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	$P = IV = I^2 R$

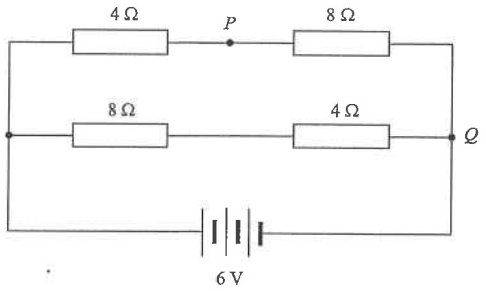
Use the following data wherever necessary :

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	$\varepsilon_o = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$

Part A : HKCE examination questions

1. < HKCE 1980 Paper II - 32 >

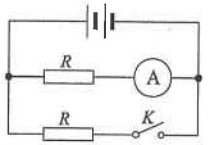
In the circuit shown, the battery has an e.m.f. of 6 V with negligible internal resistance. Four resistors are connected to the battery as shown in the figure.



What is the potential difference between points P and Q ?

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

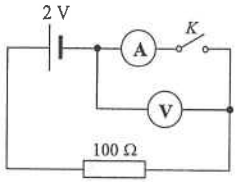
2. < HKCE 1980 Paper II - 38 >



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 ?

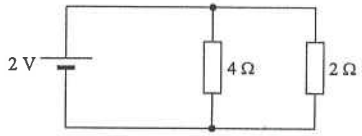
	K open	*K* closed
A.	0 V	0 V
B.	0 V	2 V
C.	1 V	1 V
D.	2 V	0 V

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.

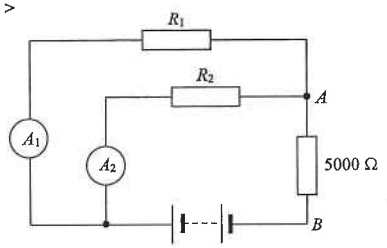
5. < HKCE 1981 Paper II - 29 >



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

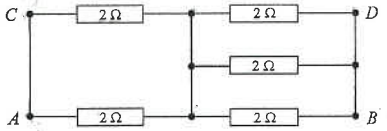
6. **< HKCE 1981 Paper II - 28 >**



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 >**

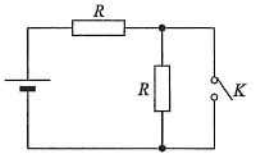


The diagram shows a network of resistors, where the resistance of each resistor is 2 Ω. What are the equivalent resistances across AB and AD respectively ?

	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. $4P$

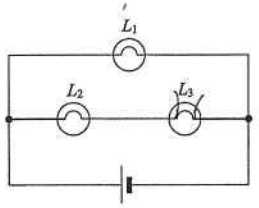
9. **< HKCE 1982 Paper II - 1 >**

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 >**



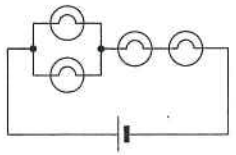
In the circuit shown, the cell has negligible internal resistance. If the lamp L_3 burns out, then

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

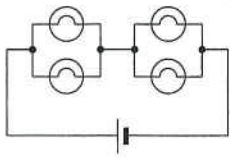
11. **< HKCE 1982 Paper II - 30 >**

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 ?

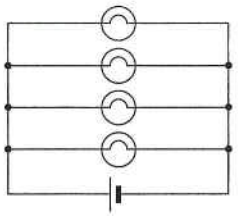
A.



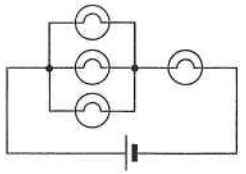
B.



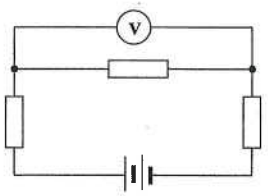
C.



D.



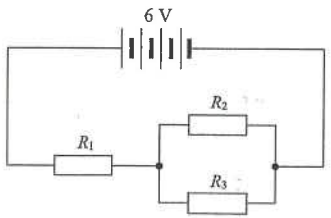
12. **< HKCE 1982 Paper II - 33 >**



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.

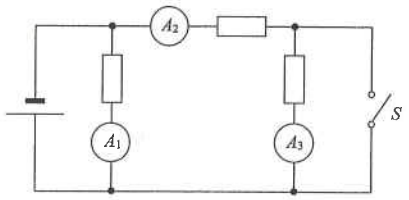
A. (1) only
B. (1) & (2) only
C. (1) & (3) only
D. (1), (2) & (3)

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

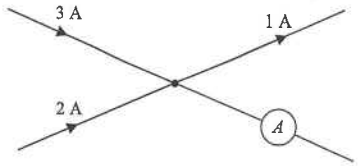
16. **< HKCE 1983 Paper II - 31 >**



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 >**

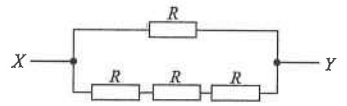
An immersion heater of resistance 50 Ω raises the temperature of 1 kg of water by 20°C in 3 minutes, the voltage supply being 200 V. What would be the energy wasted ?
(Specific heat capacity of water = 4.2 kJ kg^{-1} $°C^{-1}$)

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

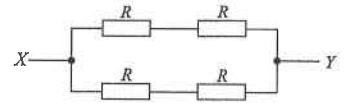
19. **< HKCE 1984 Paper II - 32 >**

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

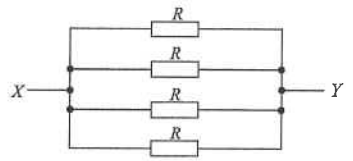
(a)



(b)



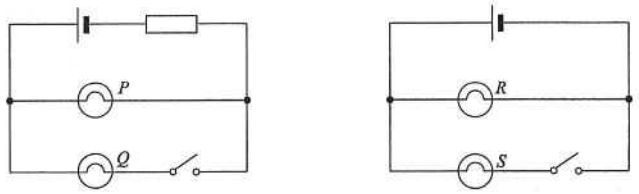
(c)



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)

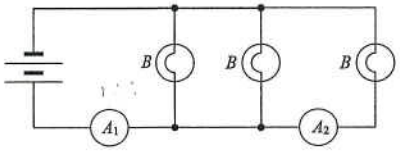
20. **< HKCE 1984 Paper II - 33 >**



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 >**

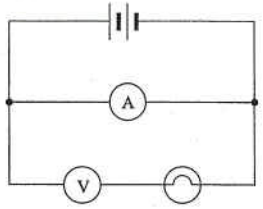
An immersion heater A takes 10 minutes to boil a kettle of water while another heater B takes 40 minutes to boil the same kettle of water under the same voltage supply. If the resistance of heater A is 100 Ω, what is the resistance of heater B ?

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.



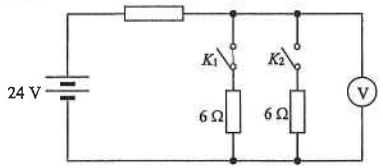
24. **< HKCE 1985 Paper II - 44 >**

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)

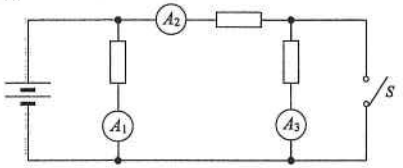
25. **< HKCE 1985 Paper II - 38 >**



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 >**



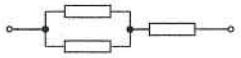
In the above circuit A_1, A_2 and A_3 are ammeters connected to a constant voltage source. What will happen to the readings of the ammeters if the switch S is closed ?

	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

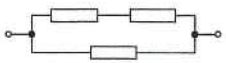
27. **< HKCE 1986 Paper II - 30 >**

Arrange the following circuits in ascending order of equivalent resistances :

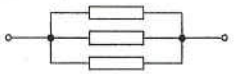
(1)



(2)

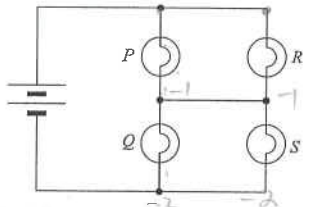


(3)



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

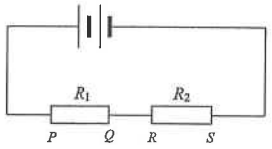
28. **< HKCE 1987 Paper II - 28 >**



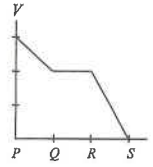
Four identical lamps P, Q, R and S are connected to a battery as shown above. If lamp P is blown, which of the following would happen ?

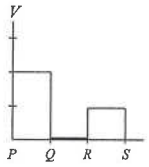
A. Lamp R becomes brighter.
B. Lamp Q becomes brighter.
C. Lamp S becomes brighter.
D. Lamps Q and S remain at the same degree of brightness.

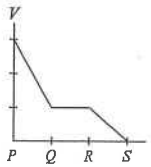
29. **< HKCE 1987 Paper II - 32 >**

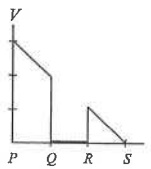


The above circuit shows two resistors R_1 and R_2 connected in series to a battery. The resistance of R_1 is greater than that of R_2. The ends of the resistors are marked P, Q, R and S. Which of the graphs best shows how the potential V varies along PS ?

A.


B.


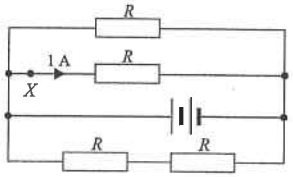
C.


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 ?

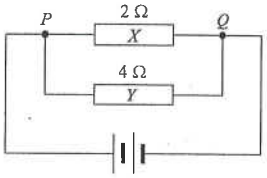
A. 1 A
B. 2 A
C. 2.5 A
D. 3 A



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 ?

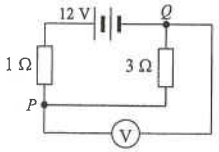
A. $E_1 = 4E_2$
B. $E_1 = 2E_2$
C. $E_1 = E_2$
D. $2E_1 = E_2$



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

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

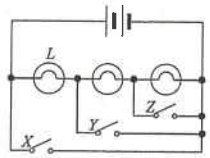
A. 3 V
B. 6 V
C. 9 V
D. 12 V



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 >**

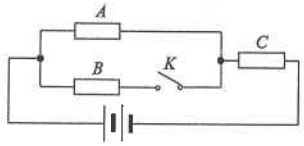
Two copper wires, A and B, of the same length have the ratio of mass of 4 : 9. Assuming the cross-sections are uniform, what is the ratio of the resistance of A to that of B ?

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

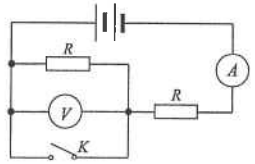
35. **< HKCE 1989 Paper II - 31 >**

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



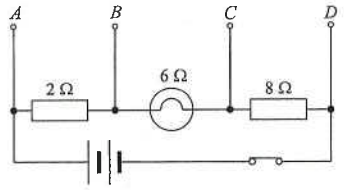
36. **< HKCE 1989 Paper II - 38 >**



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 ?

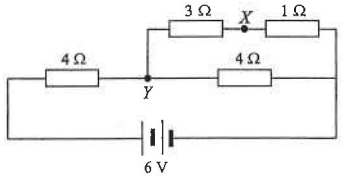
A. across *AB*
B. across *BC*
C. across *CD*
D. across *AD*

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. $2T$
D. $4T$

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



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

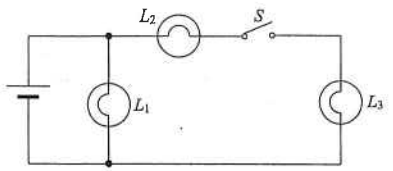
A. zero.
B. 1.5 V.
C. 3.0 V
D. 4.5 V.

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

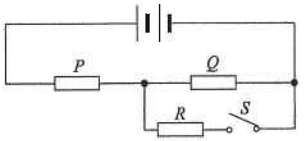
In the circuit shown, L_1, L_2 and L_3 are identical light bulbs. Which of the following statements is/are correct when the switch *S* is closed ?

(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 >**



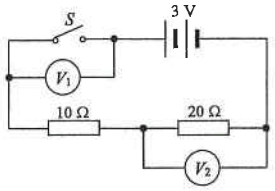
In the above circuit, *P*, *Q* and *R* are identical resistors. Which of the following is true when switch *S* is closed ?

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 ?

