** no change) of magnetic field. [1]

< OR >

Only when the magnet is entering or leaving the coil, [1]
there is a change in magnetic field. [1]

15. (a)



< Correct direction of current > [1]

< Correct poles of magnet > [1]

(b) Work done by the student in pushing the magnet. [1]

(c) ∗ Move the magnet more quickly
∗ Use a stronger magnet
∗ Use a coil with more turns
∗ Insert a soft iron in the coil

< any one or two correct > [1]

< the third one correct > [1]

16. (a) When S is closed, current starts to flow in the coil and produces magnetic field.

Thus an increase of the magnetic field occurs through the ring. [1]

By Lenz Law, an eddy current is induced in the ring to oppose the change.

Opposing magnetic force acts on the ring to make it jump up momentarily. [1]

However, when the current reaches its steady value, no change of field results and the ring falls back. [1]

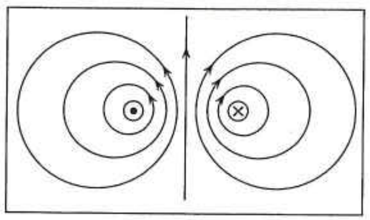
(b) (i) The ring will float steadily above the coil in air. [1]

(ii) Practical use : magnetic levitation of a train [1]

(iii) Rate of increase in internal energy $= \dfrac{7.8 \times (40-25)}{50}$ [1]

$= 2.3 \text{ J s}^{-1}$ [1]

17. (a)



< direction correct > [1]

< pattern correct > [1]

(b) $B = \dfrac{4\pi \times 10^{-7} \times 5}{2\pi}\left(\dfrac{1}{0.02} - \dfrac{1}{0.07}\right)$ [1]

$= 3.6 \times 10^{-5}$ T [1]

17. (c) (i) The length of the trace represents the peak-to-peak voltage of the induced voltage in the search coil. [1]

It is proportional to the peak value of the magnetic field produced by the a.c. currents. [1]

(ii) The working of the search coil would not be affected by the Earth's magnetic field. [1]

Since the Earth's magnetic field is steady, no e.m.f. can be induced in the search coil. [1]

18. (a) $g = \dfrac{GM}{R_E^{\,2}}$ $\quad \therefore GM = gR_E^2 = (9.81) \times (6.4 \times 10^6)^2$

By $\dfrac{GMm}{r^2} = \dfrac{mv^2}{r}$ [1]

$\therefore v = \sqrt{\dfrac{GM}{r}} = \sqrt{\dfrac{9.81 \times (6.4 \times 10^6)^2}{6.8 \times 10^6}}$ [1]

$= 7690 \text{ m s}^{-1}$ [1]

(b) $\varepsilon = BvL$

$= (30 \times 10^{-6}) \times (7690) \times (20 \times 10^3)$ [1]

$= 4610$ V [1]

Any **ONE** of the followings : [1]

∗ The cable is always perpendicular to the B-field
∗ The magnetic field is uniform over this 20 km cable
∗ The satellite and the shuttle move with the same speed

19. (a) $B = \dfrac{\mu_o N I}{\ell} = \dfrac{(4\pi \times 10^{-7})(1 \times 10^3)(60 \times 10^{-3})}{0.5}$ [1]

$= 1.51 \times 10^{-4}$ T [1]

(b) $N\Phi = NBA$ [1]

$= (1 \times 10^3)(1.51 \times 10^{-4})(\pi \times 0.025^2)$

$= 2.96 \times 10^{-4}$ Wb [1]

20. (a) Yes, the coil would resist being turned. [1]

When the coil is turned, a current is induced.

By Lenz's law, magnetic forces acts on the coil to give a moment to oppose its rotation. [1]

(b) No. [1]

Since there is no induced current through the coil, no magnetic forces act to rotate the coil. [1]

20. (c) $\varepsilon = N\dfrac{\Delta\Phi}{\Delta t} = NA\dfrac{\Delta B}{\Delta t} = (100)(\pi \times 0.05^2)(0.3) = 0.236\ \text{V}$ [1]

$I = \dfrac{\varepsilon}{R} = \dfrac{0.236}{10}$ [1]

$\therefore\ I = 0.0236\ \text{A}$ [1]

21. When the blades are turned, the coil inside the motor will rotate in the magnetic field of the magnet. [1]

An induced e.m.f. will be set up in the coil. [1]

The induced current flows through the bulb and lights up the bulb. [1]

Kinetic energy is converted to electrical energy and then to heat and light energy. [1]

22.

< The conducting wire connected to the light-beam galvanometer > [1]
< The wire placed between the pairs of magnets > [1]
< Two hands holding the wire > [1]

Connect the long wire to the galvanometer and place the wire across the magnetic field.

To investigate the factor affecting the induced e.m.f. : (Any **TWO** of the followings)

∗ **Rate of movement**

Move the wire slowly across the field and then quickly across the field. [1]

The galvanometer would deflect more for a faster rate. [1]

∗ **Number of turns**

Move the wire across the field. Then wind the wire into a few number of turns and move it again. [1]

The galvanometer would deflect more for more number of turns of the wire. [1]

∗ **Relative movement**

Move the wire vertically down across the field and then up across the field. [1]

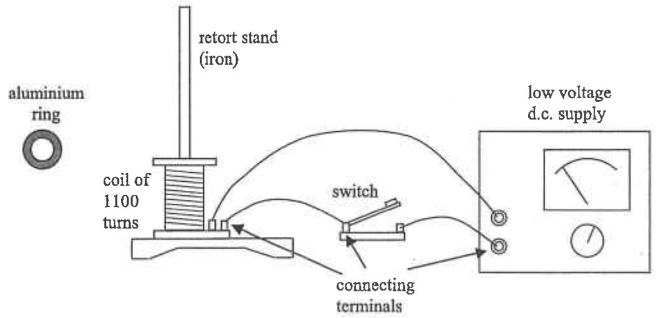
The galvanometer would deflect to one side and then to the opposite side. [1]

∗ **Polarities of magnet**

Move the wire vertically down across the field, the galvanometer would deflect to one side. [1]

Reverse the polarities of magnets and repeat the experiment, the galvanometer would deflect to the opposite side. [1]

23. (a)



< the connection of the 3 wires is ALL correct > [1]

Place the aluminium ring on the top of the coil through the rod of the retort stand. [1]

When the switch is closed, the ring jumps up momentarily and falls down. [1]

As the aluminium ring experiences a sudden increase of magnetic field produced by the coil at the start, [1]

according to Lenz's Law, eddy currents are induced in the ring to oppose this change. [1]

A repelling upward magnetic force then exerts on the ring to push it up.

When the current and magnetic field becomes constant, the ring falls back as eddy current no longer flows. [1]

(b) (i) The aluminium ring floats above the coil in the air. [1]

(ii) The ring remains at rest on the coil without moving up. [1]

24. (a) (i) Any **ONE** of the followings : [1]

∗ The air loses its insulating properties.

∗ The air becomes conducting.

∗ Charges can pass through the air between the clouds and the Earth.

(ii) $E = \dfrac{V}{d}$ [1]

$V = Ed = (3 \times 10^5) \times (2000) = 6 \times 10^8\ \text{V}$ [1]

(b) (i) Magnetic field into paper [1]

$B = \dfrac{\mu_o I}{2\pi r}$ [1]

$= \dfrac{4\pi \times 10^{-7} \times 30000}{2\pi \times 1500}$

$= 4 \times 10^{-6}\ \text{T}$ [1]

24. (b) (ii) When the lightning current is increasing, the induced current flows in the anticlockwise direction [1]
so as to oppose the increase of magnetic field. [1]

After reaching maximum, the lightning current is decreasing,
the induced current flows in the clockwise direction (**OR** opposite direction). [1]

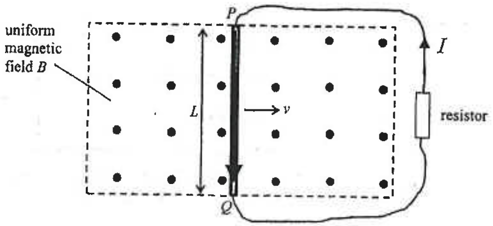
(iii) Electric field [1]

E-field increases (**OR** builds up) before lightning occurs [1]

OR

Lightning current and magnetic field only exist during lightning. [1]

25. (a) (i) [1]



(ii) By Lenz's law, a magnetic force F_B acts on the rod to oppose its motion. [1]
An applied force F is needed to balance F_B to maintain uniform motion. [1]
$\therefore\ F = BIL$ [1]

(iii) Mechanical power input : $P = Fv = (BIL)\,v$ [1]
Power input = electrical power output
$\therefore\ BILv = \xi I$ [1]
$\therefore\ \xi = BLv$

(b) (i) The horizontal component is perpendicular to the mast. [1]

OR

The vertical component is parallel to the mast

(ii) $\xi = (B\cos 30°)\,L\,v$ [1]
$= (50 \times 10^{-6} \cos 30°)\,(20)\,(6)$
$= 5.12 \times 10^{-3}$ V (accept 5.12 mV) [1]

More electrons at end X [1]

(iii) No current [1]

Both the cable and the mast cut the field lines, both have same e.m.f. induced
and the two induced e.m.f. oppose each other. [1]

OR

There is no change of magnetic flux through the loop of the circuit. [1]

Hong Kong Diploma of Secondary Education Examination

Physics – Compulsory part (必修部分)

Section A – Heat and Gases (熱和氣體)
1. Temperature, Heat and Internal energy (溫度、熱和內能)
2. Transfer Processes (熱轉移過程)
3. Change of State (形態的改變)
4. General Gas Law (普適氣體定律)
5. Kinetic Theory (分子運動論)

Section B – Force and Motion (力和運動)
1. Position and Movement (位置和移動)
2. Newton's Laws (牛頓定律)
3. Moment of Force (力矩)
4. Work, Energy and Power (作功、能量和功率)
5. Momentum (動量)
6. Projectile Motion (拋體運動)
7. Circular Motion (圓周運動)
8. Gravitation (引力)

Section C – Wave Motion (波動)
1. Wave Propagation (波的推進)
2. Wave Phenomena (波動現象)
3. Reflection and Refraction of Light (光的反射及折射)
4. Lenses (透鏡)
5. Wave Nature of Light (光的波動特性)
6. Sound (聲音)

Section D – Electricity and Magnetism (電和磁)
1. Electrostatics (靜電學)
2. Electric Circuits (電路)
3. Domestic Electricity (家居用電)
4. Magnetic Field (磁場)
5. Electromagnetic Induction (電磁感應)
6. Alternating Current (交流電)

Section E – Radioactivity and Nuclear Energy (放射現象和核能)
1. Radiation and Radioactivity (輻射和放射現象)
2. Atomic Model (原子模型)
3. Nuclear Energy (核能)

Physics – Elective part (選修部分)

Elective 1 – Astronomy and Space Science (天文學和航天科學)
1. The universe seen in different scales (不同空間標度下的宇宙面貌)
2. Astronomy through history (天文學的發展史)
3. Orbital motions under gravity (重力下的軌道運動)
4. Stars and the universe (恆星和宇宙)

Elective 2 – Atomic World (原子世界)
1. Rutherford's atomic model (盧瑟福原子模型)
2. Photoelectric effect (光電效應)
3. Bohr's atomic model of hydrogen (玻爾的氫原子模型)
4. Particles or waves (粒子或波)
5. Probing into nano scale (窺探納米世界)

Elective 3 – Energy and Use of Energy (能量和能源的使用)
1. Electricity at home (家居用電)
2. Energy efficiency in building (建築的能源效率)
3. Energy efficiency in transportation (運輸業的能源效率)
4. Non-renewable energy sources (不可再生能源)
5. Renewable energy sources (可再生能源)

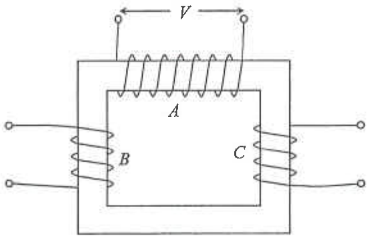
Elective 4 – Medical Physics (醫學物理學)
1. Making sense of the eye (眼的感官)
2. Making sense of the ear (耳的感官)
3. Medical imaging using non-ionizing radiation (非電離輻射醫學影像學)
4. Medical imaging using ionizing radiation (電離輻射醫學影像學)

The following list of formulae may be found useful :

Power in a circuit	$P = IV = I^2 R$
Ratio of secondary voltage to primary voltage in a transformer	$\frac{V_P}{V_S} \approx \frac{N_P}{N_S}$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper II - 45 >**



Three coils A, B and C are wrapped around an iron core as shown. Coil A has N turns while coil B and C both have $\frac{1}{2}N$ turns. If an input voltage V is applied across A, what will be the voltage acting across coil C ?

