Class – 12 – Physics Chapter wise Mock test
Chapter – 03 – Current Electricity

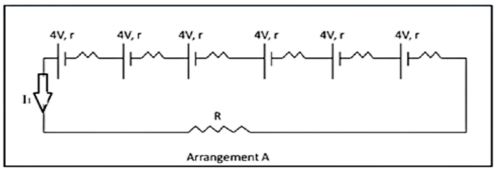
Maximum Marks: 70 **Time allowed: 3 hours**

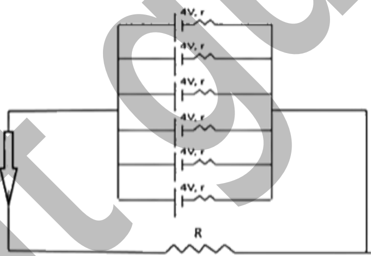
General Instructions:

1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. All the sections are compulsory.
4. **Section A** contains **sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B** contains **five questions of two marks each, Section C** contains seven questions of three marks each, **Section D** contains **two case study-based questions of four marks each** and **Section E** contains **three long answer questions of five marks each.**
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.

SECTION – A

1. Sheetal had 6 identical cells, each of electromotive force (emf) 4 V and internal resistance 'r'. She connected them to an external resistor 'R' in two different arrangements as shown and measured the current as 'I_1' and 'I_2' respectively

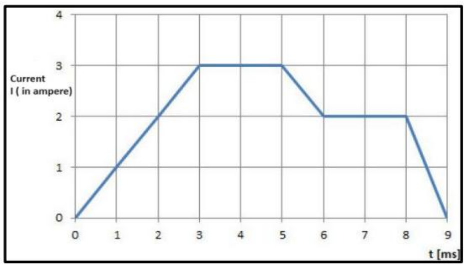




Arrangement B

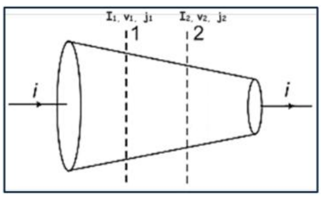
If 'I_2' is found to be greater than 'I_1', then which relation is true?
(a) $R > r$
(b) $R = r$
(c) $R < r$
(d) $R = 6r$

2. The current passing through a wire varies with time as provided below. The charge passing through the wire from 0s to 5s is:
(a) 12.5 mC
(b) 9 mC
(c) 4.5 mC
(d) 10.5 mC

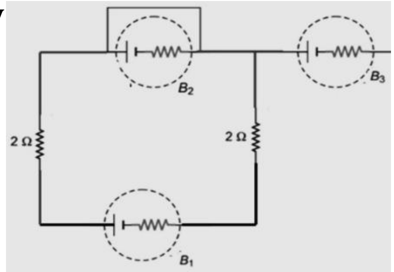


3. A current I is flowing through a wire of non-uniform cross-section as shown in the figure. Which of the following options gives the correct variation of current (i), drift velocity (v), and current density (j) across the wire?

S.No.	Current	Current density	Drift velocity
(a)	$I_1 > I_2$	$j_2 = j_1$	$v_2 < v_1$
(b)	$I_1 = I_2$	$j_2 > j_1$	$v_2 > v_1$
(c)	$I_1 < I_2$	$j_2 < j_1$	$v_2 = v_1$
(d)	$I_1 = I_2$	$j_2 = j_1$	$v_2 = v_1$



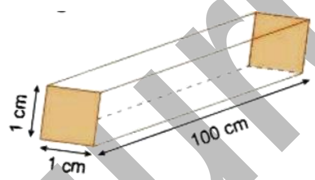
4. Each of the batteries connected in the circuit is of electromotive force (emf) 4V resistance of 1 ohm. What is the potential difference across the battery B_2?



(a) 0 V
(b) 2.67 V
(c) 4 V
(d) 1.33 V

5. The resistance of a metal wire increases with increasing temperature on account of
(a) decrease in free electron density.
(b) decrease in relaxation time.
(c) increase in mean free path.
(d) increase in the mass of electron.

6. Dimensions of a block are 1cm x 1cm x 100 cm. If specific resistance of its material is $3 \times 10^{-7}\ \Omega$ m, then the resistance between the opposite rectangular faces is



(a) $3 \times 10^{-9}\ \Omega$
(b) $3 \times 10^{-7}\ \Omega$
(c) $3 \times 10^{-5}\ \Omega$
(d) $3 \times 10^{-3}\ \Omega$

7. Resistivity of a given conductor depends upon
(a) temperature.
(b) length of conductor.
(c) area of cross-section.
(d) shape of the conductor.