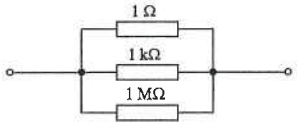
	Voltmeter V_1	Voltmeter V_2
A.	0 V	2 V
B.	0 V	3 V
C.	1 V	2 V
D.	3 V	0 V



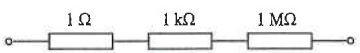
43. **< HKCE 1991 Paper II - 31 >**

The following diagrams show three networks consisting of different resistors.

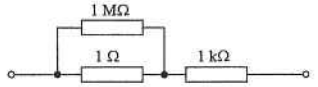
(1)



(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

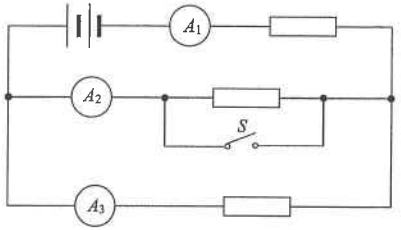
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only

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.

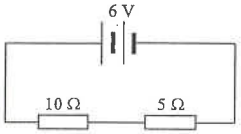
46. **< HKCE 1992 Paper II - 31 >**



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

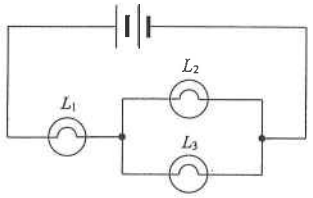
47. **< HKCE 1992 Paper II - 32 >**



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 >**

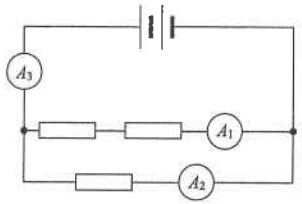


In the circuit, L_1 , L_2 and L_3 are identical light bulbs. Which of the following statements is/are true ?

(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 >**



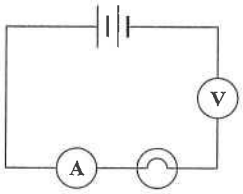
In the circuit shown above, all resistors are identical and the ammeters are of negligible resistance. If the readings of ammeter A_1 is 2 A, find the readings of ammeters A_2 and A_3 .

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

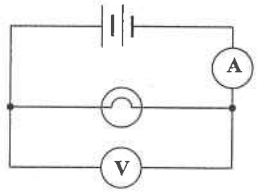
50. **< HKCE 1993 Paper II - 30 >**

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

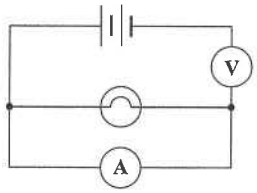
A.



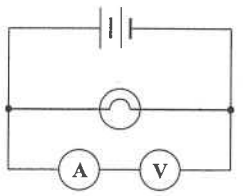
B.



C.

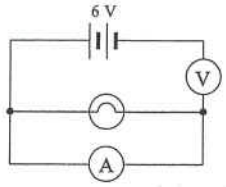


D.



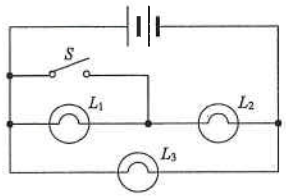
51. **< HKCE 1994 Paper II - 26 >**

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.

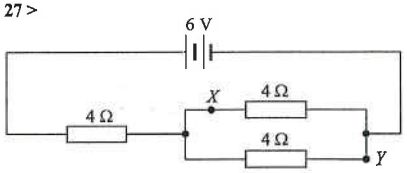
52. **< HKCE 1994 Paper II - 28 >**



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.

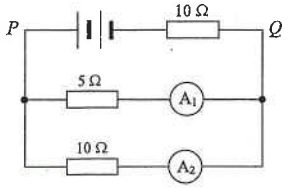
A. 0 V
B. 1 V
C. 2 V
D. 3 V

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

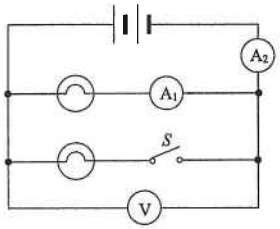
55. **< HKCE 1995 Paper II - 27 >**



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 >**

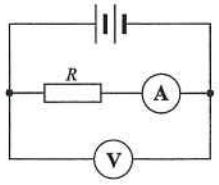
Which of the following pairs of physical quantities has the same units ?

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

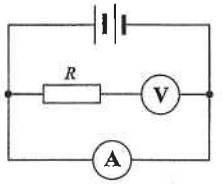
58. **< HKCE 1996 Paper II - 30 >**

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.

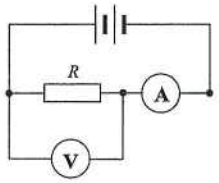
A.



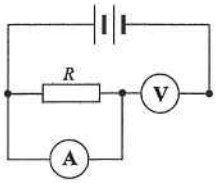
B.



C.



D.

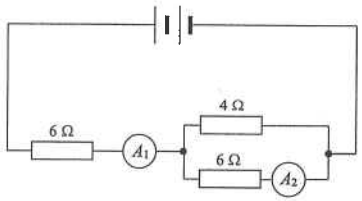


59. **< HKCE 1996 Paper II - 1 >**

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 >**

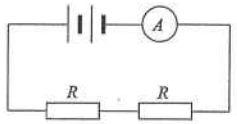


Figure (a)

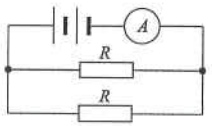


Figure (b)

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 >**

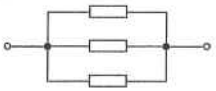
Which of the following expressions represents a physical quantity which is different from the others ?

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

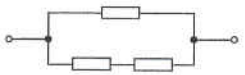
63. **< HKCE 1997 Paper II - 29 >**

All the resistors in the below networks are identical.

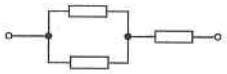
(1)



(2)



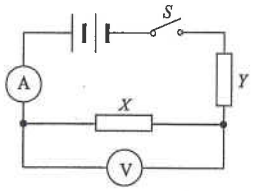
(3)



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)

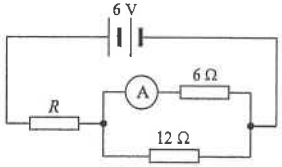
64. **< HKCE 1997 Paper II - 31 >**



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.

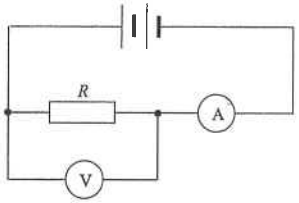
65. **< HKCE 1998 Paper II - 30 >**



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 >**



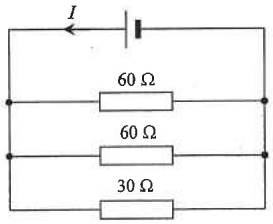
A student uses the above circuit to find the resistance of a resistor R (i.e. resistance $= \frac{\text{voltmeter reading}}{\text{ammeter reading}}$).

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

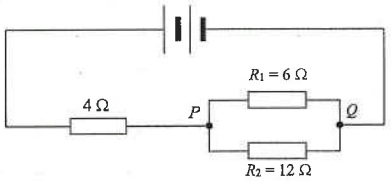
67. **< HKCE 1999 Paper II - 28 >**



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 >**

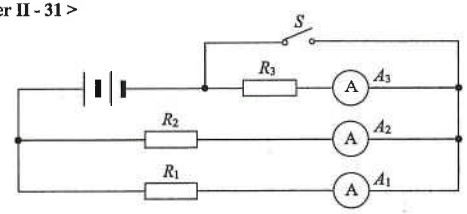


Three resistors are connected to a battery as shown above. Which of the following statements is/are correct ?

(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 >**

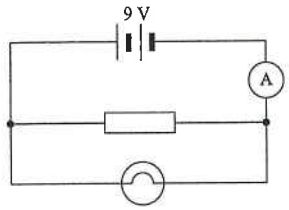


If switch S in the above circuit is closed, which of the following statements is/are correct ?

(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

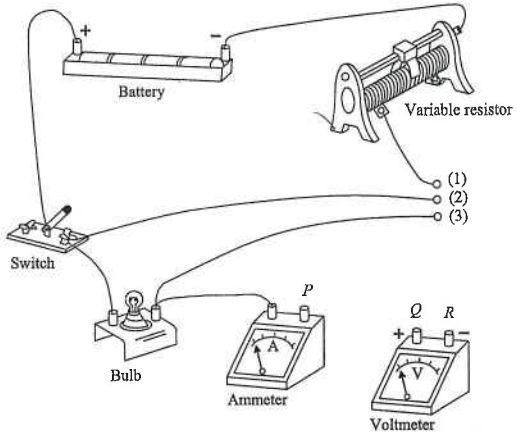
70. **< HKCE 2000 Paper II - 34 >**



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 ?

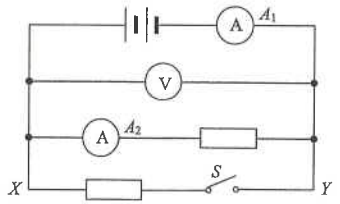
	Wire (1)	Wire (2)	Wire (3)
A.	P	Q	R
B.	P	R	Q
C.	Q	P	R
D.	R	P	Q

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 >**



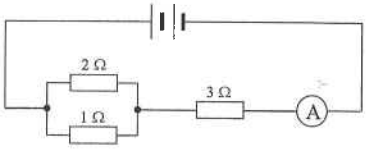
In the above circuit, the two resistors are identical. If switch S is closed, which of the following predictions is **incorrect** ?

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.

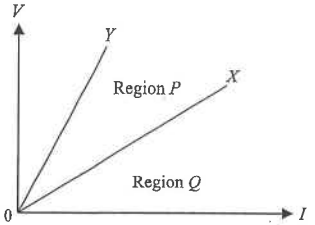
74. **< HKCE 2001 Paper II - 29 >**

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 ?

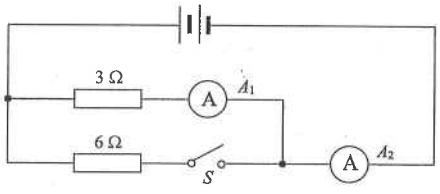
(1) The resistance of X is higher than that of Y.
(2) If X and Y are connected in series, the V-I graph of the combined resistor will lie in region P.
(3) If X and Y are connected in parallel, the V-I graph of the combined resistor will lie in region Q.

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 >**

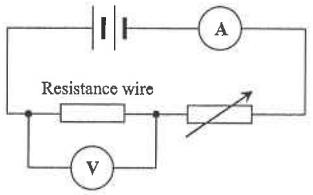


Figure (a)

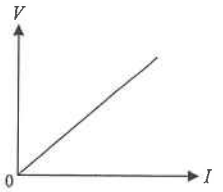
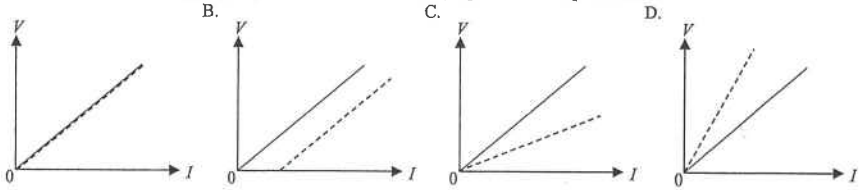


Figure (b)

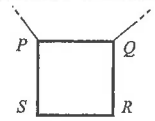
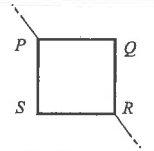
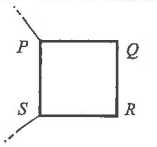
Figure (a) shows a circuit used to investigate how the voltage V across a resistance wire varies with the current I through the wire. The result is shown in Figure (b). If the experiment is repeated using a thinner wire of the same material and of equal length, which of the following graphs (denoted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

A. B. C. D.



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

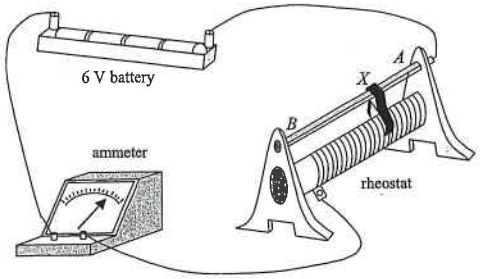
A square loop $P\ Q\ R\ S$ is made of uniform resistance wire. Let X, Y and Z be the equivalent resistance of the loop when connected as shown below :

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 >**



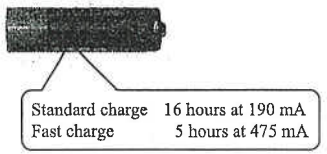
An ammeter and a rheostat of range 0 – 40 Ω are connected to a 6 V battery. The sliding contact is located at a position X where $AX = \frac{1}{4} AB$ as shown above. Find the ammeter reading.