A. $\frac{1}{4}V$

B. $\frac{1}{2}V$

C. $2V$

D. $4V$

2. **< HKCE 1980 Paper II - 34 >**

What is/are the advantage(s) of using high voltage in power transmission over long distances ?

(1) Current in the transmission cables can be reduced.
(2) Less energy is wasted as heat.
(3) Higher voltage can be used in household circuit.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

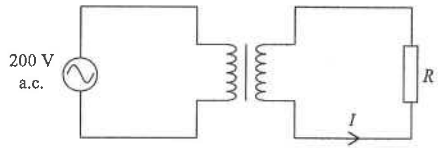
3. **< HKCE 1980 Paper II - 41 >**

Which of the following statements concerning direct current (d.c.) and alternating current (a.c.) is/are correct ?

(1) The magnitude of voltage in d.c. is constant while that in a.c. varies.
(2) The direction of current in d.c. does not change while that of a.c. reverses periodically.
(3) Both d.c. and a.c. can have heating effect on a resistor.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

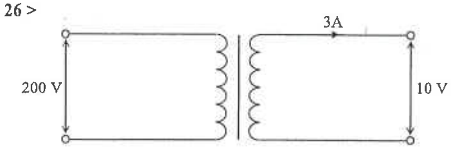
4. **< HKCE 1982 Paper II - 34 >**



In the transformer shown, the ratio of the number of turns on the primary coil to that on the secondary coil is 10 : 1. If the power input is 50 W, find the current in the secondary coil, assuming that the transformer has a 80% efficiency.

A. 1.0 A
B. 1.5 A
C. 2.0 A
D. 2.5 A

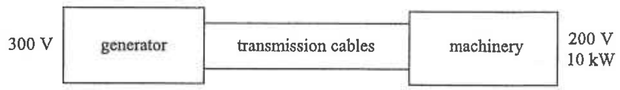
5. **< HKCE 1984 Paper II - 26 >**



As shown in the diagram, a 200 V mains supply is stepped down to 10 V by a transformer. If the output current is 3 A and the efficiency of the transformer is 75%, what is the current in the primary coil ?

A. 0.1 A
B. 0.2 A
C. 0.3 A
D. 0.4 A

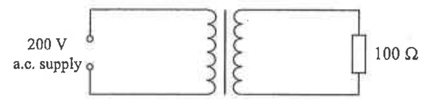
6. **< HKCE 1985 Paper II - 39 >**



The 300 V generator in the above diagram is supplying electrical power to operate a piece of machinery which has a rating of 10 kW at 200 V. The total resistance of the transmission cables is 2 Ω. What is the power loss in the transmission system ?

A. 2.5 kW
B. 5 kW
C. 10 kW
D. 20 kW

7. **< HKCE 1985 Paper II - 41 >**



The diagram shows a transformer with the primary coil connected to an a.c. voltage of 200 V while the secondary coil is connected to a resistor of 100 Ω. If there are 100 turns in the primary coil and 10 turns in the secondary coil, what is the current passing through the resistor ? (Assume that the efficiency of the transformer is 100%)

A. 0.05 A
B. 0.1 A
C. 0.2 A
D. 1 A

8. **< HKCE 1986 Paper II - 29 >**

A transformer can be used to
(1) step-up the voltage of a given a.c. supply.
(2) increase the power of a given a.c. supply.
(3) step-up the voltage of a given battery.

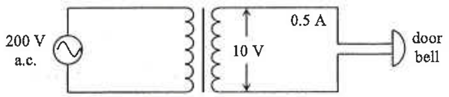
A. (1) only
B. (2) only
C. (1) & (2) only
D. (2) & (3) only

9. **< HKCE 1986 Paper II - 34 >**

The efficiency of a transformer is 50% and the input and output voltages are 200 V and 12 V respectively. If the power output is 30 W, the input current is

A. 0.15 A
B. 0.3 A
C. 1.5 A
D. 2.5 A

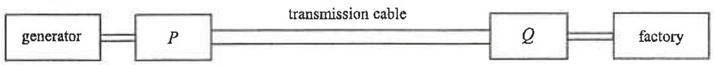
10. **< HKCE 1988 Paper II - 29 >**



In the circuit diagram shown, the transformer is 100% efficient. Which of the following statements is/are correct ?
(1) The current in the primary coil is 0.5 A.
(2) The resistance of the door-bell is 20 Ω.
(3) The ratio of the number of turns in the primary coil to that in the secondary coil is 20 : 1.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

11. **< HKCE 1989 Paper II - 36 >**



The figure above shows how electrical power can be transmitted to a distant factory. The transformers *P* and *Q* should be

	P	*Q*
A.	step up	step up
B.	step up	step down
C.	step down	step up
D.	step down	step down

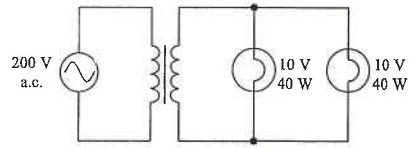
12. **< HKCE 1989 Paper II - 41 >**

Which of the following correctly shows the major change of energy in the devices ?

	Device	From	To
(1)	an electric motor	electrical	mechanical
(2)	a loudspeaker	sound	mechanical
(3)	a transformer	electrical	electrical

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

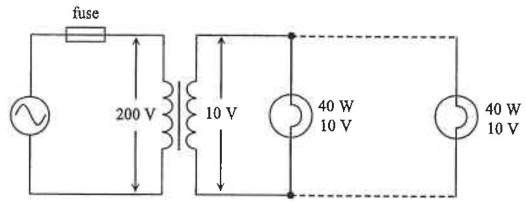
13. **< HKCE 1990 Paper II - 37 >**



In the circuit shown, the efficiency of the transformer is 80%. If the two lamps are to work at their rated values, what is the current in the primary coil and what kind of transformer is being used ?

	Current in primary coil	Transformer
A.	0.2 A	20 : 1 step down
B.	0.4 A	20 : 1 step down
C.	0.5 A	20 : 1 step down
D.	0.4 A	10 : 1 step down

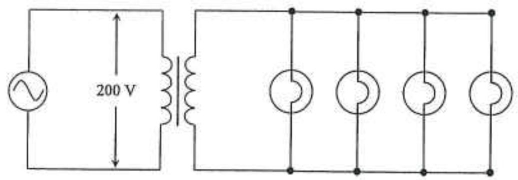
14. **< HKCE 1991 Paper II - 38 >**



In the above circuit diagram, the transformer is 100% efficient. What is the maximum number of identical light bulbs, each of rating '40 W, 10 V' that can be connected in parallel across the secondary coil without blowing the fuse ?
(Assume that the fuse will blow if the current flowing through it exceeds 15 A.)

A. 3
B. 20
C. 60
D. 75

15. **< HKCE 1992 Paper II - 34 >**



In the circuit shown, the rating of each light bulb is '20 W, 10 V'. The current in the primary coil is 0.5 A. If all the bulbs work at their rated values, find the turns ratio and the efficiency of the transformer.

	Turns ratio	Efficiency
A.	5 : 1 step down	80%
B.	20 : 1 step down	20%
C.	20 : 1 step down	40%
D.	20 : 1 step down	80%

16. **< HKCE 1992 Paper II - 35 >**

Which of the following can increase the efficiency of a transformer ?

(1) Increasing the number of turns of the secondary coil.
(2) Using a laminated iron core.
(3) Using a thicker copper wires to make the coils.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

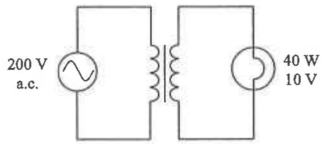
17. **< HKCE 1994 Paper II - 34 >**

An electrical power of 100 kW is transmitted at 20 kV through cables of total resistance of 4 Ω. Find the voltage drop and power loss in the cables.

	Voltage drop	Power loss
A.	20 V	20 W
B.	20 V	100 W
C.	100 V	20 W
D.	100 V	100 W

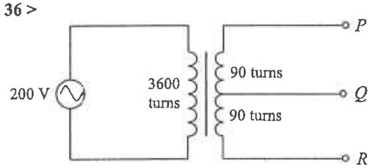
18. **< HKCE 1994 Paper II - 35 >**

In the circuit shown, the rating of the light bulb is '40 W, 10 V'. The efficiency of the transformer is 80%. If the bulb works at its rated value, find the current in the primary coil.



A. 0.16 A
B. 0.2 A
C. 0.25 A
D. 1.6 A

19. **< HKCE 1996 Paper II - 36 >**



The primary coil of a transformer has 3600 turns and is connected to 200 V a.c. supply. The secondary coil has 180 turns, which can be tapped at different points as shown above. A '40 W, 10 V' light bulb is connected to the transformer so that it works at its rated value. Which of the following statements is/are correct ?

(1) The bulb should be connected to points *P* and *Q*.
(2) The current through the bulb is 4 A.
(3) If the efficiency of the transformer is 80%, the current in the primary coil is 0.25 A.

A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

20. **< HKCE 1997 Paper II - 32 >**

Which of the following devices converts mechanical energy into electrical energy when it works ?

A. a transformer
B. a dynamo
C. a motor
D. a microphone

21. **< HKCE 1998 Paper II - 35 >**

A 4 V a.c. supply is stepped up to 20 V by a transformer. If the current in the primary coil is 1 A and the power loss of the transformer is 0.8 W, find the current in the secondary coil.

A. 0.04 A
B. 0.16 A
C. 0.2 A
D. 0.24 A

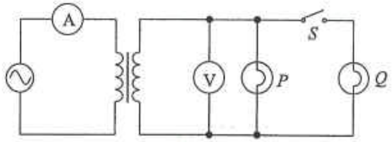
22. **< HKCE 1999 Paper II - 34 >**

Which of the following is/are the advantage(s) of using high voltages for long distance transmission of electricity ?

(1) The transmission speed can be increased.
(2) Some heavy industries operate at high voltages.
(3) The energy loss in the transmission cable can be reduced.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

23. **< HKCE 1999 Paper II - 31 >**



Two bulbs *P* and *Q* are connected to an ideal transformer as shown. Which of the following statements is/are true when switch *S* is closed ?

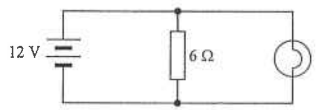
(1) The brightness of bulb *P* decreases.
(2) The reading of the ammeter increases.
(3) The reading of the voltmeter remains unchanged.

A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

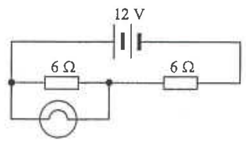
24. **< HKCE 1999 Paper II - 36 >**

A '6 V, 6 W' light bulb is to be operated at its rated value. Three circuits are set up as shown below.

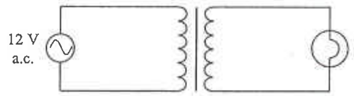
(1)



(2)



(3)

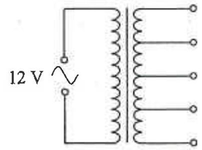


Number of turns
in primary coil = 200
in secondary coil = 100

The power supplies all have negligible internal resistance. In which of the above circuits is the bulb working at its rated value ?