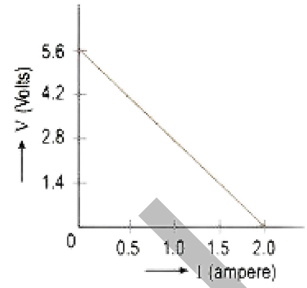
8. A metal rod of length 10 cm and a rectangular cross-section of 1cm × ½ cm is connected to a battery across opposite faces. The resistance will be
(a) maximum when the battery is connected across 1 cm x 1/2 cm faces.
(b) maximum when the battery is connected across 10 cm x 1 cm faces.
(c) maximum when the battery is connected across 10 cm x 1/2 cm faces.
(d) same irrespective of the three faces.

9. Kirchhoff's junction rule is a reflection of
(a) conservation of current density vector.
(b) conservation of charge.
(c) the fact that the momentum with which a charged particle approaches a junction is unchanged (as a vector) as the charged particle leaves the junction.
(d) the fact that there is no accumulation of charged at a junction.

10. Two sources of equal emf are connected in series. This combination is, in turn connected to an external resistance R. The internal resistance of two sources are r_1 and r_2 ($r_2 > r_1$). If the potential difference across the source of internal resistance r_2 is zero, then R equals to
(a) $\frac{r_1 + r_2}{r_2 - r_1}$ (b) $r_2 - r_1$ (c) $\frac{r_1\ r_2}{r_2 - r_1}$ (d) $\frac{r_1 + r_2}{r_1\ r_2}$

11. If n, e, τ and m have their usual meanings, then the resistance of a wire of length l and cross- sectional area A is given by
(a) $\frac{ne^2 A}{2m\tau\, l}$ (b) $\frac{ml}{ne^2\, \tau A}$ (c) $\frac{m\tau\, A}{ne^2\, l}$ (d) $\frac{ne^2\, \tau\, A}{2ml}$

12. A straight line plot showing the terminal potential difference (V) of a cell as a function of current (I) drawn from it, is shown in the figure.
The internal resistance of the cell would be then
(a) 2.8 ohms
(b) 1.4 ohms
(c) 1.2 ohms
(d) zero



In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.
(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true but R is not the correct explanation of A.
(c) A is true but R is false.
(d) A is false and R is also false.

13. **Assertion (A):** An electron has a high potential energy when it is at a location associated with a more negative value of potential, and a low potential energy when at a location associated with a more positive potential.
Reason (R): Electrons move from a region of higher potential to region of lower potential.

14. **Assertion (A):** When three electric bulbs of power 200 W, 100 W and 50 W are connected in series to a source, the power consumed by the 50 W bulb is maximum.
Reason (R): In a series circuit, current is the same through each bulb, but the potential difference across each bulb is different.

15. **Assertion (A):** An electrical bulb starts glowing instantly as it is switched on.
Reason (R): Drift speed of electrons in a metallic wire is very large.

16. **Assertion (A):** The conductivity of an electrolyte is very low as compared to a metal at room temperature.
Reason (R) The number density of free ions in electrolyte is much smaller as compared to number density of free electrons in metals. Further, ions drift much more slowly, being heavier.

SECTION - B

17. What is the drift velocity of electrons? How does it elucidate the flow of electrical current within a conductor?

18. Describe the conductivity of a conductor. Elaborate on how a metallic conductor's conductivity changes in relation to temperature

OR

What is the rationale behind utilising alloys in the creation of standard resistance coils?

19.How does the mobility of electrons in a conductor change, if the potential difference applied across the conductor is doubled, keeping the length and temperature of the conductor constant?

20. Explain the factors on which internal resistance of a cell depends?

21. If a current I passes through two wires of identical length and radius—one made of nichrome and the other of copper—connected in series, which wire experiences greater heating? Justify your answer.

SECTION – C

22. Calculate the average drift velocity of conduction electrons in a copper wire of cross-section 10^{-7} m^2 carrying a current of 1 A. Assume that each copper atom contributes one conduction electron. Given that density of copper = 9 x 10^3 kg m^{-3} and its atomic
mass = 63.5.