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.

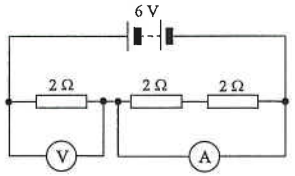
A. 182.4 C
B. 3040 C
C. 10 944 C
D. 27 360 C



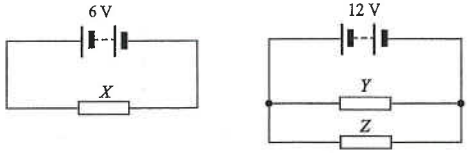
81. **< HKCE 2004 Paper II - 29 >**

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



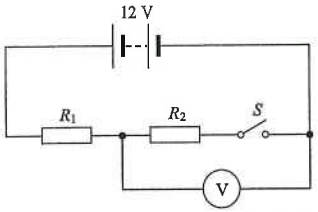
82. **< HKCE 2004 Paper II - 32 >**



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

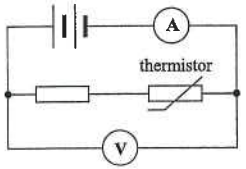
83. **< HKCE 2005 Paper II - 19 >**



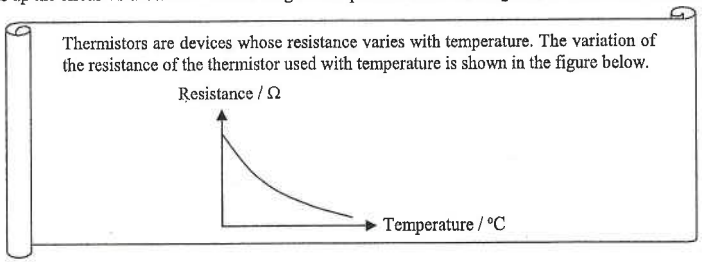
In the above circuit, what is the reading of the voltmeter when switch S is closed ?

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

Questions 84 and 85 :

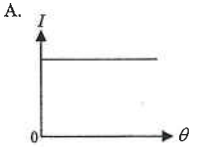


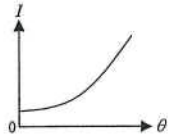
A teacher sets up the circuit as shown in the above Figure and provides the following information to her students.

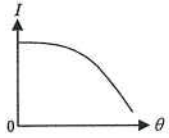


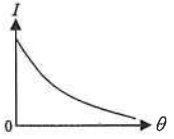
84. **< HKCE 2005 Paper II - 40 >**

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

A. 

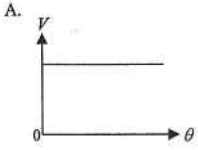
B. 

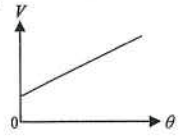
C. 

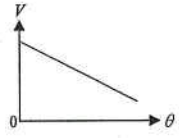
D. 

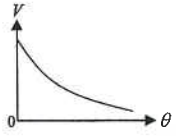
85. **< HKCE 2005 Paper II - 41 >**

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

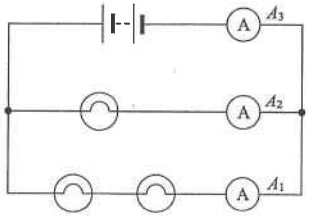
A. 

B. 

C. 

D. 

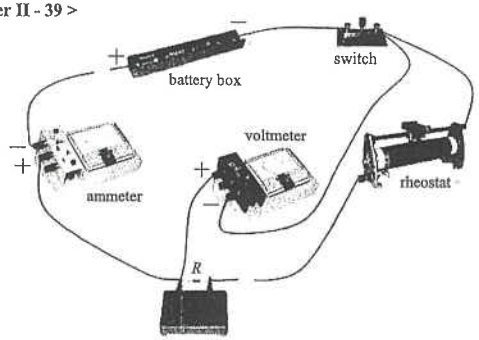
86. **< HKCE 2005 Paper II - 18 >**



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

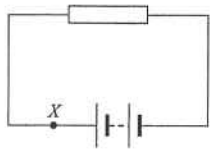
88. **< HKCE 2006 Paper II - 35 >**

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

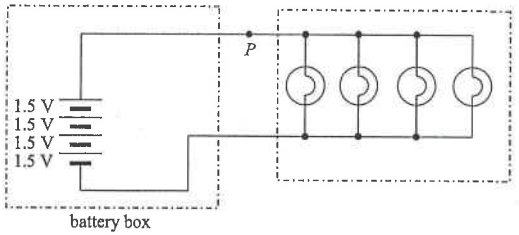
89. **< HKCE 2006 Paper II - 23 >**



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}

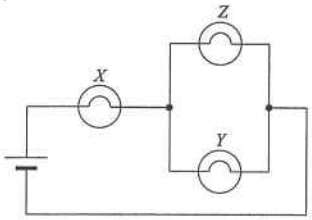
90. **< HKCE 2006 Paper II - 24 >**



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

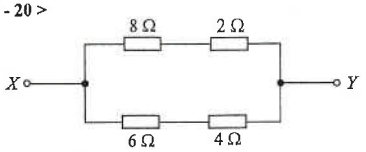
91. **< HKCE 2006 Paper II - 26 >**



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

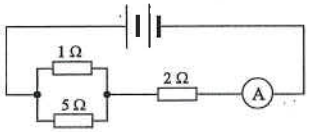
92. **< HKCE 2007 Paper II - 20 >**



In the circuit shown, a voltage of 10 V is applied across *X Y*. 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

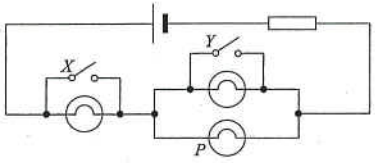
94. **< HKCE 2007 Paper II - 22 >**

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

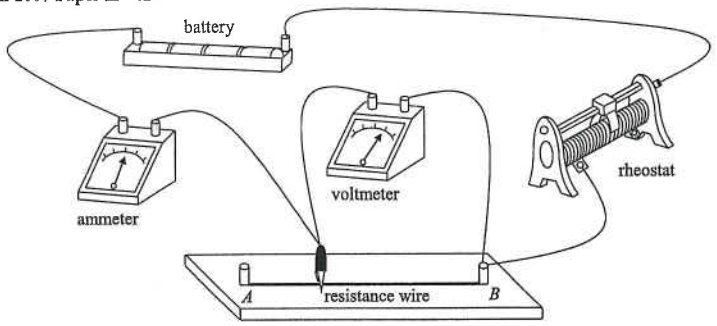
95. **< HKCE 2007 Paper II - 23 >**

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.

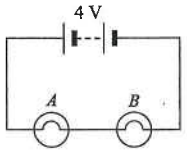
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

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

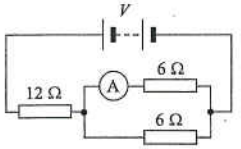


98. **< HKCE 2008 Paper II - 23 >**

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

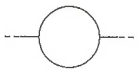
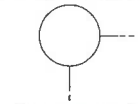
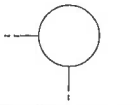
99. **< HKCE 2008 Paper II - 21 >**



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 >

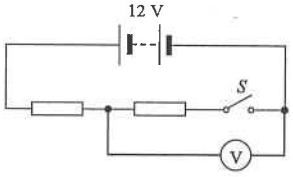
Method of connection	Equivalent resistance
	X
	Y
	Z

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 >

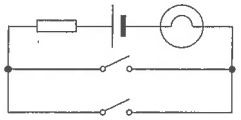
Two identical resistors are connected in series in the circuit shown. What are the readings of the voltmeter when S is open and when S is closed respectively ?

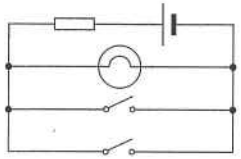


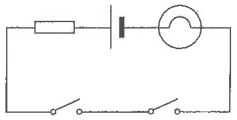
	S is open	S is closed
A.	zero	6 V
B.	zero	12 V
C.	12 V	6 V
D.	12 V	12 V

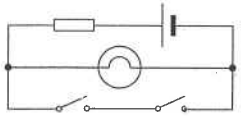
102. < HKCE 2010 Paper II - 17 >

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 ?

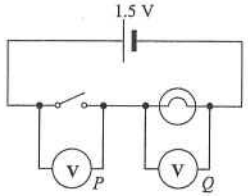
A.


B.


C.


D.


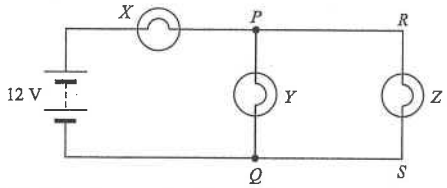
103. < HKCE 2010 Paper II - 18 >



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 >

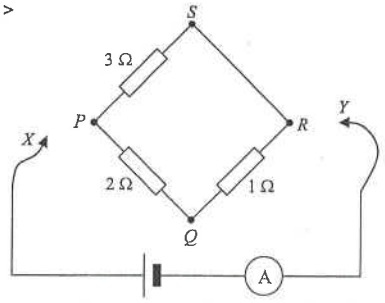


Three identical bulbs X, Y and Z are connected to a 12 V battery in the circuit above. Which of the following statements are correct ?

(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 >

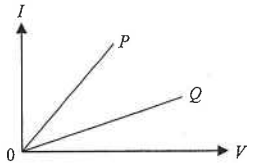


In the circuit shown, wires X and Y are to be connected to two points in the resistor network $PQRS$. Across which two points should X and Y be connected to so that the ammeter reading will be a minimum ?

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 ?

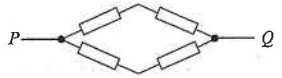
(1) Both of them obey Ohm's law.
(2) The resistance of P is greater than that of Q.
(3) If they are connected in parallel to a battery, the current passing through P will be greater than that passing through Q.

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

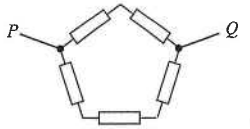
107. **< HKCE 2011 Paper II - 19 >**

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

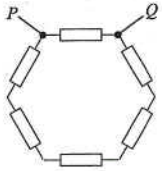
A.



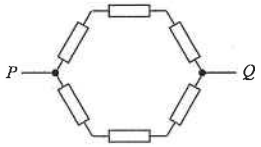
B.



C.



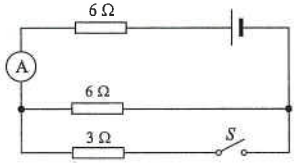
D.



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 ?

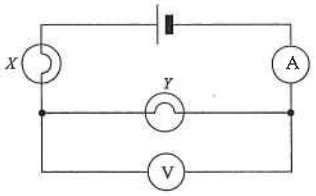
A. 1.5 A
B. 2.0 A
C. 2.5 A
D. 3.0 A



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.

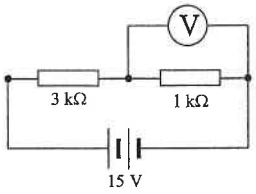


Part B : HKAL examination questions

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

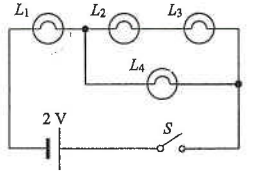


111. **< HKAL 1980 Paper I - 47 >**

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.

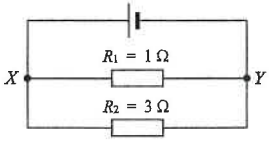
A. (1) only
B. (3) only
C. (1) & (2) only
D. (2) & (3) only



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 ?

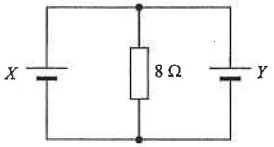
A. $4E_1 = E_2$
B. $3E_1 = E_2$
C. $E_1 = E_2$
D. $E_1 = 3E_2$



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 ?