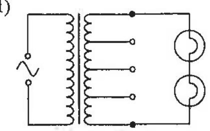
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

25. < HKCE 2001 Paper II - 34 >

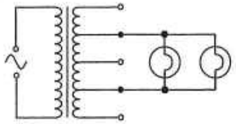


A 12 V a.c. supply is connected to a transformer with turns ratio 1 : 1. The secondary coil is tapped at equal intervals as shown above. Two '6 V, 0.5 W' light bulbs are connected to the secondary coil of the transformer. In which of the following cases will the two bulbs work at their rated values ?

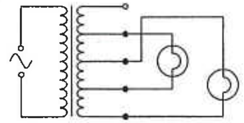
(1)



(2)



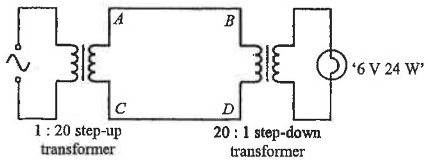
(3)



A. (3) only
B. (1) & (2) only
C. (2) & (3) only
D. (1), (2) & (3)

26. < HKCE 2001 Paper II - 38 >

The figure shows a model power line. An a.c. supply and two ideal transformers are used to operate a lamp of rating '6 V, 24 W'. The total resistance of the cables *AB* and *CD* is 10 Ω. If the lamp operates at its rated value, find the power loss in the cables.



A. 0.4 W
B. 3.6 W
C. 160 W
D. 1440 W

27. < HKCE 2005 Paper II - 43 >

Which of the following statements about long distance power transmission at high alternating voltages are correct ?

(1) Alternating voltages can be stepped up or down efficiently by transformers.
(2) For a given transmitted power, the current will be reduced if a high voltage is adopted.
(3) The power loss in the transmission cables will be reduced if a high voltage is adopted.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

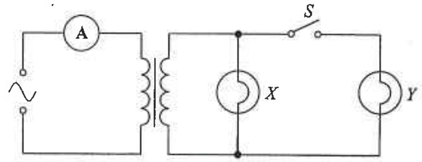
28. < HKCE 2006 Paper II - 38 >

The photograph shows an adaptor for charging up the battery inside a mobile phone. Which of the following statements about the adaptor are correct ?

(1) It is used to step down the voltage from the mains to a value for the mobile phone.
(2) It can convert the voltage from a.c. to d.c.
(3) It is black so that it can radiate heat more efficiently than those in other colours.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

29. < HKCE 2006 Paper II - 37 >



In the above circuit, the transformer is ideal (efficiency = 100%). At the beginning, the switch *S* is closed and the light bulbs *X* and *Y* are operated at their rated values. What would happen to the brightness of the bulb *X* and the ammeter reading if *S* is now opened ?

	Brightness of *X*	Ammeter reading
A.	increases	increases
B.	increases	decreases
C.	remains unchanged	decreases
D.	remains unchanged	remains unchanged

30. < HKCE 2007 Paper II - 44 >

Specification :

Voltage input	220 V
Voltage outputs	6 V & 12 V

The above figure shows a portable transformer. It outputs different voltage by varying the turns ratio between the primary and the secondary coils. Assume that there is no power loss in the transformer and the resistance of the load remains unchanged, when the output changes from 6 V to 12 V, which of the following statements describing the transformer is/are correct ?

(1) The number of turns of the primary coil should be doubled and the number of turns of the secondary coil remains unchanged.
(2) The input current should be doubled.
(3) The output power should be 4 times as before.

A. (2) only
B. (3) only
C. (2) & (3) only
D. (1), (2) & (3)

31. < HKCE 2008 Paper II - 41 >

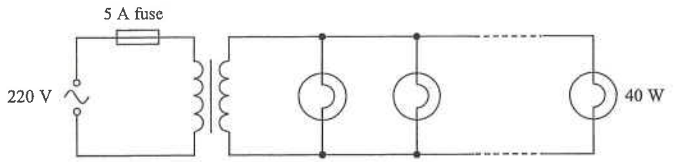
Specification :

Input	a.c. 220 V
Output	a.c. 12 V, 100 mA

The above figure shows a transformer. Assume the transformer is ideal, what is the current drawn from the mains supply if the transformer delivers currents at the rated value ?

A. 5.5 mA
B. 100 mA
C. 1200 mA
D. 1830 mA

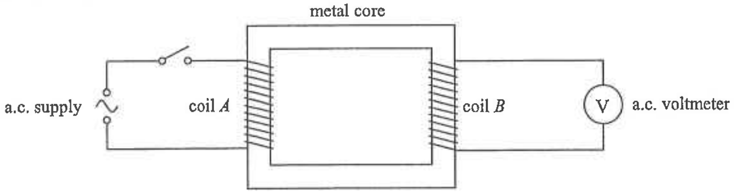
32. **< HKCE 2010 Paper II - 44 >**



In the circuit above, the primary coil of a transformer is connected to the 220 V mains supply with a 5 A fuse. The efficiency of the transformer is 90%. What is the maximum number of identical 40 W light bulbs, operating at their rated values, that can be connected in parallel to the secondary coil without blowing the fuse ?

A. 24
B. 25
C. 27
D. 28

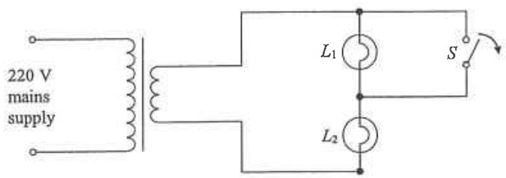
33. **< HKCE 2010 Paper II - 43 >**



The figure shows a metal core with two coils. When the switch is closed, the a.c. voltmeter shows a reading. Which of the following combinations will give the largest voltmeter reading ?

	material of the metal core	no. of turns of coil A	no. of turns of coil B
A.	copper	500	1000
B.	copper	1000	500
C.	iron	500	1000
D.	iron	1000	500

34. **< HKCE 2011 Paper II - 42 >**



The figure above shows an ideal transformer. The primary coil of the transformer is connected to the 220 V a.c. mains and two lamps L_1 and L_2 are connected in series to the secondary coil. Initially, S is closed. Which of the following statements is correct when S is opened ?

A. The current in the primary coil of the transformer decreases.
B. The voltage across the secondary coil of the transformer increases.
C. The brightness of L_1 decreases.
D. The brightness of L_2 increases.

35. **< HKCE 2011 Paper II - 43 >**

Electrical power is transmitted from a power station to local substations by an alternating current and high voltage. It is because

(1) the voltage of an alternating current can be stepped up or down using transformers easily.
(2) by using high voltages, electrical power can be transmitted faster along the cables.
(3) by using high voltages, there is less power loss in the transmission cables.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

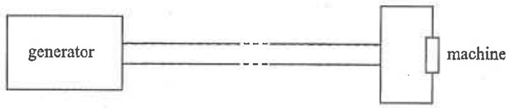
Part B : HKAL examination questions

36. **< HKAL 1984 Paper I - 26 >**

A power station supplied electrical power to a user. The power generated by the station is 1200 kW. After stepping up, the voltage transmitted to the cable is 132 kV. If the total resistance of the transmission cable is 550 Ω, find the electrical power available to the user.

A. 700 kW
B. 1155 kW
C. 1195 kW
D. 1200 kW

37. **< HKAL 1995 Paper IIA - 30 >**

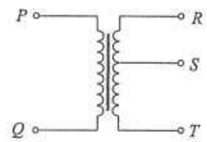


A large machine in a factory consumes 10 kW of electrical power at a voltage of 500 V. If the generator from the power station transmits electrical power to the factory through cables of total resistance 0.2 Ω, the voltage produced by the generator should be

A. 500 V
B. 501 V
C. 502 V
D. 504 V

38. **< HKAL 2008 Paper IIA - 19 >**

When 240 V a.c. is applied across PQ of an ideal transformer, the voltages measured across RS and ST are 4 V and 8 V respectively. If 6 V a.c. is now applied across ST, what will be the voltages measured across PQ and RS ?



	Voltage across PQ	Voltage across RS
A.	0 V	0 V
B.	180 V	0 V
C.	0 V	3 V
D.	180 V	3 V

39. **< HKAL 2013 Paper IIA - 34 >**

The electrical power dissipated by a heater when connected to a 10 V d.c. supply is two times of that when the heater is connected to a sinusoidal a.c. supply. What is the peak voltage of the sinusoidal a.c. supply ?

A. 5 V
B. $5\sqrt{2}$
C. 10 V
D. $10\sqrt{2}$

Part C : HKDSE examination questions

40. **< HKDSE Sample Paper IA - 33 >**

Power is transmitted over long distances at high alternating voltages. Which statements are correct ?

(1) Alternating voltages can be stepped up or down efficiently by transformers.

(2) For a given transmitted power, the current will be reduced if a high voltage is adopted.

(3) The power loss in the transmission cables will be reduced if a high voltage is adopted.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

41. **< HKDSE 2014 Paper IA - 30 >**

When a heater is connected to a d.c. voltage of 10 V, the power dissipated is P. If the heater is connected to a sinusoidal a.c., the power dissipated becomes $\frac{1}{2}P$. What is the r.m.s. voltage of this a.c. source ? Assume that the resistance of the heater is constant.

A. $\sqrt{5}$ V

B. $5\sqrt{2}$ V

C. 10 V

D. $10\sqrt{2}$ V

42. **< HKDSE 2016 Paper IA - 30 >**

A sinusoidal a.c. of a certain frequency delivers a r.m.s. voltage $V_{\text{r.m.s.}}$. If its frequency is doubled and its peak voltage is halved, what would be the r.m.s. voltage ?

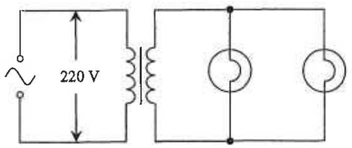
A. $\frac{1}{2}V_{\text{r.m.s.}}$

B. $\frac{1}{\sqrt{2}}V_{\text{r.m.s.}}$

C. $\frac{1}{2\sqrt{2}}V_{\text{r.m.s.}}$

D. $V_{\text{r.m.s.}}$

43. **< HKDSE 2016 Paper IA - 31 >**



In the above circuit, each light bulb works at its rated value '22 W, 11 V'. The current in the primary coil is 0.25 A. Find the efficiency of the transformer.

A. 20%
B. 40%
C. 64%
D. 80%

44. **< HKDSE 2017 Paper IA - 29 >**

A heater of resistance 100 Ω is connected to the mains supply. The r.m.s. voltage of the mains supply is 110 V. Which of the following statements are correct ?

(1) The peak voltage across the heater is 156 V.

(2) The power dissipated by the heater is 121 W.

(3) The power dissipated by the heater will be doubled if the r.m.s. voltage of the mains supply doubles.

A. (1) & (2) only
B. (1) & (3) only
C. (2) & (3) only
D. (1), (2) & (3)

45. **< HKDSE 2017 Paper IA - 30 >**

The input terminal of a transformer is connected to the 220 V mains supply. Ten identical light bulbs are connected in parallel to the output terminal of the transformer. All the light bulbs are working at their rated values of '3 V, 1.5 W'. If the efficiency of the transformer is 70%, what is the current drawn from the mains supply ?

A. 0.007 A

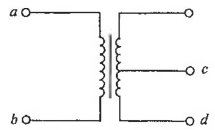
B. 0.048 A

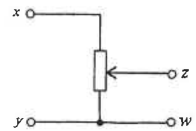
C. 0.068 A

D. 0.097 A

46. **< HKDSE 2018 Paper IA - 30 >**

In the circuits below, if a 12 V sinusoidal a.c. is applied across *ab* and across *xy* respectively, the voltages across *cd* and *zw* are both 6 V. Now if a 6 V sinusoidal a.c. is applied across *cd* and across *zw* respectively, what would be the voltages across *ab* and *xy* respectively ?



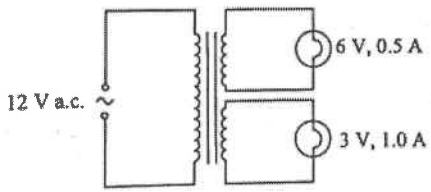


	voltage across *ab*	voltage across *xy*
A.	12 V	12 V
B.	12 V	6 V
C.	6 V	6 V
D.	12 V	0 V

47. <HKDSE 2019 Paper IA-29>

48. <HKDSE 2019 Paper IA-30>

49. <HKDSE 2020 Paper IA-29>



The figure shows an ideal transformer with two secondary coils connected to two light bulbs marked '6 V, 0.5 A' and '3 V, 1.0 A' respectively. When a 12 V a.c. supply is connected to the primary coil, the bulbs work at their respective rated values. Estimate the current in the primary coil.