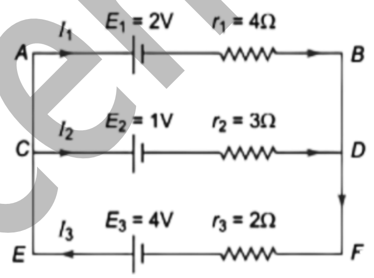
23. The number density of electrons in copper is 8.5 x 10^{28} m^{-3}. Find the current flowing through a copper wire of length 0.2m, area of cross-section 1 mm^2, when connected to a battery of 3 V. Given that electron mobility = 4.5 x 10^{-6} m^2 V^{-1} s^{-1} and charge on electron
= 1.6 x 10^{-19} C.

24. A current of 1.8 A flows through a wire of area of cross-section 0.5mm^2. Find the current density in the wire. If the number density of electrons in the wire is 8.8 x 10^{28} m^{-3}, find the drift velocity of electrons.

25. When a potential difference of 1.5 V is applied across a wire of length 0.2 m and area of cross- section 0.3 mm^2, a current of 2.4 A flows through the wire. If the number density of free electrons in the wire is 8.4 x 10^{28} m^{-3}, calculate the average relaxation time. Given that mass of electron = 9.1 x 10^{-31} kg and charge on electron = 1.6 × 10^{-19} C.

26. Using the concept of free electrons in a conductor, derive the expression for the conductivity of a wire in terms of number density and relaxation time. Hence obtain the relation between current density and the applied electric field E.

27. State Kirchhoff's rules. Use these rules to write the expressions for the currents I_1, I_2 and I_3 in the circuit diagram shown.



28. A wire of resistance 5 ohm is drawn out so that its length is increased to twice its original length. Calculate its new resistance.

OR

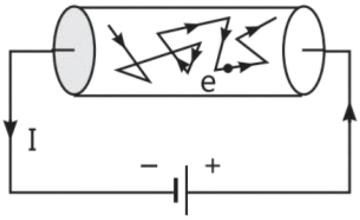
(a) The electron drift arises due to the force experienced by electrons in the electric field inside the conductor. But force should cause acceleration. Why then do the electrons acquire a steady average drift speed?
(b) If the electron drift speed is so small, and the electron's charge is small, how can we still obtain large amounts of current in a conductor? (c) When electrons drift in a metal from lower to higher potential, does it mean that all the 'free' electrons of the metal are moving in the same direction?
(d) Are the paths of electrons straight lines between successive collisions (with the positive ions of the metal) in the
(i) absence of electric field, (ii) presence of electric field?

SECTION - D

Case Study Based Questions

29. Case Study 1

Metals have a large number of free electrons nearly 10^{28} per cubic metre. In the absence of electric field, average terminal speed of the electrons in random motion at room temperature is of the order of 10^5m s^1. When a potential difference V is applied across the two ends of a given conductor, the free electrons in the conductor experience a force and are accelerated towards the positive end of the conductor. On their way, they suffer frequent collisions with the ions/atoms of the conductor and lose their gained kinetic energy. After each collision, the free electrons are gain accelerated due to electric field, towards the positive end of the conductor and lose their gained kinetic energy in the next collision with the ions/atoms of the conductor. The average speed of the free electrons with which they drift towards the positive end of the conductor under the effect of applied electric field is called drift speed of the electrons.



Read the given passage carefully and give the answer of the following questions:[4]

Q1. Magnitude of drift velocity per unit electric field is:

a. current density b. current c. resistivity d. mobility

Q2. The drift velocity of the electrons depends on:

a. dimensions of the conductor b. number density of free electrons in the conductor

c. Both a. and b. d. Neither a. nor b.

Q3. We are able to obtain fairly large currents in a conductor because:

a. the electron drift speed is usually very large

b. the number density of free electrons is very high and this can compensate for the low values of the electron drift speed and the very small magnitude of the electron charge

c. the number density of free electrons as well as the electron drift speeds are very large and these compensate for the very small magnitude of the electron charge

d. the very small magnitude of the electron charge has to be divided by the still smaller product of the number density and drift speed to get the electric current

Q4. Drift speed of electrons in a conductor is very small i.e., i = 10^{-4} m s^{-1}. The electric bulb glows immediately when the switch is closed because:

a. drift velocity of electron increases when switch is closed

b. electrons are accelerated towards the negative end of the conductor

c. the drifting of electrons takes place at the entire length of the conductor

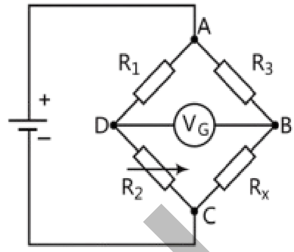
d. the electrons of conductor move towards the positive end and protons of conductor move towards negative end of the conductor