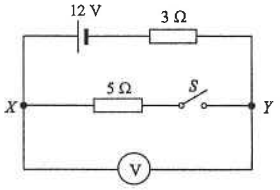
A. zero
B. 0.42 A
C. 0.50 A
D. 0.83 A



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



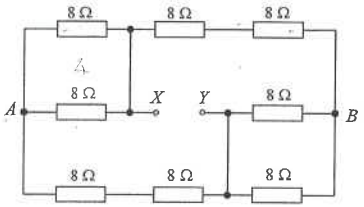
115. **< HKAL 1985 Paper I - 44 >**

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)

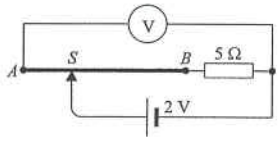
116. **< HKAL 1986 Paper I - 34 >**



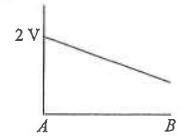
In the circuit shown, if a battery of e.m.f. 20 V with negligible internal resistance is connected across *XY*, what is the current given out by this battery ?

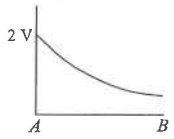
A. 1.0 A.
B. 2.0 A.
C. 2.5 A.
D. 4.0 A.

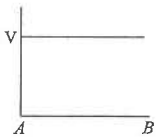
117. **< HKAL 1987 Paper I - 31 >**

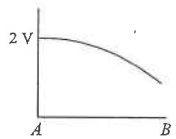


In the above figure, *AB* is a resistance wire of uniform cross-section, and *S* is a sliding contact. The 2 V battery has negligible internal resistance, and the connected voltmeter is ideal. Which of the following graphs shows the correct variation of voltage measured by the voltmeter when the contact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

A.


B.


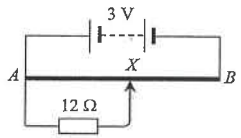
C.


D.


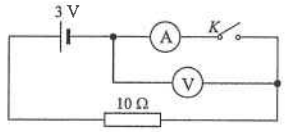
118. **< HKAL 1989 Paper I - 31 >**

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 >**



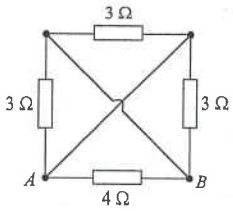
In the circuit shown, *V* is a voltmeter of high internal resistance and *A* is an ammeter of low internal resistance. What is the voltmeter reading when (a) switch *K* is open, (b) switch *K* is closed ?

	***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

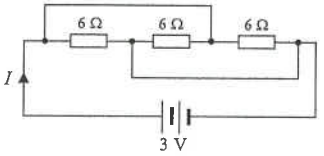
A. 0.8 Ω.
B. 1.2 Ω.
C. 1.5 Ω.
D. 2.0 Ω.



121. **< HKAL 1990 Paper I - 33 >**

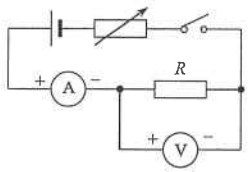
In the circuit shown, the battery has negligible internal resistance. The current *I* delivered by the battery is

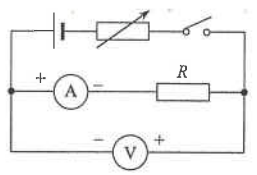
A. 0.5 A.
B. 0.9 A.
C. 1.2 A.
D. 1.5 A.

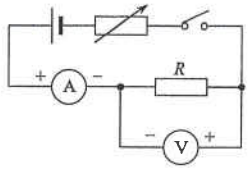


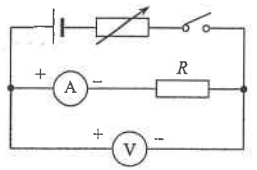
122. **< HKAL 1990 Paper I - 34 >**

Which of the following circuits is best used for the measurement of a high resistance *R* ?

A.


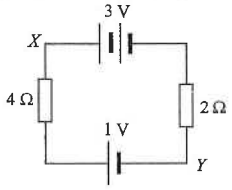
B.


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 ?



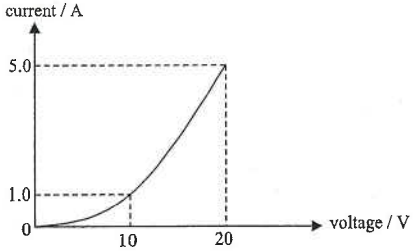
A. 1.33 V
B. 1.67 V
C. 2.00 V
D. 2.33 V

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

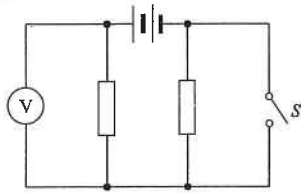
125. **< HKAL 1998 Paper IIA - 19 >**



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 >**

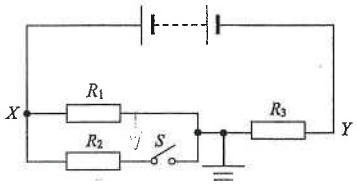
Three resistors of resistance R_1, R_2 and R_3 are connected in parallel. It is known that $R_1 > R_2 > R_3$. The equivalent resistance of this combination is R. Which of the following statements is/are correct ?

(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

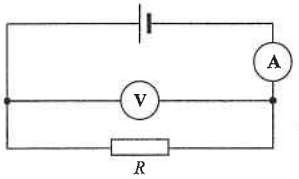
128. **< HKAL 1999 Paper IIA - 19 >**

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 >**

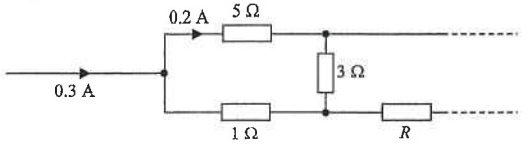


The above circuit can be used to find the resistance of the resistor R. The voltmeter and the ammeter are not ideal. Which of the following statements is/are correct ?

(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 >**

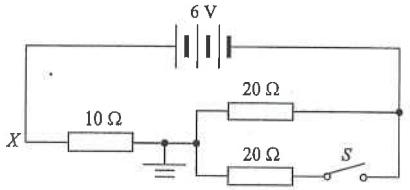


The figure shows part of the circuit in a network of resistors. According to the marked values, find the magnitude and direction of the current passing through the resistor R.

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 >**

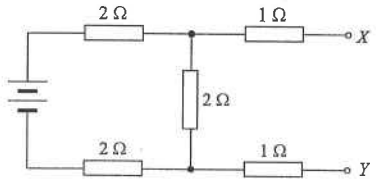
In the circuit shown, a battery of e.m.f. 6 V and negligible internal resistance is connected to three resistors. What are the electric potential at X before and after switch S is closed ?



	Before	After
A.	+ 6 V	+ 3 V
B.	+ 3 V	+ 3 V
C.	+ 2 V	+ 2 V
D.	+ 2 V	+ 3 V

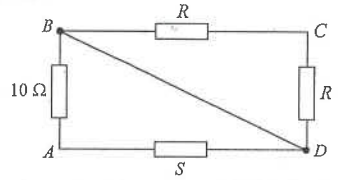
132. **< HKAL 2003 Paper IIA - 27 >**

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

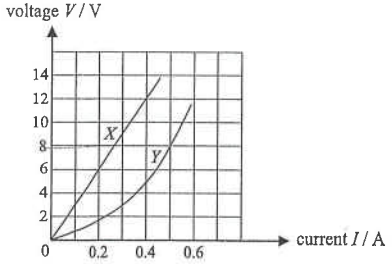
133. **< HKAL 2003 Paper IIA - 20 >**



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

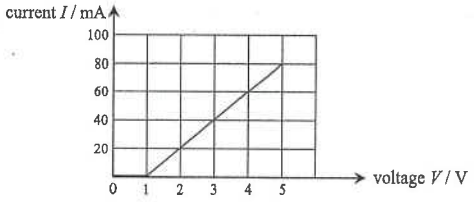
134. **< HKAL 2007 Paper IIA - 16 >**



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 >**

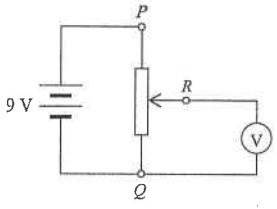


Figure (a)

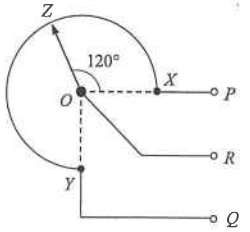


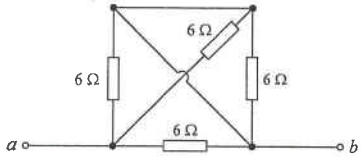
Figure (b)

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 >**

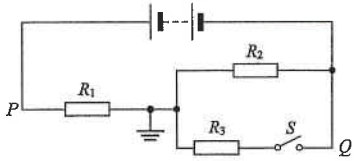
Which of the following statements concerning an ammeter are correct ?

(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)

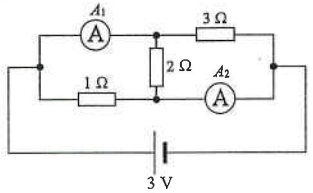
139. **< HKAL 2013 Paper IIA - 24 >**

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.

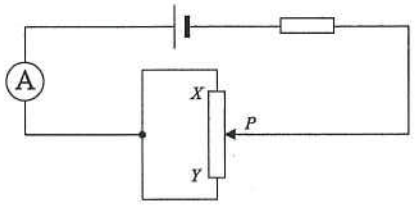
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

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 ?

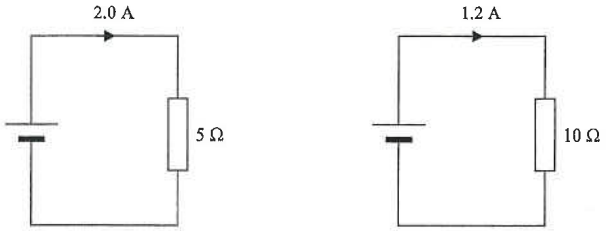
(1) Two resistors consume more power than one resistor.
(2) Two resistors draw more current than one resistor.
(3) The equivalent resistance of two resistors is greater than that of one resistor.

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.

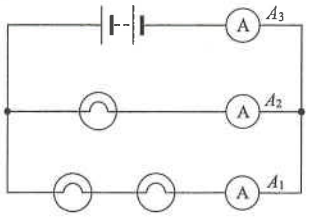


A cell has a constant e.m.f. and internal resistance. If a resistor of resistance 5 Ω is connected in series with the cell, the current is 2.0 A. If the resistor is replaced by another resistor of resistance 10 Ω, the current in the circuit becomes 1.2 A. What is the value of the internal resistance ?

A. 1.5 Ω
B. 2.0 Ω
C. 2.5 Ω
D. 3.0 Ω

Part D : HKDSE examination questions

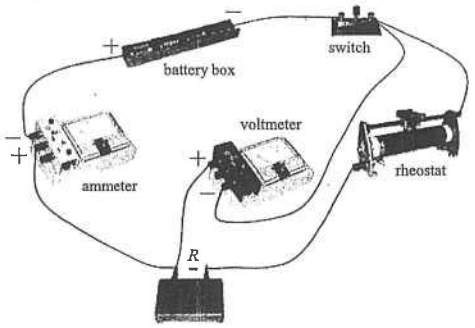
147. < HKDSE Sample Paper IA - 27 >



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.

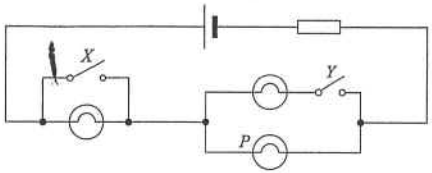
A. (1) only
B. (2) only
C. (1) & (3) only
D. (2) & (3) only

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. $4R$

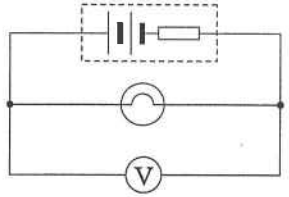
150. < HKDSE Practice Paper IA - 29 >



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 >

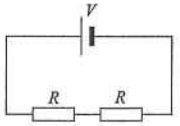


Figure (a)

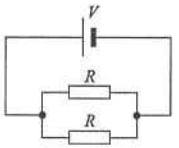
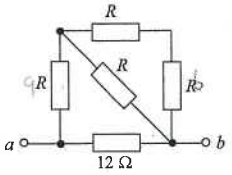


Figure (b)

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. $16P$

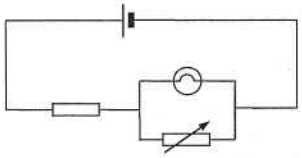
153. < HKDSE 2012 Paper IA - 26 >



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.

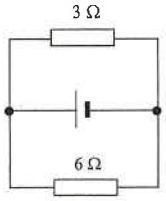
154. < HKDSE 2012 Paper IA - 27 >



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.