A. 0.25 A
B. 0.50 A
C. 0.75 A
D. 1.0 A

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

M.C. Answers

1. B	11. B	21. B	31. A	41. B
2. C	12. C	22. B	32. A	42. A
3. D	13. C	23. D	33. C	43. D
4. C	14. D	24. B	34. A	44. A
5. B	15. D	25. D	35. B	45. D
6. B	16. D	26. A	36. B	46. B
7. C	17. B	27. D	37. D	47. C
8. A	18. C	28. D	38. D	48. B
9. B	19. D	29. C	39. C	49. B
10. D	20. B	30. B	40. D	

M.C. Solution

1. B

By $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

$\therefore \frac{(V_C)}{(V)} = \frac{(N/2)}{(N)}$ $\quad \therefore V_C = \frac{V}{2}$

2. C

✓ (1) If high voltage is used, the current through the transmission cables would be small by $P = VI \ \therefore V\uparrow \Rightarrow I\downarrow$

✓ (2) By $P = I^2 R \ \therefore I\downarrow \Rightarrow P_{loss}\downarrow$
$\therefore$ less energy is wasted as heat during the transmission of power

× (3) Voltage in power transmission >> voltage in household circuit
$\therefore$ voltage need to be stepped down

3. D

× (1) The magnitude of voltage in d.c. may not be constant, such as that produced by d.c. generator.

✓ (2) Electron flows in the opposite direction of current.
In d.c., since the direction of current does not change, direction of electron flow does not change.

✓ (3) Current has heating effect on resistor, which does not depend on the direction of current.

4. C

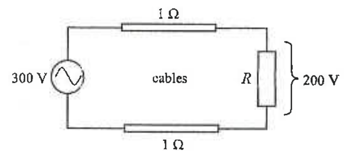
$\eta = \frac{P_{out}}{P_{in}}$ $\quad \therefore 80\% = \frac{P_{out}}{(50)}$ $\quad \therefore P_{out} = 40\text{ W}$

$V_S = \frac{N_S}{N_P} \cdot V_P = \frac{1}{10} \times 200 = 20\text{ V}$ $\quad \therefore I = \frac{P_{out}}{V_S} = \frac{40}{20} = 2\text{ A}$

5. B

$\eta = \frac{P_{out}}{P_{in}} = \frac{V_s I_s}{V_p I_p}$ $\quad \therefore 75\% = \frac{(10)(3)}{(200) I_p}$ $\quad \therefore I_p = 0.2\text{ A}$

6. B



Let the resistance of the machinery be R.

Since the cables and machinery are in series, they have the same current I.

$R = \frac{V_r^2}{P_r} = \frac{(200)^2}{(10\times10^3)} = 4\,\Omega$ $\quad \therefore I = \frac{300}{2+4} = 50\text{ A}$

OR

By $P = VI$ $\quad \therefore (10\times10^3) = (200)\,I$ $\quad \therefore I = 50\text{ A}$

Power loss in the cables : $P_{loss} = I^2 R = (50)^2 (2) = 5000\text{ W} = 5\text{ kW}$

7. C

By $\frac{V_S}{V_P} = \frac{N_S}{N_P}$ $\quad \therefore \frac{V_S}{(200)} = \frac{10}{100}$ $\quad \therefore V_S = 20\text{ V}$

By $V_S = I_S R$ $\quad \therefore (20) = I_s (100)$ $\quad \therefore I_s = 0.2\text{ A}$

8. A

✓ (1) Transformer can step-up the voltage of a.c.

× (2) Transformer cannot be used to increase the power.

× (3) Transformer cannot work on d.c., but battery gives d.c. steady voltage.

9. B

$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_{in} I_{in}}$

$\therefore 50\% = \frac{(30)}{(200) I_{in}}$ $\quad \therefore I_{in} = 0.3\text{ A}$

10. D

× (1) For 100 % efficiency, $(200)I_P = (10)(0.5)$ $\therefore I_P = 0.025$ A

✓ (2) $R = \dfrac{V}{I} = \dfrac{10}{0.5} = 20\ \Omega$

✓ (3) $\dfrac{N_P}{N_S} = \dfrac{V_P}{V_S} = \dfrac{200}{10} = 20$

11. B

High voltage is used in electricity transmission, thus P should be a step up transformer to step up the voltage in cable.
After transmission, the voltage has to be stepped down to be used in factory, thus Q is a step down transformer.

12. C

✓ (1) motor : electrical energy → mechanical energy

× (2) loudspeaker : electrical energy → sound

✓ (3) transformer : electrical energy → electrical energy

13. C

$\eta = \dfrac{P_{out}}{P_{in}} = \dfrac{P_{out}}{V_P I_P}$ $\therefore 80\,\% = \dfrac{(2\times 40)}{(200)\,I_P}$ $\therefore I_P = 0.5$ A

Turns ratio in transformer : $\dfrac{N_P}{N_s} = \dfrac{V_P}{V_s} = \dfrac{200}{10} = 20$

It is a step down transformer since $N_P > N_S$.

14. D

$V_P I_P = P_{out}$ $\therefore (200)(15) = n\,(40)$ $\therefore n = 75$

15. D

Turns ratio : V_S = rated voltage = 10 V $\therefore \dfrac{N_P}{N_S} = \dfrac{V_P}{V_S} = \dfrac{200}{10} = 20$

As the voltage changes from 200 V to 10 V, it is a step down transformer.

Efficiency : $\eta = \dfrac{(20\times 4)}{(200)(0.5)} = 80\,\%$

16. D

× (1) If number of turns of the secondary coil is increased, secondary voltage is increased, however, power loss would not decrease, thus the efficiency remains unchanged. (Although power output increases, but power input also increases to give the same efficiency.)

✓ (2) If laminated iron core is used, eddy current can be reduced, thus power loss is reduced.

✓ (3) If thicker copper wire is used, the resistance of the coils is reduced, thus heating effect of current in the two coils is reduced, so power loss is reduced.

24. B

× (1) Voltage across bulb = 12 V ≠ 6 V, thus the bulb cannot work at its rated value.

× (2) Resistance of the light bulb : $R = \frac{V_r^2}{P_r} = \frac{(6)^2}{(6)} = 6\ \Omega$

Equivalent resistance of the bulb and the left resistor = $\frac{6}{2} = 3\ \Omega$

Thus, voltage across the light bulb is 4 V, the light bulb cannot work at its rated value.

✓ (3) Secondary voltage : $V_S = \frac{100}{200} \times 12 = 6\text{ V}$ ∴ the light bulb work at its rated value.

25. D

✓ (1) The output voltage is 12 V ∴ each light bulb shares 6 V ∴ work at rated values

✓ (2) Two intervals give an output voltage of 6 V ∴ work at rated values

✓ (3) Each light bulb is connected across two intervals ∴ each has an voltage of 6 V ∴ work at rated values

26. A

For the lamp to operate at its rated value, the current through the lamp should be $\frac{24}{6} = 4$ A

As it is a step down transformer, the current through the wire *ABCD* should be $\frac{4}{20} = 0.2$ A

Power loss in the cables = $I^2R = (0.2)^2(10) = 0.4$ W

27. D

✓ (1) Power transmission needs transformers for stepping up and down, and transformers work on a.c. only

✓ (2) For a give transmitted power, $P = VI$, thus current I is reduced if voltage V is increased.

✓ (3) By $P_{loss} = I^2R$, reduced current resulting from high voltage gives smaller power loss.

28. D

✓ (1) Since the voltage of a mobile phone is very low, about a few volts,
the adaptor must contain a step-down transformer for stepping down the voltage.

✓ (2) Since the battery of a mobile phone is d.c., the adaptor must convert the a.c. voltage of the mains to d.c.

✓ (3) Since transformer would give out heat when it operates,
black colour can increase the radiation of heat since black surface is a good emitter of heat.

29. C

(1) Since the secondary voltage of the transformer remains unchanged,
the power dissipated by bulb *X* is unchanged, thus the brightness of *X* remains unchanged.

(2) Since secondary current is decreased, by $\frac{I_S}{I_P} = \frac{N_P}{N_S}$ = constant, primary current should also decrease.

30. B

× (1) By $V_S : V_P = N_S : N_P$, if the number of turns of the primary coil is doubled,
the output voltage would change from 6 V to 3 V.

× (2) Since the output voltage is doubled, by $P_{out} = V_S^2 / R$, output power P_{out} becomes 4 times.
As there is no power loss, $P_{in} = P_{out}$, thus input power P_{in} also becomes 4 times.
By $P_{in} = V_P I_P$, as V_P is unchanged, I_P should be 4 times.

✓ (3) By $P = V_S^2 / R$, when V_S is doubled, the output power becomes 4 times.

31. A

Since the transformer is ideal, the efficiency is 100%, i.e. power input is equal to power output.

∴ $V_P I_P = V_S I_S$

∴ $(220\text{ V})\, I_P = (12\text{ V})(100\text{ mA})$ ∴ $I_P = 5.45\text{ mA} \approx 5.5\text{ mA}$

32. A

Assume the maximum number of light bulbs is n. The maximum primary current is 5 A which is limited by the fuse.

$$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{out}}{V_P I_P}$$

∴ $(90\%) = \frac{40\,n}{(220)(5)}$ ∴ $n = 24.75$

The maximum number of light bulbs should be 24 so that the fuse would not blow.

33. C

The metal core should use iron so that there is good magnetic flux linkage between the two coils.

To give larger voltmeter reading, the transformer should be stepped up.

Thus, number of turns in coil *A* is 500 and number of turns in coil *B* is 1000 can give the largest voltmeter reading.

34. A

Before *S* is open, L_1 is shorted and thus only L_2 lights up. The resistance is *R*.
After *S* is open, both lamps light up and the equivalent resistance is 2*R*, thus the secondary current decreases.

✓ A. Since $I_S : I_P = N_P : N_S$, with the same turns ratio, the decrease of I_S gives the decrease of I_P.

× B. The secondary voltage should remain unchanged as it depends on the turns ratio and V_P only.

× C. The brightness of L_1 should increase as it is not lit up initially.

× D. The brightness of L_2 should decrease as the current flowing through it is decreased.

35. B

✓ (1) Since transformers work on a.c., thus a.c. voltage can be changed easily.

× (2) Electrical power is transmitted with the speed of light, and is independent of the voltages.

✓ (3) By using high voltage, current in cables is reduced, thus less power is lost in the transmission cables.

36. B

$I = \dfrac{P}{V} = \dfrac{1200\times10^3}{132000} = 9.09\text{ A}$

$P_{out} = P_{in} - P_{loss} = P_{in} - I^2R$

$= (1200\times10^3) - (9.09)^2(550) = 1.155\times10^6\text{ W} = 1155\text{ kW}$

37. D

$I = \dfrac{P}{V} = \dfrac{(10\times10^3)}{(500)} = 20\text{ A}$

Voltage across the cables $= (20)\times(0.2) = 4\text{ V}$

E.m.f. produced by generator $= 500 + 4 = 504\text{ V}$

38. D

Since the voltage is directly proportional to the number of turns,

$N_{PQ} : N_{RS} : N_{ST} = 240 : 4 : 8 = 60 : 1 : 2$

If $V_{ST} = 6\text{ V}$, then $V_{PQ} : V_{RS} : 6 = 60 : 1 : 2$

$\therefore V_{PQ} = 180\text{ V}$ and $V_{RS} = 3\text{ V}$

39. C

For d.c. : $P_1 = \dfrac{V^2}{R} = \dfrac{(10)^2}{R}$

For a.c. : $P_2 = \dfrac{V_{rms}^{\ 2}}{R}$

$\dfrac{P_1}{P_2} = \dfrac{(10)^2}{V_{rms}^{\ 2}} = 2$ $\therefore V_{rms} = 7.07\text{ V}$

Peak voltage : $V_o = \sqrt{2}\,V_{rms} = \sqrt{2}\times7.07 = 10\text{ V}$

40. D

✓ (1) Transformers work on a.c. efficiently.