OR

The number density of free electrons in a copper conductor is 8.5 x $10^{28}$$m^{-3}$. How long does an electron take to drift from one end of a wire 3.0 m long to its other end? The area of cross-section of the wire is 2.0 x 10^{-6} m^2 and it is carrying a current of 3.0 A.

a. 8.1 x 10^4 s b. 2.7 x 10^4 s c. 9 x 10^3 s d. 3 x 10^3 s

30. **Case Study 2 :** ***Read the text carefully and answer the questions: [4]***



A Wheatstone bridge is an electrical circuit used to measure an unknown electrical resistance by balancing two legs of a bridge circuit, one leg of which includes the unknown component. The primary benefit of the circuit is its ability to provide extremely accurate measurements.

The resistance is adjusted until the bridge is 'balanced' and no current flows through the galvanometer. At this point, the voltage between the two mid-points (B and D) will be zero.

Therefore, the ratio of the two resistances in the known leg is equal to the ratio of the two resistances in the unknown leg.

Read the given passage carefully and give the answer of the following questions:

Q1. In balanced Wheatstone bridge:
a. potential at points B and D remain same
b. large current flows through the circuit
c. battery becomes over heated
d. resistances become small

Q2. Wheatstone bridge is used to measure:
a. unknown current
b. unknown voltage
c. unknown charge
d. unknown resistance

Q3. Wheatstone bridge is implemented in lab using:
a. ammeter
b. voltmeter
c. meter bridge
d. potentiometer

Q4. Condition for balanced Wheatstone bridge:
a. $R_1/R_2 = R_3/R_x$
b. $R_3 = R_1 \times R_x$
c. $R_1 = R_3 \times R_x$
d. None of these

OR

Wheatstone bridge is analogous to:
a. cantilever
b. simple level system
c. gear train
d. mechanical clutch

SECTION - E

31. Three resistors of 3Ω, 4 Ω, and 6 Ω are connected in parallel. The combination is connected to a cell of e.m.f. 2 V and internal resistance 2/3 Ω. Find the current drawn from the cell and the current through 3 Ω resistance.

OR

In the network shown in Fig. 2.17, $E_1 = 6V$, $E_2 = 4V$, $r_1 = 2Ω$, $r_2 = 3Ω$ and $R_3 = 5$ Ω. Find the currents passing through the resistors r_1, r_2 and R_3

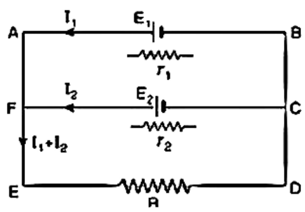


Fig. 2.17

32. Two cells of e.m.f. 2V and 1V and of internal resistances 1Ω and 2Ω respectively have their positive terminals connected by a wire of 10Ω resistance and their negative terminals by a wire of 4Ω resistance. Another coil of 10Ω is connected between the middle points of these wires. Find the potential difference across the 10 coil.

OR

Q. For the circuit shown in Fig. 2.21, calculate the potential difference between the points B and D.

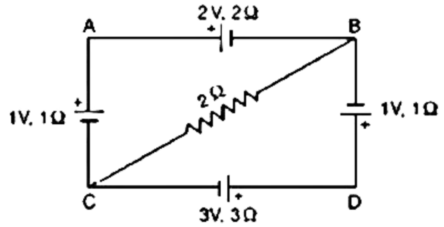


Fig. 2.21

33. Four resistances P = 5Ω, Q = 6Ω, R= 50Ω and X = 60 Ω are connected in the four arms of the Wheatstone bridge. If a cell of e.m.f. 1.5 V and negligible internal resistance is connected across the bridge, calculate the current in the arms of the Wheatstone bridge and the cell.

OR

[a] A steady current flows in a metallic conductor of non-uniform cross section of non- uniform cross section. Which of these quantities is constant along the conductor: current, current density, electric field, drift speed?

[b] Is Ohm's law universally applicable for all conducting elements?

If not, give examples of elements which do not obey Ohm's law.

[c] A low voltage supply from which one needs high currents must have very low resistance. Why?

[d] A high tension (HT) supply of, say, 6 kV must have a very large internal resistance