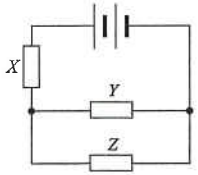
155. < HKDSE 2012 Paper IA - 28 >



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

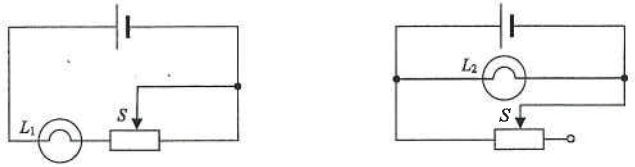
156. < HKDSE 2013 Paper IA - 30 >



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

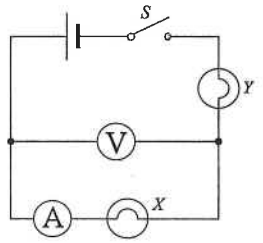
157. < HKDSE 2013 Paper IA - 31 >



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

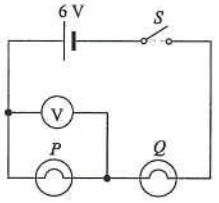
158. < HKDSE 2013 Paper IA - 32 >



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.

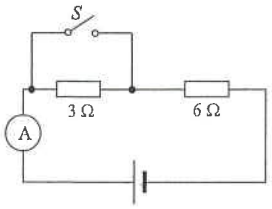
159. < HKDSE 2014 Paper IA - 25 >



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.

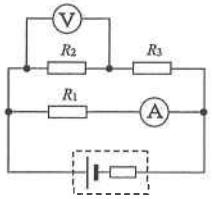
160. < HKDSE 2014 Paper IA - 24 >



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 >



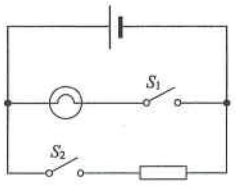
In the above circuit, the cell has a finite internal resistance and both meters are ideal. In which situation below will the readings of the ammeter and the voltmeter suddenly increase ?

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.

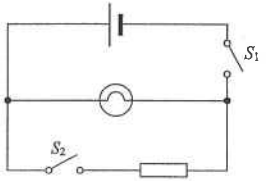
162. < HKDSE 2015 Paper IA - 25 >

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 ?

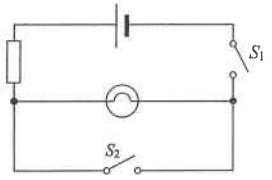
A.



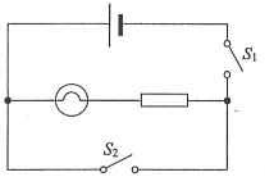
B.



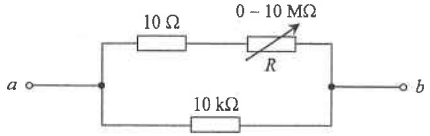
C.



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

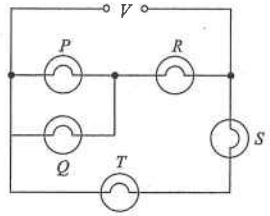
164. < HKDSE 2016 Paper IA - 26 >

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 >



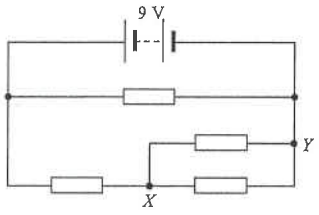
In the above circuit, all the bulbs are identical. If the voltage V gradually increases, which bulb(s) will burn out first ?

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.

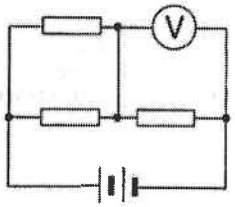
B.

C.

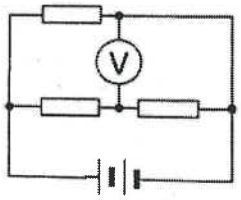
D.

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 $= 6 \times \frac{8}{4+8} = 4$ 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 $R \propto \ell \ \therefore R \rightarrow \frac{1}{2}R$

Power : $P = \frac{V^2}{R} \ \therefore P \propto \frac{1}{R} \ \therefore P \rightarrow 2P$

Since $E = Pt$, as same energy is required for boiling,

$\therefore P \rightarrow 2P \Rightarrow t \rightarrow \frac{1}{2}t$

$\therefore$ 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.

$P = \frac{V^2}{R} = \frac{(2)^2}{(4)} = 1$ 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

$\therefore\ P' = \frac{V^2}{R}$ $\therefore\ P' = 2P$

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 : $P = \frac{V^2}{R}$ $\therefore$ R decreases $\Rightarrow$ power given out by the cell increases $\Rightarrow$ total brightness increases

As more lamps in parallel $\Rightarrow$ equivalent resistance R decreases $\therefore$ 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

$\therefore\ P = I^2 R \propto R$ $\therefore\ \frac{R_1}{R_2} = \frac{P_1}{P_2} = \frac{1}{4}$

When connecting in parallel, same voltage flows through 2 resistors

$\therefore\ P = \frac{V^2}{R} \propto \frac{1}{R}$ $\therefore\ \frac{P_1}{P_2} = \frac{R_2}{R_1} = 4$

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) $R_a = \frac{R \times 3R}{R+3R} = \frac{3}{4}R$

(b) $R_b = \frac{2R \times 2R}{2R+2R} = R$

(c) $R_c = \frac{R}{4}$

$\therefore\ R_c < R_a < R_b$

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.

$\therefore\ A_2 = \frac{1.8}{3} = 0.6\ \text{A}$

22. D

$E = Pt = \frac{V^2}{R} \cdot t$ $\quad\therefore\ t \propto R$ as same energy E is required for same heating process

$\therefore\ \frac{t_B}{t_A} = \frac{R_B}{R_A}$ $\quad\therefore\ \frac{(40)}{(10)} = \frac{R_B}{(100)}$ $\quad\therefore\ R_B = 400\ \Omega$

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

$\therefore\ V = 24 \times \frac{3}{3+6} = 8\ \text{V}$

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) $R_1 = \frac{1}{2} + 1 = \frac{3}{2}\Omega$ $\quad$ (2) $R_2 = \frac{1 \times 2}{1+2} = \frac{2}{3}\Omega$ $\quad$ (3) $R_3 = \frac{1}{3}\Omega$

$\therefore\ R_3 < R_2 < R_1$

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 $\quad\therefore\ Q$ 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 = $1 \times \frac{R}{2R} = 0.5$ 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

$\therefore\ V_{PQ} = \frac{3}{3+1} \times 12 = 9\ \text{V}$

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 $R \propto \frac{1}{A}$

For the same length : area A ∝ volume ∝ mass m

$\therefore\ R \propto \frac{1}{A} \propto \frac{1}{m}$

$\therefore\ \frac{R_A}{R_B} = \frac{m_B}{m_A} = \frac{9}{4}$

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 :

$$P_2 = \frac{(V/3)^2}{R} = \frac{1}{9}\cdot\frac{V^2}{R}$$

$\therefore\ \frac{P_1}{P_2} = \frac{\frac{1}{4}}{\frac{1}{9}} = \frac{9}{4}$

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

$E = Pt = \frac{V^2}{R}\cdot t$

As same energy E is required for boiling :

$\therefore\ t \propto \frac{1}{V^2}$

$\therefore\ \frac{t_2}{t_1} = \frac{V_1^2}{V_2^2}$ $\therefore\ \frac{t_2}{T} = \frac{(200)^2}{(100)^2}$

$\therefore\ t_2 = 4T$

39. B

equivalent resistance of the circuit $= 4 + \frac{(3+1)\times 4}{(3+1)+4} = 6\ \Omega$

current through $XY = \frac{6}{6} \times \frac{1}{2} = 0.5\ \text{A}$

p.d. between X and Y = voltage across the 3 Ω resistor $= 3 \times 0.5 = 1.5\ \text{V}$

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 × 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 ⇒ $V_1 = 0\ \text{V}$.

Voltmeter V_2 : $V_2 = \frac{20}{10+20} \times 3 = 2\ \text{V}$

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 : $I = \frac{V}{R} = \frac{6}{10+5} = 0.4\,\text{A}$

Power dissipated in the 10 Ω resistor : $P = I^2R = (0.4)^2(10) = 1.6\,\text{W}$

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 $P = I^2R$)

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 $A_2 = 2 \times 2 = 4\,\text{A}$

$\therefore$ $A_3 = A_1 + A_2 = 2 + 4 = 6\,\text{A}$

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 $\Rightarrow$ current is very small $\Rightarrow$ ammeter would not burn out

× B. Very small current $\Rightarrow$ light bulb would not burn out

× C. Large resistance voltmeter $\Rightarrow$ share all the voltage of the circuit $\Rightarrow$ reading of voltmeter is 6 V

✓ D. Very small current $\Rightarrow$ reading of ammeter is zero

52. A

S is closed $\Rightarrow$ no current through L_1 as it is shorted $\Rightarrow$ 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 $\Rightarrow$ 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 : $I = \frac{V}{R} = \frac{6}{6} = 1\,\text{A}$

Current flow through point X = 0.5 A

P.d. between X and Y = 0.5×4 = 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 $\Rightarrow$ I_1 : no change

✓ (2) S closed $\Rightarrow$ equivalent resistance decreases $\Rightarrow$ more current given out by battery $\Rightarrow$ 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 $\Rightarrow$ voltage measured by voltmeter $\approx$ 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 : $I = \frac{1.8}{4} = 0.45$ 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) = $\frac{R}{2}$

Ammeter reading : $I = \frac{V}{R} \propto \frac{1}{R} \Rightarrow I' = \frac{2R}{R/2} \cdot I = 4I$

Total power dissipated : $P = \frac{V^2}{R} \propto \frac{1}{R} \Rightarrow P' = \frac{2R}{R/2} \cdot P = 4P$

62. D

✓ A. $\frac{W}{t} = P$

✓ B. $\frac{V^2}{R} = P$

✓ C. $Fv = P$

× D. $m \cdot \ell_v = E$

63. A

Let the resistance of each resistor be R.

(1) $R_1 = \frac{1}{3}R$ (2) $R_2 = \frac{(2R)(R)}{2R+R} = \frac{2}{3}R$ (3) $R_3 = \frac{R}{2} + R = \frac{3}{2}R$

∴ 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 = $\frac{2.4}{12}$ = 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 : $R = \frac{V}{I} = \frac{3.6}{0.6} = 6\ \Omega$

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 $R = \frac{V}{I}$, $I \uparrow \Rightarrow R \downarrow$.

67. A

Equivalent resistance of two 60 Ω resistors = $\frac{60}{2}$ = 30 Ω = the resistance at the 3rd row (30 Ω resistor)

∴ Current through 30 Ω resistor = $\frac{I}{2}$

68. C

× (1) For same voltage : $I = \frac{V}{R} \propto \frac{1}{R}$ ∴ current through R_1 is doubled that through R_2

✓ (2) R_1 and R_2 are in parallel $\Rightarrow$ same voltage across each of them

✓ (3) Equivalent resistance of $PQ = \frac{6 \times 12}{6+12} = 4\ \Omega$ ∴ 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 $\Rightarrow$ equivalent resistance of circuit ↓ $\Rightarrow$ current ↑

× (2) For same voltage, $I = \frac{V}{R} \propto \frac{1}{R}$. Ratio of R kept unchanged $\Rightarrow$ ratio of I is unchanged

× (3) S closed $\Rightarrow$ R_3 is shorted $\Rightarrow$ 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	$\therefore \Omega = V A^{-1}$
✓	B	Power = Energy / time	$\therefore W = J s^{-1}$
×	C	Charge = Current × time	$\therefore C = A s$
✓	D	Voltage = Energy / charge	$\therefore V = J C^{-1}$

73. C

✓	A	As equivalent resistance of the circuit ↓, current given out by battery ↑ $\therefore$ reading of A_1 ↑
✓	B	Since still same voltage across A_2 and the resistor in series $\therefore$ 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 ↑ $\therefore$ power delivered by battery ↑

74. A

Equivalent resistance of the circuit $= \frac{2\times1}{2+1}+3 = 3.67\ \Omega$

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 $\therefore$ resistance of Y is higher than that of X
×	(2)	The equivalent resistance of X and Y in series must be greater $\therefore$ the slope must be greater than Y.
✓	(3)	The equivalent resistance of X and Y in parallel must be smaller $\therefore$ 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 $= \frac{3\text{ V}}{6\ \Omega} = 0.5$ 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.