✓ (2) By $P = VI$, for the same P, higher V means that smaller transmission current I.

✓ (3) By $P_{loss} = I^2R$, smaller I means that P_{loss} can be reduced.

41. B

For d.c. : $P = \dfrac{V^2}{R}$ $\therefore (P) = \dfrac{(10)^2}{R}$

For a.c. : $P = \dfrac{V_{rms}^{\ 2}}{R}$ $\therefore (\tfrac{1}{2}P) = \dfrac{V_{rms}^{\ 2}}{R}$

Combine the two equations : $\dfrac{1}{(\frac{1}{2})} = \dfrac{(10)^2}{(V_{rms})^2}$ $\therefore V_{rms} = 5\sqrt{2}\text{ V}$

42. A

By $V_{r.m.s.} = \dfrac{V_o}{\sqrt{2}}$

Thus, if the peak voltage is halved, the r.m.s. voltage is also halved.

43. D

$\eta = \dfrac{P_{out}}{P_{in}} = \dfrac{P_{out}}{V_P I_P} = \dfrac{(22\times2)}{(220)(0.25)} = 80\%$

44. A

✓ (1) Peak voltage : $V_o = \sqrt{2}\,V_{rms} = \sqrt{2}\times110 = 156\text{ V}$

✓ (2) Power : $P = V_{rms}^{\ 2}/R = (110)^2/(100) = 121\text{ W}$

× (3) Since $P \propto V^2$, if V doubles, power P should be 4 times.

45. D

By $\eta = \dfrac{P_{out}}{P_{in}} = \dfrac{P_{out}}{V_{in}I_{in}}$

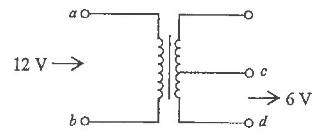
$\therefore 70\% = \dfrac{(1.5\times10)}{(220)I_P}$

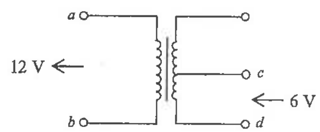
$\therefore I_P = 0.097\text{ A}$

46. B

For the **transformer**, if the input voltage 12 V a.c. is applied across *ab*, the output voltage across *ab* is 6 V.

Thus, the turns ratio is 12 : 6 = 2 : 1 and it is a step-down transformer.

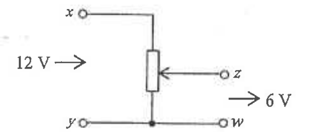


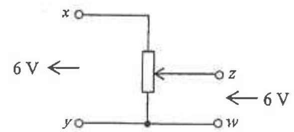


If the input voltage is 6 V a.c. across *cd*, since now the turns ratio is 1 : 2,

the output voltage across *ab* is 12 V and it becomes a step-up transformer.

For the **potential divider**, if the input voltage 12 V a.c. is applied across *xy*, the output voltage across *zw* is 6 V.





If the input voltage 6 V is applied across *zw*, since current only flows through the lower part of the resistor,

no current flows to the upper part of the resistor, the voltage across the upper part of the resistor is 0 V,

thus, the voltage across *xy* is still 6 V.

The following list of formulae may be found useful :

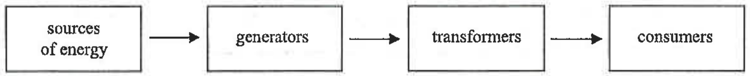
Power in a circuit $P = IV = I^2 R$

Ratio of secondary voltage to primary voltage in a transformer $\frac{V_P}{V_S} \approx \frac{N_P}{N_S}$

Part A : HKCE examination questions

1. **< HKCE 1980 Paper I - 9 >**

The figure below is a block diagram showing how electric power is supplied to consumers.

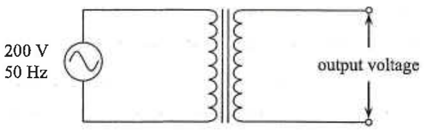


(a) One source of energy is from wind. State the conversion of energy in the generators and describe how the energy conversion is possible. (3 marks)

(b) Why is the efficiency of a transformer always less than 100% ? Mention one method of improving transformer efficiency. (4 marks)

(c) Explain why a 40 W fluorescent tube appears to be brighter than a 40 W filament lamp. (2 marks)

2. **< HKCE 1981 Paper I - 7 >**



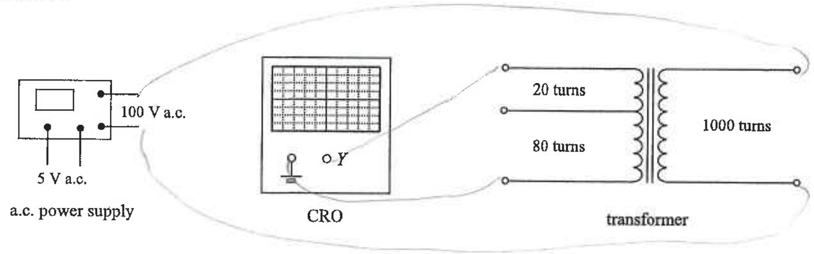
The primary coil of a transformer is connected to a 200 V, 50 Hz a.c. mains supply. Suppose the primary coil has 2000 turns and the secondary coil has 100 turns.

(a) Find the output voltage across the secondary coil. (3 marks)

2. (b) Find the frequency of the output voltage. (1 mark)

3. **< HKCE 1982 Paper I - 9 >**

The following pieces of apparatus (as shown in the below figure) are provided : an a.c. power supply, a C.R.O. and a transformer.



In the above diagram, show how you would connect the above pieces of apparatus to display a 10 V a.c. on the CRO. (6 marks)

4. **< HKCE 1983 Paper I - 7 >**

(a) 22000 W of electrical power are transmitted through a cable with a resistance of 0.5 Ω at 11000 V.

(i) Find the current passing through the cable. (2 marks)

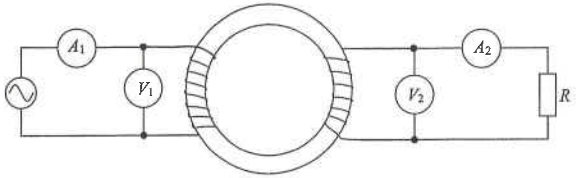
(ii) Find the power lost in the cable during transmission. (3 marks)

(iii) Why should a high voltage be used in power transmission ? (2 marks)

(b) Describe briefly how an alternating current of 11000 V can be stepped down to 200 V. (2 marks)

5. < HKCE 1987 Paper I - 8 >

The figure shows an arrangement to study the input and output characteristics of a transformer.



The readings of the ammeters and voltmeters are as follows:

Reading of A_1 = 2.5 A

Reading of A_2 = 1.8 A

Reading of V_1 = 12 V

Reading of V_2 = 2 V

(a) (i) Calculate the power input of the transformer. (1 mark)

(ii) Calculate the power output of the transformer. (1 mark)

(iii) Calculate the efficiency of the transformer. (1 mark)

(b) Suppose R is now replaced by another resistor of higher resistance.

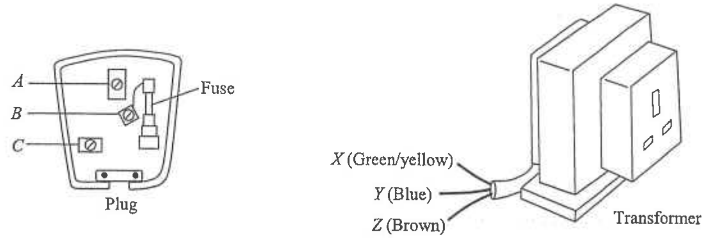
(i) How would the reading of the ammeter A_1 change ? (1 mark)

(ii) How would the reading of the ammeter A_2 change ? (1 mark)

(c) Suggest TWO changes in the transformer which will improve its efficiency. In each case, give ONE reason to support your suggestion. (4 marks)

6. < HKCE 1990 Paper I - 7 >

The below figure shows a 3-pin electrical plug and a transformer. The three wires X, Y, Z of the transformer are to be connected to the plug. The plug will be connected to a 200 V a.c. power supply. The output voltage of the transformer will be 110 V. Assume the transformer is 100% efficient.



(a) (i) To which of the terminals A, B, and C of the plug should each of the wires X, Y and Z be connected ? (2 marks)

(ii) Explain briefly why the fuse should be connected to the terminal B. (2 marks)

(iii) Suggest one reason why it is necessary to have the X-wire connection. (2 marks)

(iv) Find the turns ratio (primary coil to secondary coil) of the transformer. (2 marks)

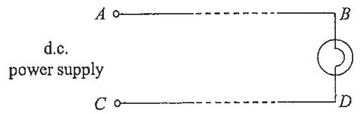
(b) An iron of rated values "110 V, 1100 W" is connected to the output of the transformer and switched on for half an hour.

(i) Calculate the current drawn from the transformer by the iron. (2 marks)

(ii) Calculate the cost of electricity if one kilowatt-hour of electrical energy costs 80 cents. (2 marks)

(iii) If fuses marked 1 A, 3 A and 7 A are available, which one is most appropriate to be used in the plug in the figure ? Explain your choice. (3 marks)

7. < HKCE 1995 Paper I - 5 >



Two long wires AB and CD of total resistance 4 Ω are used to connect a d.c. power supply to a lamp. The lamp is working at its rated value '12 V, 24 W'.

(a) Find

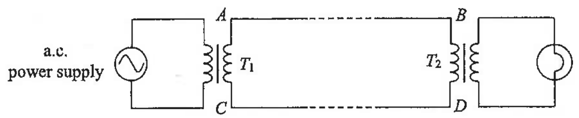
(i) the resistance of the lamp, (2 marks)

(ii) the current flowing through the lamp, (2 marks)

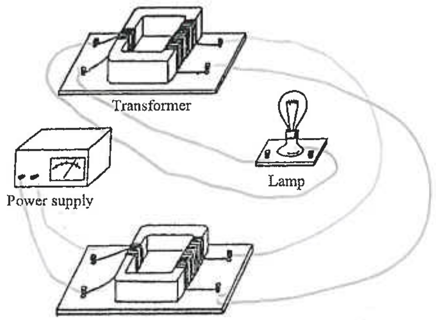
(iii) the power loss in the wires, (2 marks)

(iv) the efficiency of the circuit supplying power to the lamp. (2 marks)

(b) To reduce the power loss in the wires, an a.c. power supply and two transformers are used as shown in the figure below.



(i) In the figure below, draw wires to connect the terminals of the components according to the figure above. (3 marks)

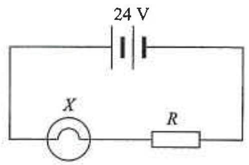


(ii) Explain how the arrangement can reduce the power loss in the wires. (3 marks)

8. < HKCE 1997 Paper I - 7 >

Two students suggest using a 24 V d.c. supply and a 24 V a.c. supply separately to operate a lamp X rated at '6 V, 12 W'.

(a)



A student connects X in series with a 24 V d.c. supply and a resistor R (see the Figure above). If X works at its rated value,

(i) find the current flowing through X, (2 marks)

(ii) find the voltage drop across R, (1 mark)

(iii) find the resistance of R, (2 marks)

(iv) what percentage of the electric power provided by the d.c. supply is dissipated in R ? (3 marks)

(b) The other student suggests that X can also be made to work by using a 24 V a.c. supply together with a transformer.

(i) Draw a circuit diagram to show how X, the a.c. supply and the transformer are connected. (2 marks)

(ii) What is the advantage of using this method over the one shown in the above Figure ? (1 mark)

(iii) Determine the turns ratio (primary to secondary) of the transformer for X to work at its rated value, and calculate the primary current if the transformer is 100% efficient. (4 marks)

9. **< HKCE 2000 Paper I - 10 >**

(a) A transformer is used to operate a '110 V, 1000 W' electric cooker at its rated value from the 220 V a.c. mains supply in Hong Kong. The primary coil of the transformer has 5000 turns and the efficiency of the transformer is 80%. Find

(i) the number of turns in the secondary coil of the transformer, (2 marks)

(ii) the operating resistance of the cooker, (2 marks)

(iii) the power input of the transformer, (2 marks)

(iv) the current flowing in the primary coil of the transformer. (2 marks)

(b) Figure 1 shows a travel cooker and the label attached on it. The cooker has a voltage selector switch shown in Figure 2.