$X = \frac{1\times3}{1+3} = 0.75\ \Omega$ $\quad Y = \frac{2\times2}{2+2} = 1\ \Omega$ $\quad Z = \frac{1\times3}{1+3} = 0.75\ \Omega$

$\therefore X = Z < Y$

79. B

The current flows through the resistance coil between XB only.

Resistance of coil between $XB = 40\times\frac{3}{4} = 30\ \Omega$

Current : $I = \frac{V}{R} = \frac{6}{30} = 0.2$ A

80. C

$Q = It$

$= (190\times10^{-3})\times(16\times60\times60)$

$= 10944$ 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 $= \frac{6}{2} = 3$ A

Voltmeter reading = 6 V

82. D

Let the resistance of X be R.

By $P = \frac{V^2}{R}$ $\quad \therefore (20) = \frac{(6)^2}{R}$ $\quad \therefore R = 1.8\ \Omega$

Equivalent resistance of Y and $Z = \frac{1.8}{2} = 0.9\ \Omega$

Total power dissipated in Y and $Z = \frac{V^2}{R} = \frac{(12)^2}{(0.9)} = 160$ 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 = $(800 \times 10^{-3}\text{ A}) \times (3600\text{ s})$ = 2880 C

② $E = QV = (2880) \times (3.6) = 10368$ J

③ $P = \dfrac{E}{t} = \dfrac{10368}{3 \times 24 \times 3600} = 0.04\text{ W} = 40\text{ mW}$

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 × 1 = 4 A

Voltage across each light bulb = 4 × 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 = $\dfrac{1 \times 5}{1 + 5} + 2 = 2.833\ \Omega$

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 **OR** $P = VI = (1.2)\,(225 \times 10^{-3}) = 0.27$ W

$E = QV = (8100)\,(1.2) = 9720$ J $E = Pt = (0.27)\,(10 \times 3600) = 9720$ 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 = $12 + \dfrac{6}{2} = 15\ \Omega$

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. $R = 1 /$ 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.

$R_A = \frac{2+2}{2} = 2\,\Omega$ $\quad R_B = \frac{4\times6}{4+6} = 2.4\,\Omega$

$R_C = \frac{2\times10}{2+10} = 1.67\,\Omega$ $\quad R_D = \frac{2+2+2}{2} = 3\,\Omega$

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 $= 6 + \frac{6\times3}{6+3} = 8\,\Omega$

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, $V_{voltmeter} = V_{1\Omega} = 3$ V.

For series circuit, $V \propto R$ $\quad \therefore \frac{15-3}{3} = \frac{3}{R}$ $\quad \therefore R = 0.75\,\text{k}\Omega$

$\frac{1}{R} = \frac{1}{R_{1\Omega}} + \frac{1}{R_V}$ $\quad \therefore \frac{1}{(0.75)} = \frac{1}{(1)} + \frac{1}{R_V}$ $\quad \therefore R_V = 3\,\text{k}\Omega$

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)

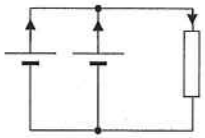
113. C

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) $\varepsilon = \frac{E}{q}$

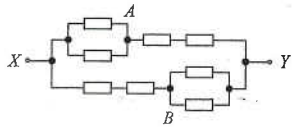
✓ (3) Open circuit $\Rightarrow$ no current $\Rightarrow$ no voltage drop across the internal resistance $\Rightarrow \varepsilon = V$

116. B

The circuit diagram can be redrawn as shown :

$\therefore$ Equivalent resistance $= \frac{\frac{8}{2}+8+8}{2} = 10\ \Omega$

$\therefore I = \frac{V}{R} = \frac{20}{10} = 2\text{ A}$



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

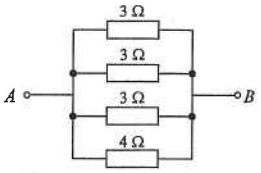
120. A

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

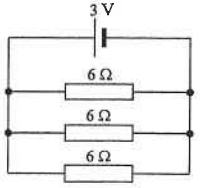
The circuit diagram can be redrawn as shown.

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

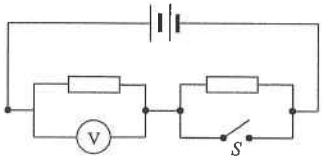
Note that the device does not obey Ohm's law, resistance is found by $R = \dfrac{V}{I}$

$\Delta R = \dfrac{20}{5} - \dfrac{10}{1} = -6\ \Omega$

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

$\therefore$ 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.

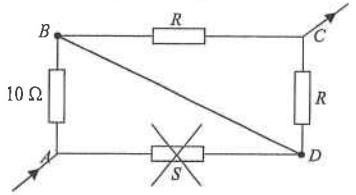
133. B

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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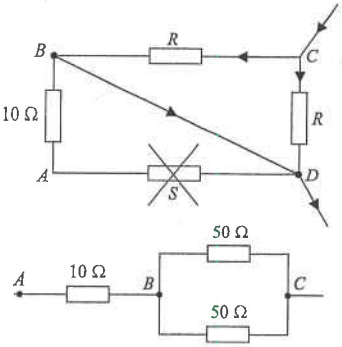
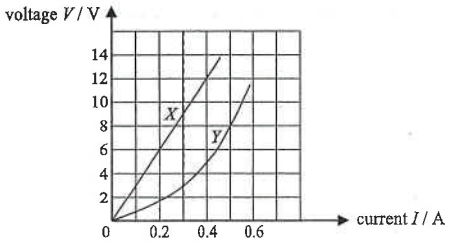


Equivalent resistance $= 10 + \dfrac{50}{2} = 35\ \Omega$

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 $R = \frac{V}{I} = \frac{0.5}{0} = \infty\,\Omega$

× (2) When $V = 2$ V : $R = \frac{2}{20\times10^{-3}} = 100\,\Omega$.

When $V = 3$ V : $R = \frac{3}{40\times10^{-3}} = 75\,\Omega$.

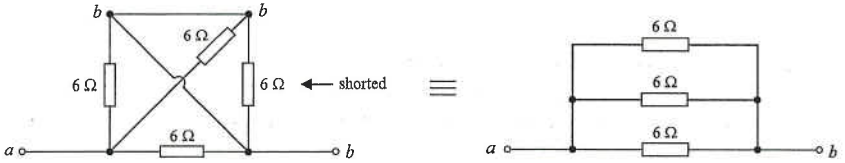
The resistance is not constant.

× (3) As the line does not pass through the origin, the current is not directly proportional to the voltage.

136. C

$V = 9\times\frac{270-120}{270} = 5$ V

137. C



Equivalent resistance : $R = \frac{6}{3} = 2\,\Omega$

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

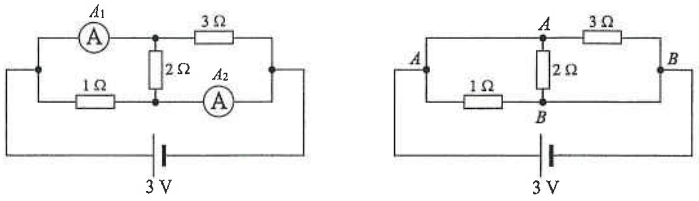
✓ A. The p.d. between PQ is equal to the p.d. across the battery, which is equal to the e.m.f. of the battery, thus it is unchanged.

✓ 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 $= \frac{3}{1} = 3$ A

Current through the 2 Ω resistor $= \frac{3}{2} = 1.5$ A

Current through the 3 Ω resistor $= \frac{3}{3} = 1$ 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 :

$(2.0)(5 + r) = (1.2)(10 + r)$ $\therefore r = 2.5\ \Omega$

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 $P = \frac{V^2}{R}$ $\therefore P \propto V^2$ $\therefore V \to 2V \Rightarrow P \to 4P$

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 $= \frac{6 \times 3}{6 + 3} = 2\ \Omega$

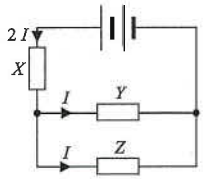
Total equivalent resistance of the whole circuit $= 2 + 2 = 4\ \Omega$

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.

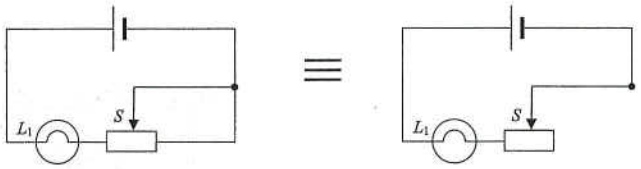
Thus the current passing through X is $2I$.

Total power dissipated by X, Y and $Z = (2I)^2R + I^2R + I^2R = 24$

$\therefore\ I^2R = 4$

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**

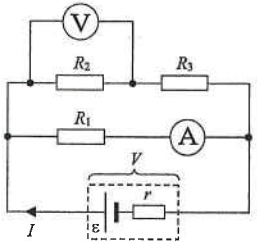
× D. As the total resistance increases, the current must decrease and less than 3 A $\therefore$ it is impossible

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.

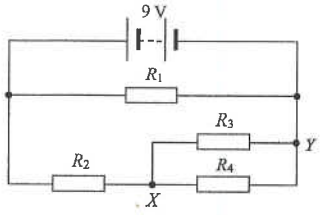
The voltage across R_1 is 9 V and is irrelevant.

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

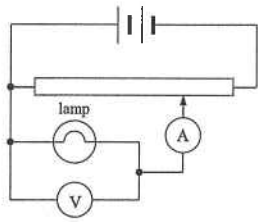


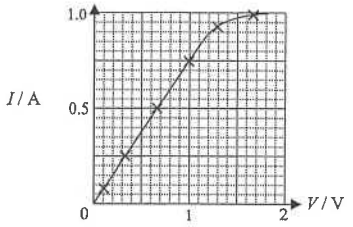
The following list of formulae may be found useful :

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	$P = IV = I^2R$
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)

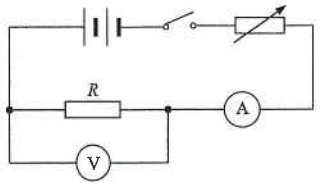
(b) Suggest a reason why Ohm's Law is not obeyed outside this range. (2 marks)

(c) Find the resistance of the lamp when the voltage is

(i) 0.5 V ; and

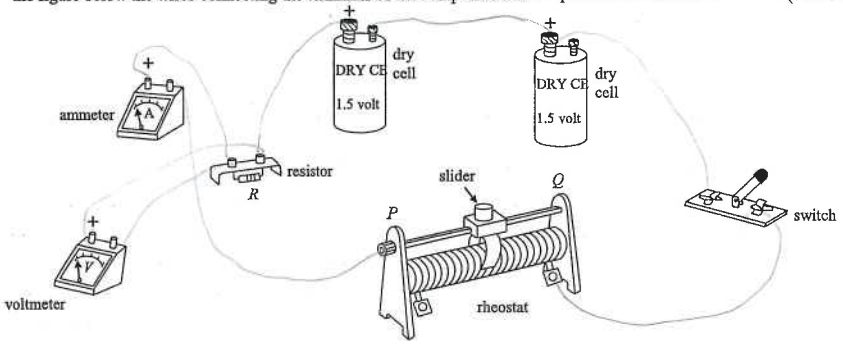
(ii) 1.5 V. (2 marks)

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)

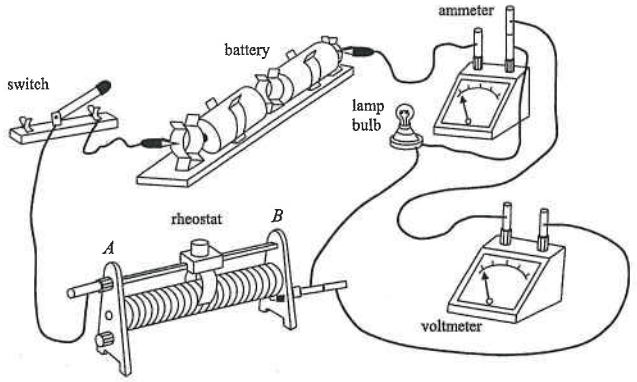


(b) State where you should set the slider of the rheostat at the beginning of the experiment. State the reason for your choice. (3 marks)

(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 >**

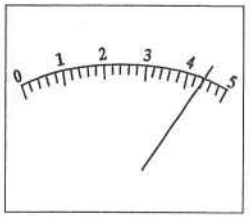


The figure above shows an experiment set-up to measure the resistance of a light bulb.

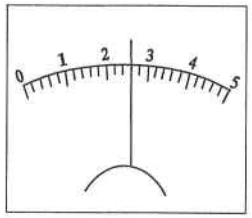
(a) Draw a circuit diagram for the experiment. Indicate on your drawn diagram the positive terminals of the ammeter and voltmeter with "+" signs. (5 marks)

(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

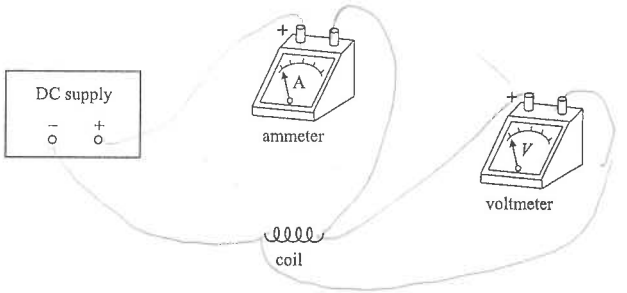
(2) the resistance

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)

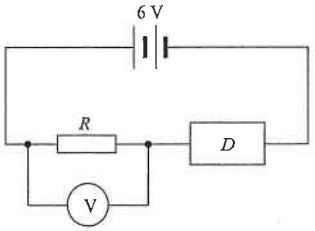
(d) How would the resistance of the metallic coil change with temperature ? (2 marks)

(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)

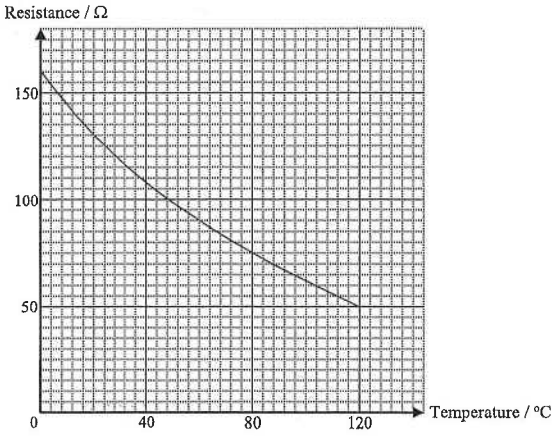
5. **< HKCE 1991 Paper I - 6 >**

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

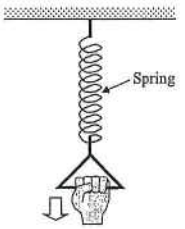
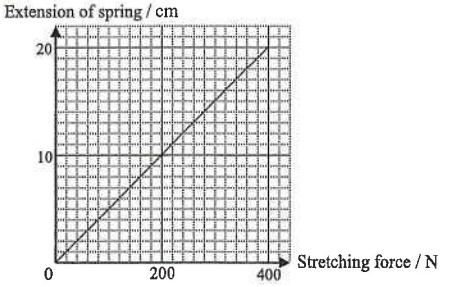


Figure 2

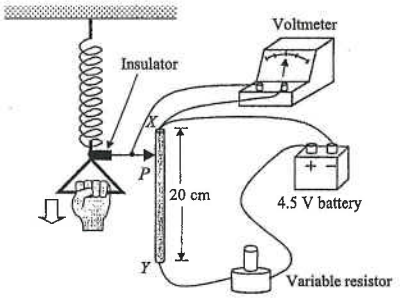


A spring is hanging freely from the ceiling and John stretches the spring with his hand as shown in Figure 1. It is known that the extension of the spring is directly proportional to the stretching force (see Figure 2).

(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 >**

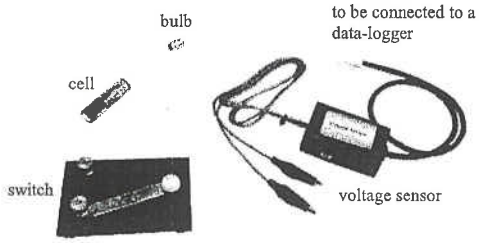


Figure 1

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.

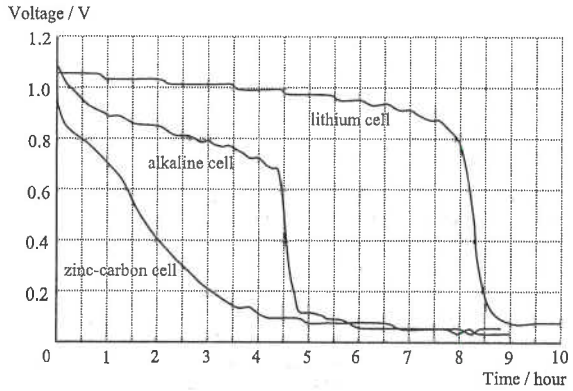


Figure 2

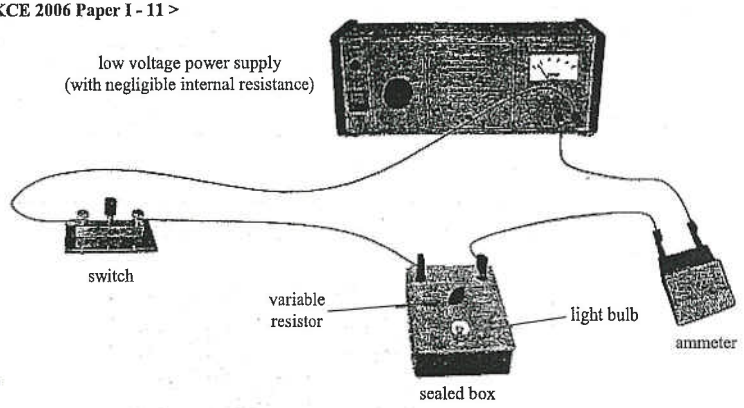
(i) A salesman claims that the lifetime of a lithium cell for lighting up the bulb is five times that of an alkaline cell. Determine whether the claim is correct or not. (2 marks)

(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)

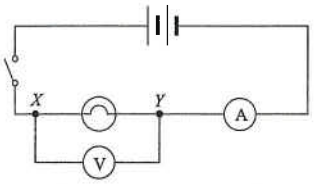
(iii) Using the data in the above Table, find the resistance of the bulb. (3 marks)

(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)

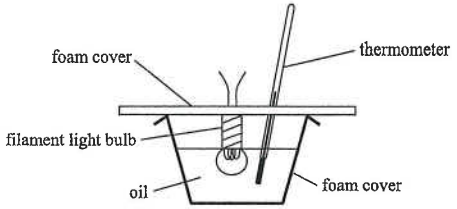
8. (c) The teacher asks Mary, "What happens if the variable resistor is set to zero ?"
"The light bulb will burn out," Mary answered.

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)

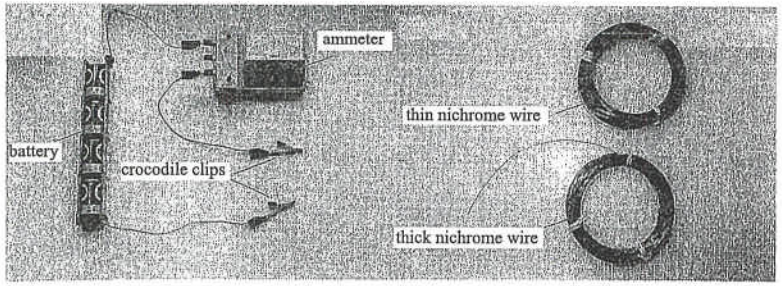
(b) Describe the energy conversion when a current passes through the filament light bulb. (1 mark)

(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)

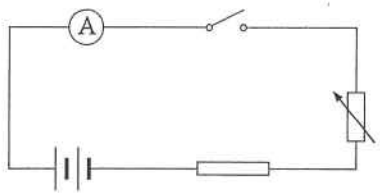


11. **< HKCE 2011 Paper I - 5 >**

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)

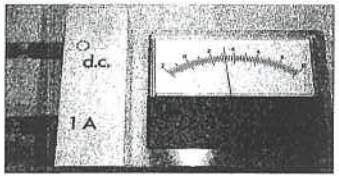
Figure (a)



(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)

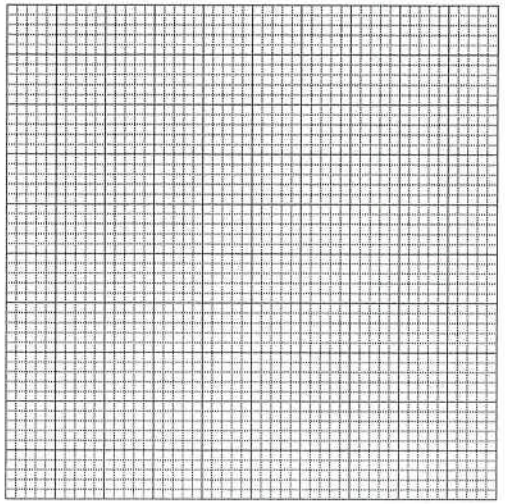


Ammeter reading = _____

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

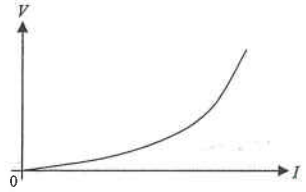
Plot a graph of voltmeter reading against ammeter reading in the Figure below. Use a scale of 1 cm representing 1 V and 0.1 A.



(iii) From the graph plotted in (b) (ii), find the resistance of the resistance wire. (2 marks)

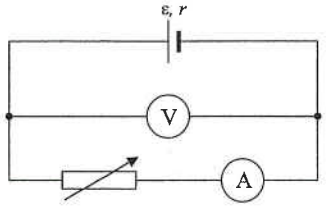
(c) Now the resistance of a filament light bulb is studied using the same experimental setup. The voltage-current graph obtained is shown in Figure (c). Explain why the graph is not a straight line. (2 marks)

Figure (c)

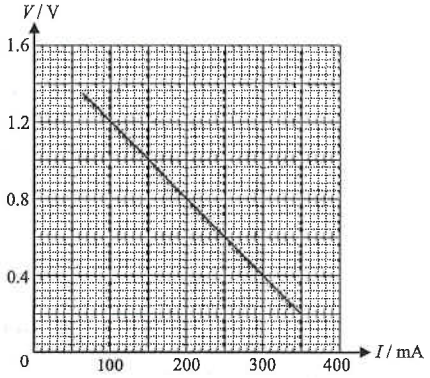


Part B : HKAL examination questions

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.

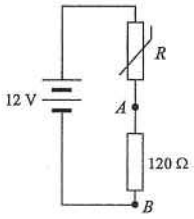
(a) Express V in terms of ε, I and r. (1 mark)

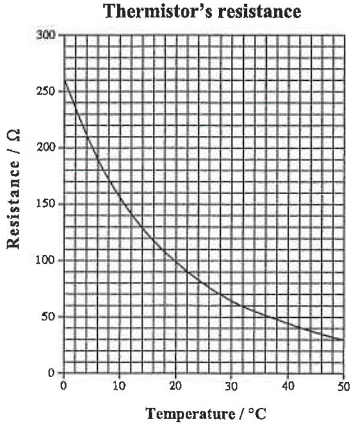
(b) Hence deduce from the graph the e.m.f. and the internal resistance of the cell. (2 marks)

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.

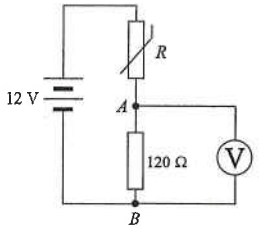




(i) Find the resistance of the thermistor R at 25°C. (1 mark)

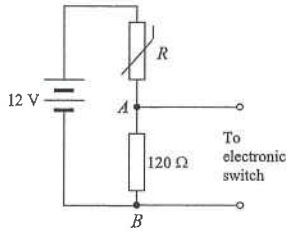
(ii) What is the potential difference V_{AB} across A and B at 25°C ? (2 marks)

(b)



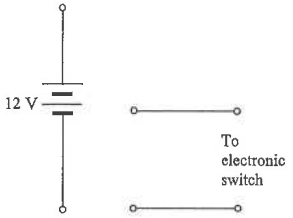
Kelly wants to confirm the above calculation by measuring V_{AB} using a voltmeter of about 1 kΩ resistance. She finds that the reading registered is slightly different from the value found in (a) despite making careful measurements. Explain why this is so. Suggest how the accuracy of the measurement 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)

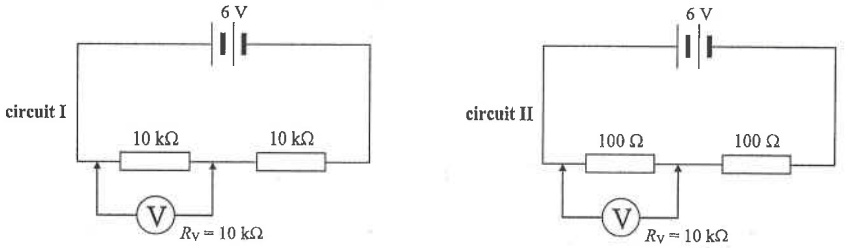
(ii)



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.