Model No : EA 2000
a.c. 120 V / 240 V
360 W
~ 50-60 Hz

Figure 1

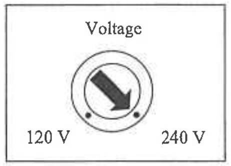


Figure 2

(i) A fuse is installed in the cooker. Explain the function of the fuse. (2 marks)

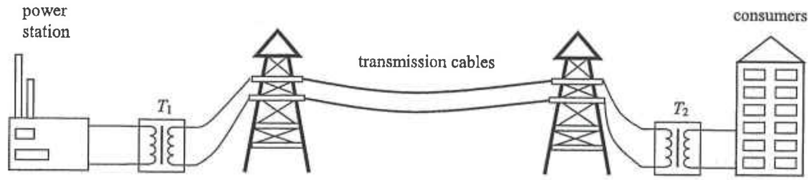
(ii) Two students make the following remarks about using the cooker in Hong Kong :

John: The voltage selector switch should be set to 120 V and the output of the cooker would be 360 W.

Peter : The voltage selector switch should be set to 240 V and the output of the cooker would be less than 360 W.

Explain whether each of the above remarks is correct. (4 marks)

10. **< HKCE 2001 Paper I - 5 >**

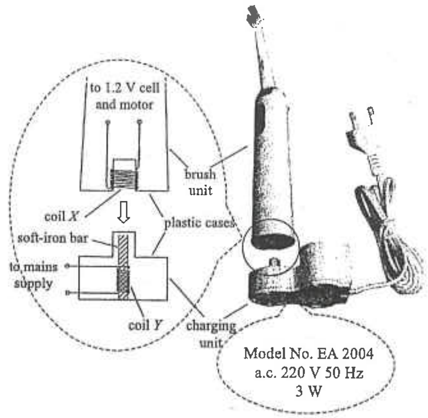


The above figure shows how electrical power generated in a power station is transmitted over long distances to consumers.

(a) State the function of the transformer T_1. (1 mark)

(b) Explain why a.c. and high voltages are used for long distance power transmission. (3 marks)

11. **< HKCE 2004 Paper I - 10 >**



The Figure above shows an electric toothbrush. It consists of a brush unit and a charging unit.

11. (a) Inside the brush unit, there is a 1.2 V rechargeable cell for driving a motor. When the toothbrush is in operation, the current flowing through the motor is 1.8 A. Calculate

(i) the power consumed by the motor, and

(ii) the energy consumed by the motor in 3 minutes. (4 marks)

(b) When the energy stored in the cell has been used up, the brush unit is placed on the charging unit to recharge the cell. The charging unit is connected to the mains supply and its label is also shown in the above Figure. It takes 16 hours to recharge the cell fully. Calculate the energy drawn by the charging unit from the mains supply in 16 hours. (2 marks)

(c) The cell inside the brush unit is connected to coil X located at the bottom of the unit. Another coil Y is located inside the charging unit with a soft-iron bar fixed inside it. When the brush unit is placed on the charging unit, the soft-iron bar lies inside coil X.

(i) The brush unit and the charging unit are completely covered by plastic cases and there is no metal contact between them. Explain how a current is produced in the brush unit to recharge the cell. (3 marks)

(ii) If coil Y has 11 000 turns, estimate the number of turns of coil X. Assume the output voltage of coil X is 3 V a.c. (2 marks)

(iii) State the function of the soft-iron bar. (1 mark)

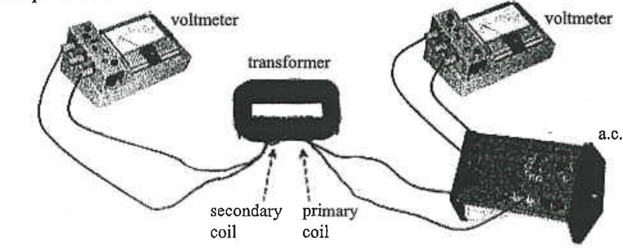
(d) The charging unit is fitted with a two-pin plug as shown in the above Figure.

(i) To which two wires of the mains supply should the pins of the plug be connected ? (1 mark)

(ii) Suggest one reason why it is safe for the charging unit to be fitted with a two-pin plug. (1 mark)

12. **< HKCE 2005 Paper I - 12 >**

Figure 1



Josephine conducts an investigation on transformers. She sets up a circuit as shown in Figure 1.

(a) Josephine varies the input voltage V_1 to the transformer and records the corresponding output voltage V_2. The results are shown in Table 1. In Figure 2, plot a graph of V_2 against V_1.

Hence draw a conclusion for this investigation.

V_1 / V	V_2 / V
1.0	1.7
2.0	3.3
3.0	5.1
4.0	6.9

Table 1

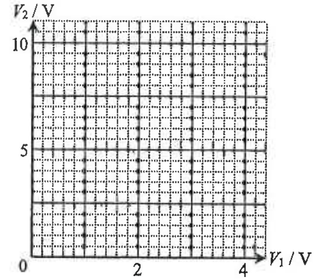


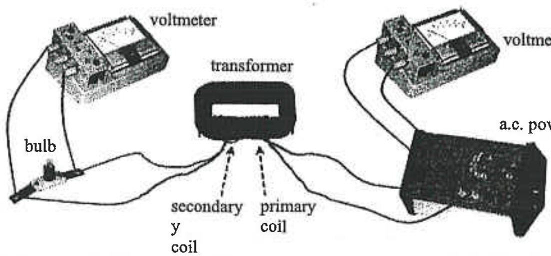
Figure 2

(2 marks)

(b) Josephine wants to study the relationship between the output voltage and the number of turns in the secondary coil of the transformer. Describe how she can conduct the experiment. (2 marks)

(c)

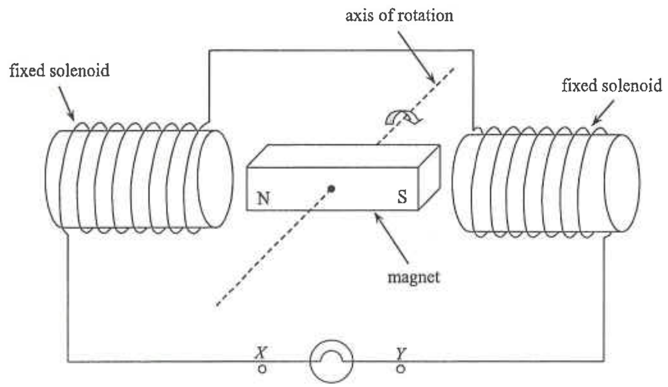
Figure 3



Josephine adds a bulb to the circuit as shown in Figure 3 above. Suggest a method that Josephine can use to estimate the efficiency of the transformer. Additional apparatus may be used if necessary. (3 marks)

13. **< HKCE 2007 Paper I - 12 >**

The Figure below shows a setup to generate electricity. A magnet is set into rotation between two fixed solenoids. The output terminals *X* and *Y* are connected to a light bulb.



(a) Explain how alternating current is generated in the above setup. (3 marks)

(b) The bulb is now removed from the setup. *X* and *Y* are then connected to the primary coil of a transformer. The secondary voltage output of the transformer is found to be 12 V. If the turns ratio of the primary coil to the secondary coil is 1 : 8, find the primary voltage. (2 marks)

(c) State the advantages of using

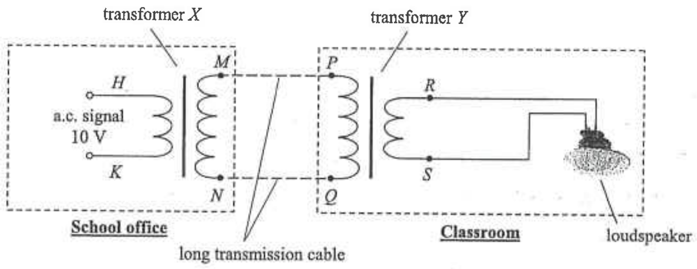
(i) a.c., and

(ii) high voltages

for long distance power transmission. (2 marks)

14. **< HKCE 2009 Paper I - 12 >**

The Figure below shows the power transmission of a bell system in a school. A signal generator in the school office produces a 10 V a.c. signal and is connected to *HK* as shown in the figure. The signal is then stepped up to 100 V and transmitted to a classroom through a long transmission cable. Assume all transformers are 100% efficient.



(a) The primary coil of transformer *X* has 500 turns. Find the number of turns in the secondary coil. (1 mark)

(b) Each wire of the transmission cable, *MP* and *NQ*, has a resistance of 80 Ω. Assume the current through the wires is 0.1 A.

(i) Find the voltage across *MP*. (2 marks)

(ii) Find the voltage across *PQ*. (1 mark)

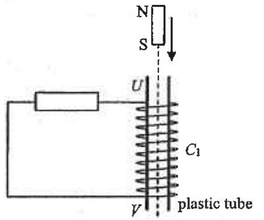
(iii) Find the power delivered to the loudspeaker. (2 marks)

(c) Suggest **TWO** methods to increase the power delivered to the loudspeaker with the same 10 V a.c. signal. (2 marks)

15. **< HKCE 2011 Paper I - 10 >**

(a) A magnet is dropped through a copper coil C_1 as shown in Figure (a). C_1 is connected to a resistor.

Figure (a)

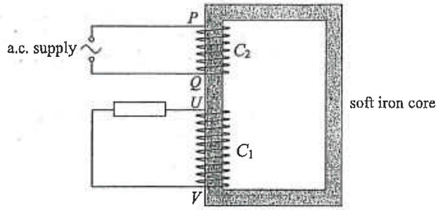


(i) What is the magnetic pole induced at end U of C_1 as the magnet approaches it ? (1 mark)

(ii) If the resistor is disconnected and the circuit becomes open, it is found that the magnet passes through C_1 in shorter time. Explain this phenomenon. (2 marks)

(b) Now, C_1 and another copper coil of smaller number of turns, C_2, are wound on a soft iron core as shown in Figure (b) to make a transformer. C_2 is connected to an a.c. supply.

Figure (b)

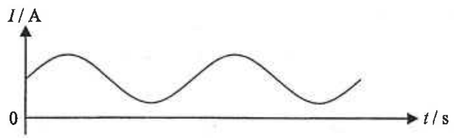


(i) What is the use of the transformer ? (1 mark)

(ii) Suggest **two** ways to improve the efficiency of the transformer. (2 marks)

(iii) Another power supply is connected to PQ to replace the a.c. supply. The variation of the current through C_2 with time is shown in Figure (c). A current flowing from P to Q through C_2 is taken as positive.

Figure (c)



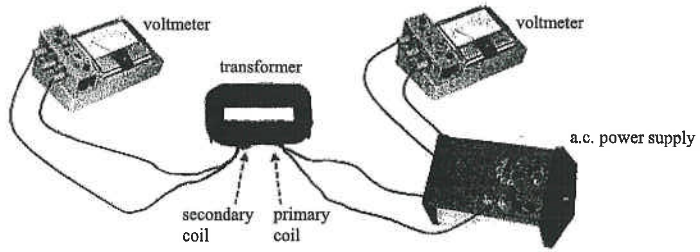
Tom claims that no induced current will be produced in C_1 as the current in C_2 has no change in direction. Comment on whether Tom's claim is correct or not. (3 marks)

Part B : HKDSE examination questions

16. **< HKDSE Sample Paper IB - 13 >**

Josephine conducts an investigation on transformers. Primary and secondary coils are wound on two soft-iron C-cores to form a transformer. She set up a circuit as shown in Figure 1.