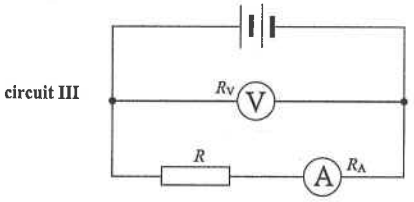


A voltmeter of internal resistance R_V = 10 kΩ is used to measure the potential difference across one of the resistors as shown.

(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 >**

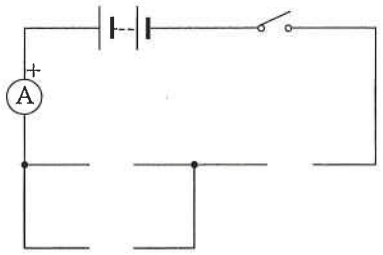
A student uses the following apparatus to measure the resistance of a tungsten filament light bulb.

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)

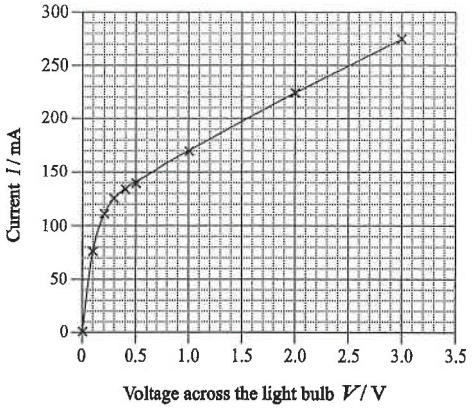
Figure 1



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)

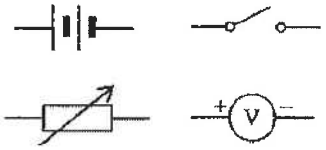
15. (c) The student claims that since the resistance of the light bulb is not a constant, the equation $R = V/I$ cannot be used to calculate the resistance of the light bulb. Briefly explain why his claim is wrong. (1 mark)

(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.

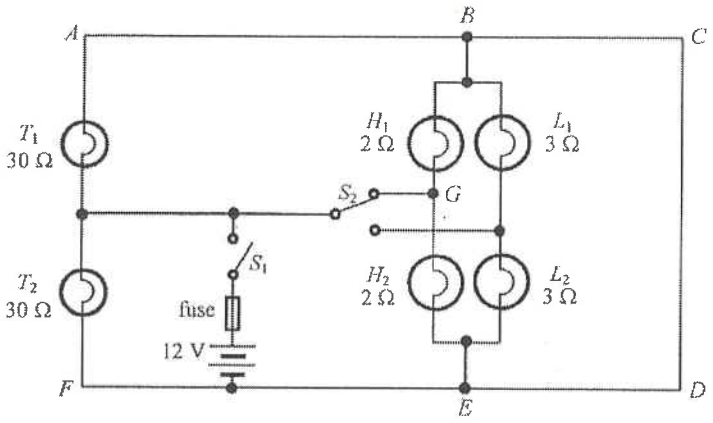


(a) With the aid of a circuit diagram, describe the procedure of an experiment to study how the terminal voltage V delivered by the battery depends on the resistance R connected to it. State ONE precaution of the experiment. (5 marks)

(b) Describe the variation of V with R and express V in terms of ξ, r and R. (2 marks)

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]

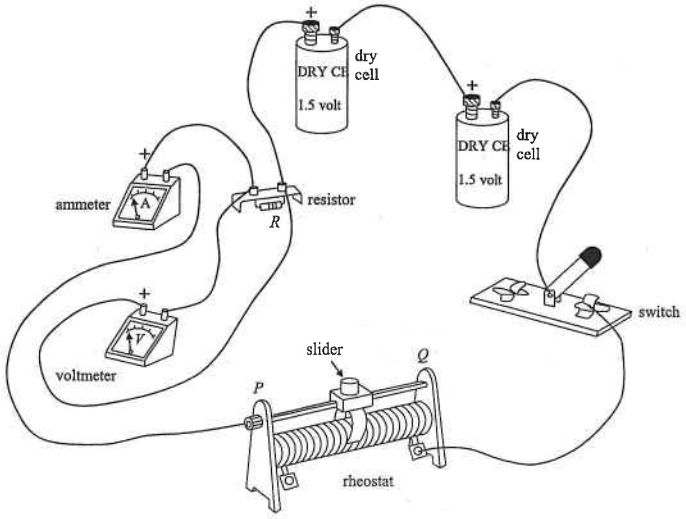
(b) The temperature of the lamp increases, [1]

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]

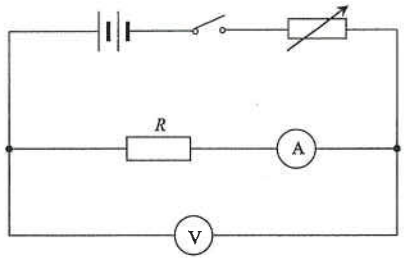
so that the resistance is maximum [1]

and current is smallest. [1]

(c) Reading of voltmeter : no change [1]

Reading of ammeter : no change [1]

2. (d) [3]

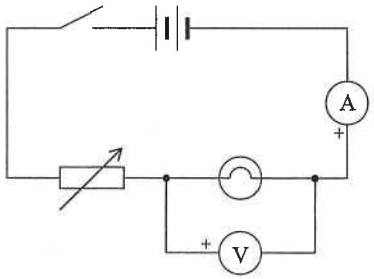


< The cells, the switch, the rheostat, the resistor and the ammeter are in series > [1]

< 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]

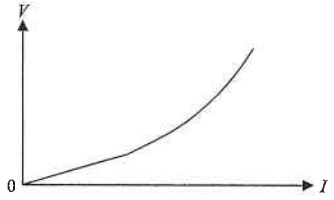
(ii) 2.6 V [1]

$\therefore\ R = \frac{V}{I} = \frac{2.6}{0.44} = 5.91\ \Omega$ [2]

(d) (i) (1) Temperature increases [1]

(2) Resistance increases [1]

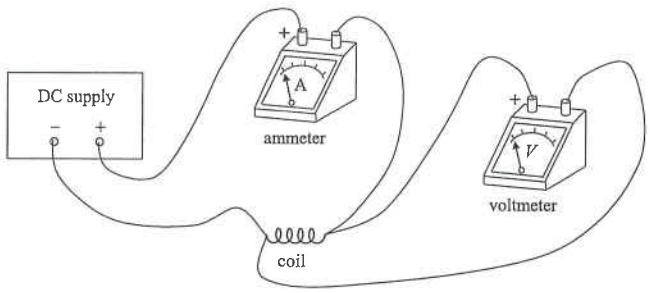
(ii)



< 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) $R = \frac{V}{I}$ [1]

$= \frac{12}{2}$ [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 : $I = \frac{V}{R} = \frac{4.7}{470}$ [1]

$= 0.01$ A [1]

(ii) Voltage across the device $D = 6 - 4.7 = 1.3$ V [1]

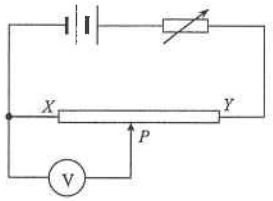
Resistance of the device $D = \frac{1.3}{0.01} = 130\ \Omega$ [1]

(iii) Temperature of the device $D = 20°C$ < 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) $F = 100$ 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 $= \frac{V}{R} = \frac{4.5}{40+20} = 0.075$ A [1]

When P touches Y,

voltmeter reading $= IR = (0.075)(20) = 1.5$ V [1]

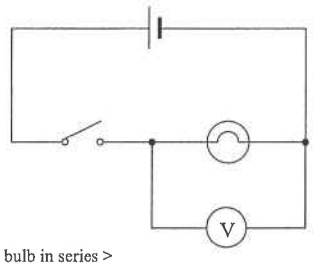
(iii) (1) Distance of P from $X = \frac{1.2}{1.5} \times 20$ [1]

$= 16$ cm [1]

(2) Since extension of spring = 16 cm , From Figure 2 [1]
stretching force = 320 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]

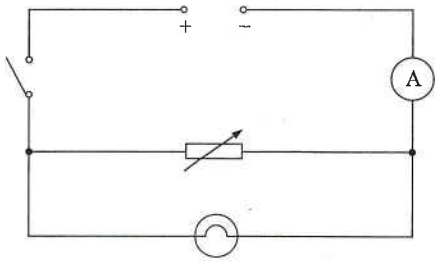
Cost per hour for alkaline cells = $\frac{3.8}{4.4}$ = \$ 0.864 < accept 0.84 to 0.86 >

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) $E = mc\Delta T$ [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]

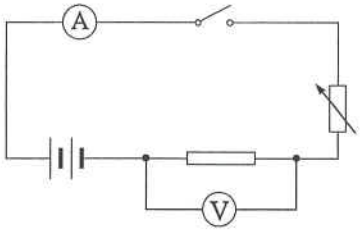
10. Connect the two crocodile clips across a certain length of the thin nichrome wire. [1]

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]

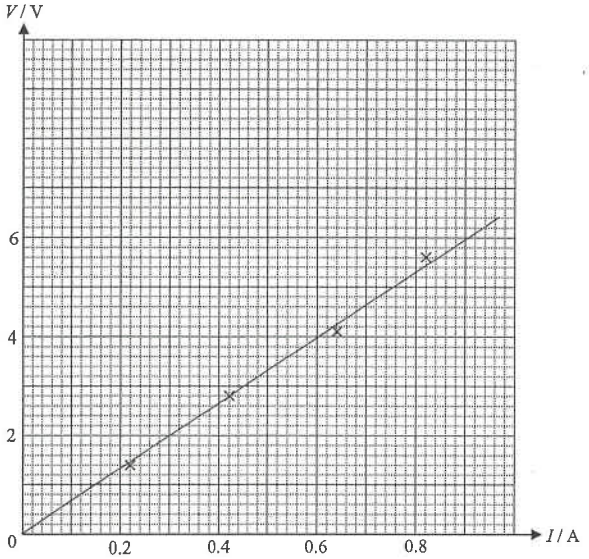
11. (a)



< 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 Ω [1]

(ii) $V_{AB} = 12 \times \frac{120}{120+80}$ [1]

$= 7.2$ 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]

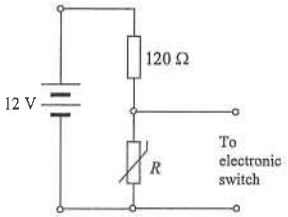
(c) (i) $V_{AB} = 6$ V

$\therefore\ V_R = 12 - 6 = 6$ 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 kΩ

Equivalent resistance = $\frac{10}{2}$ = 5 kΩ

$V = 6 \times \frac{5}{5+10}$ [1]

$= 2$ 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]

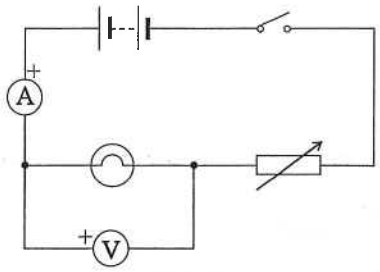
(ii) For circuit III :

$R_m = 10 + 1 = 11\ \Omega$

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 : $R = \frac{0.1}{76\times10^{-3}} = 1.32\ \Omega$ [1]

At 2.5 V : $R = \frac{2.5}{250\times10^{-3}} = 10\ \Omega$ [2]

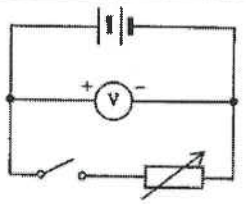
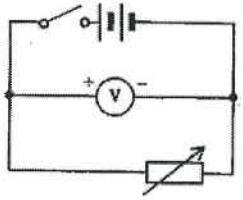
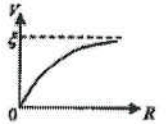
(e) At room temperature, resistance is 1.32 Ω. [1]

By $R = \rho\frac{\ell}{A}$

$\therefore\ (1.32) = (5.6\times10^{-8}) \times \frac{\ell}{(1.66\times10^{-9})}$ [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	