Figure 1



(a) Josephine varies the input voltage V_1 to the transformer and records the corresponding output voltage V_2. The results are shown in Table 1. Figure 2 shows the graph of V_2 against V_1. Draw a conclusion for this investigation. (1 mark)

V_1 / V	V_2 / V
1.5	2.5
3.0	5.1
4.5	7.6
6.0	10.0

Table 1

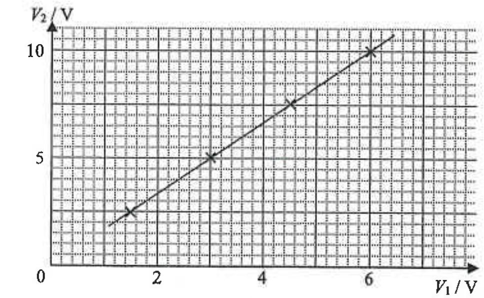


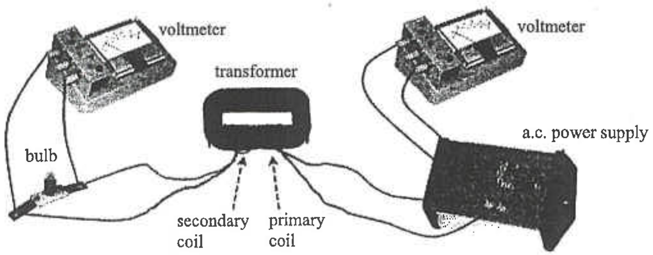
Figure 2

(b) Deduce the value of V_2 that will be produced when V_1 equals 8.0 V. (1 mark)

(c) Josephine wants to study the relationship between the output voltage and the number of turns in the secondary coil of the transformer. Describe how she can conduct the experiment. (2 marks)

16. (d)

Figure 3



Josephine adds a bulb to the circuit as shown in Figure 3 above. Suggest how Josephine can estimate the efficiency of the transformer. State the measurement(s) she must take. Additional apparatus may be used if necessary. (3 marks)

17. **< HKDSE Practice Paper IB - 10 >**

Read the following passage about ignition coils and answer the questions that follow.

Ignition coil

An ignition coil is used to produce sparks from the battery of a car to ignite the fuel in the engine. It is used to produce high-voltage pulses from a low-voltage d.c. supply.

An ignition coil consists of two coils of insulated copper wire that are wound around a common iron core. One coil, called the primary coil, is made from relatively few (tens or hundreds) turns of thick copper wire. The other coil, called the secondary coil, typically consists of many (thousands) turns of thin copper wire.

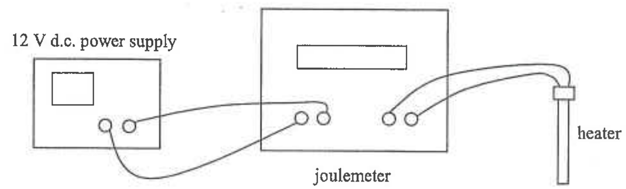
When an electric current is passes through the primary coil, a magnetic field is created. The iron core guides most of the primary coil's magnetic field to the secondary coil. When the current in the primary coil is suddenly interrupted, a high voltage pulse of many thousand volts is developed across the secondary coil. This voltage is then sufficient to cause an electrical discharge to produce a spark.

(a) Explain why a voltage is developed across the secondary coil when the current in primary coil is suddenly interrupted. (2 marks)

(b) Suggest **one** reason why the voltage developed across the secondary coil is very large. (1 mark)

(c) Assume input power to the primary coil equals to the output power of the secondary coil, explain why thick wire should be used to construct the primary coil. (2 marks)

18. **< HKDSE Practice Paper IB - 9 >**



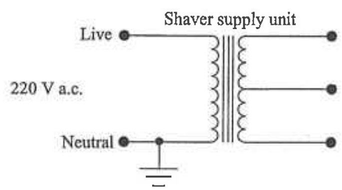
Suppose now the heater is connected to a sinusoidal a.c. power supply. The peak value of the voltage of the a.c. power supply is 15 V. How would the output power of the heater change ? (2 marks)

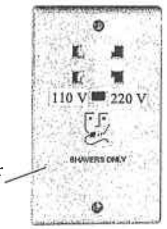
19. **< HKDSE 2012 Paper IB - 9 >**

Read the following description about the 'shaver supply unit' in bathrooms and answer the questions that follow.

The danger of electric shock is particularly high in bathrooms. Normal electric socket outlets should not be installed in bathrooms. As electric shavers and toothbrushes are becoming popular these days, a special unit, called 'shaver supply unit' is now common in bathrooms to provide electricity just for these low power consumption electric appliances (see the Figure).

The shaver supply unit consists of a transformer in which the secondary is not earthed and is completely isolated from the 220 V a.c. mains supply connecting to the primary. It can be used with 220 V or 110 V shavers.





Panel of shaver supply unit

(a) Explain why the chance of electric shock is high in bathrooms. (2 marks)

(b) Explain what would happen if the human body touches

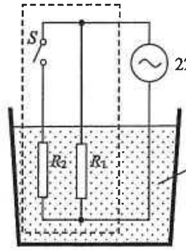
(i) the live wire of the mains supply in the primary circuit ; (2 marks)

19. (b) (ii) one of the conducting wires in the shaver circuit outlet. (2 marks)

(c) What is the turns ratio of the primary coil to the secondary coil of the transformer so as to provide 110 V ? (1 mark)

20. **< HKDSE 2012 Paper IB - 8 >**

In the circuit shown in the Figure, resistors R_1 and R_2 represent the heating elements in a heater using mains supply. Both resistors are immersed in water.



The heater can be operated in two modes, namely, heating and keeping warm, and it is controlled by the switch S. The power consumed by the heater in the heating mode is 550 W and in the mode of keeping warm is 88 W. The mains voltage is 220 V a.c.

(a) In which mode is the heater operating when switch S is open ? (1 mark)

(b) Find the resistance of R_1. (2 marks)

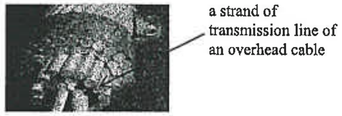
(c) When switch S is closed, calculate the current passing through resistor R_2. (3 marks)

(d) What is the *peak value* of the sinusoidal current flowing through the heater when switch S is closed ? (2 marks)

21. **< HKDSE 2015 Paper IB - 8 >**

Electricity generated from power plants are transmitted at a high voltage through overhead cables in suburban areas.

(a) Each overhead cable consists of 40 strands of identical transmission lines bundled together.



(i) One single strand of transmission line has a cross-sectional area of 1.3×10^{-5} m^2 and resistivity 2.6×10^{-8} Ω m. Find the resistance per km of a single strand of transmission line. (2 marks)

(ii) Explain why the resistance per km of an overhead cable is much smaller than that of a single strand of transmission line. Estimate the resistance per km of an overhead cable. (2 marks)

(iii) Hence, explain why a bird can stand with both feet on a high-voltage cable without getting an electric shock. (2 marks)

(b) Electrical power of 180 MW is transmitted at a voltage of 400 kV through an overhead cable.

(i) Calculate the current carried by the overhead cable. (2 marks)

(ii) Show that less than 0.1% of the electrical power is lost after transmitted through a total of 10 km of overhead cable. (2 marks)

(iii) As the voltage drop across this overhead cable is negligible, a voltage of 400 kV at the cable's end is stepped down by an ideal transformer with turns ratio 12 : 1.

(I) Find the secondary voltage from the transformer. (1 mark)

(II) State ONE factor leading to energy loss in a practical transformer and suggest the corresponding measure for improvement. (2 marks)

HKEAA's Marking Scheme is prepared for the markers' reference. It should not be regarded as a set of model answers. Students and teachers who are not involved in the marking process are advised to interpret the Marking Scheme with care.

Question Solution

1. (a) Energy conversion in a generator is from kinetic energy to electrical energy. [2]

It is achieved by the wind driving the coil into rotation inside a magnetic field. [1]

(b) There is energy loss due to eddy current. [2]

Use laminated core. [2]

OR

There is energy loss due to dissipation of energy by the resistance of the coils. [2]

Use thicker wires. [2]

(c) In a fluorescent tube, less energy is wasted as heat. [2]

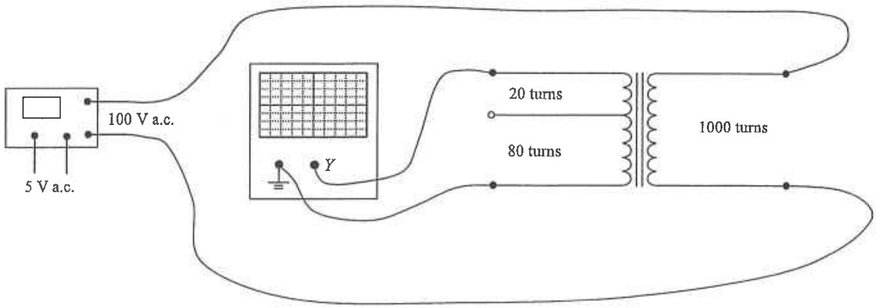
2. (a) $\dfrac{V_P}{V_S} = \dfrac{N_P}{N_S}$ [1]

$\therefore \dfrac{(200)}{V_S} = \dfrac{(2000)}{(100)}$ [1]

$\therefore V_S = 10\text{ V}$ [1]

(b) $f = 50\text{ Hz}$ [1]

3.



< Use 100 V a.c. > [1]

< Use 1000 turns as primary > [2]

< Use 100 turns as secondary > [2]

< Correct connection of the CRO > [1]

4. (a) (i) By $P = VI$ [1]

$(22000) = (11000)\,I \qquad \therefore I = 2\text{ A}$ [1]

(ii) Power loss $= I^2 R$ [1]

$= (2)^2 \times (0.5)$ [1]

$= 2\text{ W}$ [1]

(iii) To reduce the current in the transmission cables [1]

and thus reduce energy loss (**OR** power loss) during power transmission. [1]

(b) Use a step-down transformer [1]

with turns ratio $= N_P : N_S = 11000 : 200 = 55 : 1$ [1]

5. (a) (i) Power input $= 12 \times 2.5 = 30\text{ W}$ [1]

(ii) Power output $= 2 \times 1.8 = 3.6\text{ W}$ [1]

(iii) Efficiency $= \dfrac{3.6}{30} \times 100\% = 12\%$ [1]

(b) (i) A_1 decreases [1]

(ii) A_2 decreases [1]

(c) ① Use laminated core [1]
to reduce the eddy current induced in the core. [1]

② Use thicker wires for the coils [1]
to reduce the resistance and heating loss in the coils. [1]

6. (a) (i) X connected to A $\qquad$ Y connected to C $\qquad$ Z connected to B

< any ONE correct > [1]

< the other TWO correct > [1]

(ii) Any **ONE** of the following : [2]

* The fuse will blow and break the circuit if a fault develops.
* Terminal B will be connected to the live wire.

(iii) To prevent electric shock if a fault develops. [2]

(iv) Turns ratio $= \dfrac{200}{110}$ [1]

$= 1.82$ [1]

6. (b) (i) $P = VI$ [1]

$(1100) = (110)I$

$\therefore \quad I = 10$ A [1]

(ii) Energy = 1.1 kW × 0.5 h = 0.55 kWh [1]

cost = \$ 0.8 × 0.55 = \$ 0.44 [1]

(iii) $V_1 I_1 = V_2 I_2$ [1]

$(200) I_1 = (1100)$

$\therefore \quad I_1 = 5.5$ A [1]

The fuse marked 7 A should be used. [1]

7. (a) (i) $R = \frac{V^2}{P} = \frac{(12)^2}{24} = 6\ \Omega$ [2]

(ii) $I = \frac{P}{V} = \frac{(24)}{(12)} = 2$ A [2]

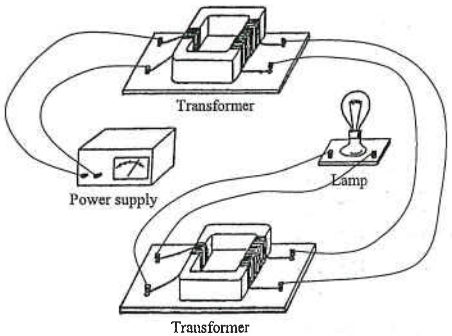
(iii) Power loss in the cables $= I^2 R = (2)^2 \times (4) = 16$ W [2]

(iv) Efficiency $= \frac{P_{out}}{P_{in}} \times 100\%$ [1]

$= \frac{24}{24+16} \times 100\%$

$= 60\%$ [1]

(b) (i) [3]



< Two wires connected from power supply to the left side of a transformer > [1]

< Two wires connected from the transformer to the right side of another transformer > [1]

< Two wires connected from the left side of the other transformer to the lamp > [1]

7. (b) (ii) Transformer T_1 steps up the voltage. [1]

The current through the cable is reduced. [1]

As power dissipated in the cables is equal to I^2R, so the power loss is reduced. [1]

8. (a) (i) Current through $X = \frac{P}{V} = \frac{12}{6}$ [1]

$= 2$ A [1]

(ii) Voltage drop across $R = 24 - 6 = 18$ V [1]

(iii) Resistance of $R = \frac{V}{I} = \frac{18}{2}$ [1]

$= 9\ \Omega$ [1]

(iv) Percentage $= \frac{2(18)}{2(24)} \times 100\%$ [2]

$= 75\%$ [1]

OR

Percentage $= \frac{2^2(9)}{2(24)} \times 100\%$ [2]

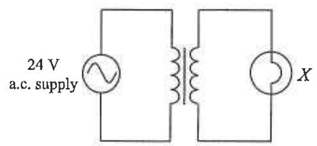
$= 75\%$ [1]

OR

Percentage $= \frac{2(18)}{2(18)+12} \times 100\%$ [2]

$= 75\%$ [1]

(b) (i)



< Correct connection of circuit > [1]

< Correct symbols > [1]

(ii) This method can reduce the power loss in the circuit. [1]

(iii) Turns ratio $= \frac{V_P}{V_S} = \frac{24}{6}$ [1]

$= 4$ [1]

Primary current $= \frac{P}{V} = \frac{12}{24}$ [1]

$= 0.5$ A [1]

9. (a) (i) $\dfrac{V_P}{V_S} = \dfrac{N_P}{N_S}$

$\therefore \dfrac{220}{110} = \dfrac{5000}{N_S}$ [1]

$\therefore N_S = 2500$ [1]

(ii) $P = \dfrac{V^2}{R}$ [1]

$\therefore (1000) = \dfrac{(110)^2}{R}$

$\therefore R = 12.1\ \Omega$ [1]

(iii) Efficiency $= \dfrac{\text{Output power}}{\text{Input power}} \times 100\%$ [1]

$(80\%) = \dfrac{1000}{P_{in}} \times 100\%$

$\therefore P_{in} = 1250$ W [1]

(iv) $P = VI$ [1]

$(1250) = I(220)$

$\therefore I = 5.7$ A [1]

(b) (i) If an excessive large current flows through the cooker [1]

the fuse will melt (blow) and breaks the circuit. [1]

(ii) John is not correct.

The selector switch should not be set to 120 V, as the applied voltage in Hong Kong is 220 V,

that is much higher than the rated voltage. [1]

The fuse of the cooker will blow. [1]

Peter is correct.

The switch should be set to 240 V, as applied voltage in Hong Kong is 220 V. [1]

Since the applied voltage is slightly less than 240 V, the output power would be less than 360 W. [1]

10. (a) T_1 is used to step up the voltage. [1]

(b) An a.c. voltage is used because it can be stepped up or down by transformers efficiently. [1]

Stepping up the voltage can reduce the current passing through the cables. [1]

This can reduce the power loss in the cables. [1]

[**OR** This can increase the efficiency of power transmission.]

11. (a) (i) $P = VI = (1.2) \times (1.8)$ [1]

$= 2.16$ W [1]

(ii) $E = Pt = (2.16) \times (3 \times 60)$ [1]

$= 388.8$ J (OR 389 J) [1]

(b) $E = Pt$

$= (3) \times (16 \times 60 \times 60)$ [1]

$= 172\ 800$ J (**OR** 173 000 J) (**OR** 173 kJ) [1]

(c) (i) When the charging unit is connected to the mains supply, an alternating current flows through coil *Y*. [1]

A changing magnetic field is set up in coil *Y* and hence in coil *X*. [1]

An induced voltage is set up in coil *X* to recharge the cell. [1]

(ii) By $\dfrac{V_P}{V_S} = \dfrac{N_P}{N_S}$

$\therefore \dfrac{220}{3} = \dfrac{11000}{N_S}$ [1]

$\therefore N_S = 150$

$\therefore$ Coil *X* has 150 turns. [1]

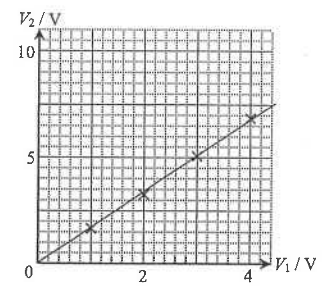
(iii) The soft iron bar can increase the strength of the magnetic field. [1]

(d) (i) The pins should be connected to the live and neutral wires. [1]

(ii) Any **ONE** of the following : [1]

* The charging unit has no metal case.
* The charging unit has a completely insulated plastic cover.
* The charging unit is double-insulated.

12. (a)



[1]

The output voltage V_2 is <u>proportional</u> to the input voltage V_1. [1]

12. (b) She should vary the number of turns of the secondary coil n_2, and measure the corresponding output voltage V_2. [1]
The input voltage V_1 and the number of turns of the primary coil n_1 should remain unchanged. [1]

(c) Josephine should use ammeters to measure the primary current I_1 and secondary current I_2, [1]
and calculate the input power $V_1 I_1$ and the output power $V_2 I_2$ [1]
The efficiency of the transformer can then be estimated by $\frac{V_2 I_2}{V_1 I_1} \times 100\%$ [1]

13. (a) The current is induced when the magnetic field between the two solenoids is changing. [1]
By Lenz's law, the induced current flows in a direction to oppose the change. [1]
When the magnet rotates towards a solenoid, the induced current flows in one direction,
and when the magnet rotates away from the solenoid, the induced current flows in the opposite direction. [1]

(b) $\frac{V_P}{V_S} = \frac{N_P}{N_S}$ [1]
$\frac{V_P}{(12)} = \frac{(1)}{(8)}$ $\therefore V_P = 1.5\text{ V}$ [1]

(c) (i) Easy to step up during transmission. [1]
(ii) Reduce power loss. [1]

14. (a) $N_S = 500 \times \frac{100}{10} = 5000$ [1]

(b) (i) $V = IR$ [1]
$= (0.1)(80) = 8\text{ V}$ [1]

(ii) $V_{PQ} = 100 - 8 - 8 = 84\text{ V}$ [1]

(iii) $P = VI$ [1]
$= (84)(0.1) = 8.4\text{ W}$ [1]

OR

$P = VI - I^2 R$ [1]
$= (100)(0.1) - (0.1)^2(80 \times 2) = 8.4\text{ W}$ [1]

(c) ① Deliver the power through the cable using a higher voltage.
(**OR** Increase the number of turns in the secondary coil of transformer X.) [1]

② Use thicker wires for the cable.
(**OR** Decrease the resistance of the cable.) [1]

15. (a) (i) South pole [1]

(ii) No induced current can flow in the open circuit. [1]
The magnet then passes through the solenoid without any resistive magnetic force. [1]

(b) (i) To step up the voltage. [1]

(ii) Use thicker wires in the coils. [1]
Use laminated core. [1]

(iii) As the magnitude of the current is varying, C_2 produces a varying magnetic field. [1]
C_1 will still experience changing magnetic field. [1]
Current will be induced in C_1 and hence, Tom's claim is wrong. [1]

16. (a) The output voltage V_2 is directly proportional to the input voltage V_1. < accept $V_2 \propto V_1$ > [1]

(b) $V_2 = 8.0 \times \frac{10}{6} = 13.3\text{ V}$ < accept 13.2 to 13.6 V > [1]

(c) The input voltage V_1 and the number of turns of the primary coil N_1 should remain unchanged. [1]
She should vary the number of turns of the secondary coil N_2 of the transformer,
and measure the corresponding output voltage V_2. [1]
The relationship can then be studied.

(d) Josephine may use ammeters to measure the primary current I_1 and secondary current I_2. [1]
She can then calculate the input power $V_1 I_2$ and the output power $V_2 I_2$. [1]
The efficiency can then be estimated by : efficiency $= \frac{\text{output power}}{\text{input power}} \times 100\%$. [1]

17. (a) When the primary current is suddenly interrupted, the magnetic field through the secondary coil changes. [1]
An e.m.f. is induced across the secondary coil. [1]

(b) The number of turns of the secondary coil is much larger than that of the primary coil. [1]
OR
The rate of change of magnetic flux is very large. [1]

(c) By $V_P I_P = V_S I_S$, as secondary voltage is higher, the primary current is larger. [1]
In order to minimize the heating effect of the primary current, thick wire of smaller resistance should be used. [1]

18. The r.m.s. voltage of the a.c. supply $= \frac{15}{\sqrt{2}} = 10.6\text{ V}$ [1]
This value is smaller than 12 V, thus the power output of the heater decreases. [1]

19. (a) In bathroom, humid air and mist contain much water that is a conductor. [1]

The water provides a conducting path between the human body and the source of electricity. [1]

OR

The water lowers the resistance between the human body and the source of electricity. [1]

(b) (i) The human body would get electric shock [1]

because current flows through the body to the Earth and returns to the Neutral wire. [1]

(ii) The human body will not get electric shock [1]

because there is no return path for the current (**OR** there is no complete circuit) [1]

(c) Turns ratio = 2 : 1 < accept turns ratio = 2 >

20. (a) keeping warm [1]

(b) $P = \frac{V^2}{R}$

$\therefore\ (88) = \frac{(220)^2}{R_1}$ [1]

$R_1 = 550\ \Omega$ [1]

(c) Power given out by the resistor $R_2 = 550 - 88 = 462$ W [1]

$P = VI$ [1]

$(462) = (220)\, I_2$

$\therefore\ I_2 = 2.1$ A [1]

OR

Total current $= \frac{P}{V} = \frac{(550)}{(220)} = 2.5$ A [1]

Current in $R_1 = \frac{(220)}{(550)} = 0.4$ A [1]

Current in $R_2 = 2.5 - 0.4 = 2.1$ A [1]

(d) Peak current $= \sqrt{2} \times 2.5$ [1]

$= 3.54$ A [1]

21. (a) (i) Consider a length of 1000 m

$R = \frac{\rho \ell}{A} = \frac{(2.6\times10^{-8})\times(1000)}{(1.3\times10^{-5})} = 2.0\ \Omega$ [1]

Resistance per km $= 2.0\ \Omega\ \text{km}^{-1}$ [1]

21. (a) (ii) The strands are connected in parallel. [1]

OR

The cross-sectional area of cable is greater than each of transmission line. [1]

Resistance of cable per km $= \frac{2.0}{40} = 0.05\ \Omega\ \text{km}^{-1}$ [1]

(iii) The resistance of the bird's body is much larger than that of the short segment of the overhead cable. [1]

OR

The potential difference across the feet is very small. [1]

Hence, negligible current flows through the bird's body. [1]

(b) (i) By $P = VI$ [1]

$\therefore\ (180 \times 10^6) = (400 \times 10^3)\, I$

$\therefore\ I = 450$ A [1]

(ii) $R = 0.05 \times 10 = 0.5\ \Omega$

$P_{loss} = I^2 R = (450)^2 \times (0.5) = 101\ 250$ W [1]

Percentage of power loss $= \frac{101250}{180\times10^6} \times 100\% = 0.05625\ \% < 0.1\ \%$ [1]

(iii) $V_S = 400 \times \frac{1}{12} = 33.3$ kV [1]

(iv) Heating loss due to the heating effect of current in the resistance of coils. [1]

Use thicker wires for the coils. [1]

OR

Power loss due to eddy current induced in the soft iron core. [1]

Use laminated soft iron core. [1]