Chapter Three

CURRENT ELECTRICITY

MCQ I

3.1 Consider a current carrying wire (current I) in the shape of a circle. Note that as the current progresses along the wire, the direction of **j** (current density) changes in an exact manner, while the current I remain unaffected. The agent that is *essentially* responsible for is

(a) source of emf.

(b) electric field produced by charges accumulated on the surface of wire.

(c) the charges just behind a given segment of wire which push them just the right way by repulsion.

(d) the charges ahead.

3.2 Two batteries of emf ε_1 and ε_2 ($\varepsilon_2 > \varepsilon_1$) and internal resistances r_1 and r_2 respectively are connected in parallel as shown in Fig 3.1.

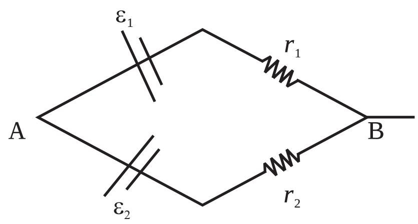

Fig 3.1

(a) The equivalent emf ε_{eq} of the two cells is between ε_1 and ε_2, i.e. $\varepsilon_1 < \varepsilon_{eq} < \varepsilon_2$.

(b) The equivalent emf ε_{eq} is smaller than ε_1 .
(c) The ε_{eq} is given by $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ always.
(d) ε_{eq} is independent of internal resistances r_1 and r_2.

3.3 A resistance R is to be measured using a meter bridge. Student chooses the standard resistance S to be 100Ω. He finds the null point at l_1 = 2.9 cm. He is told to attempt to improve the accuracy. Which of the following is a useful way?

(a) He should measure l_1 more accurately.
(b) He should change S to 1000Ω and repeat the experiment.
(c) He should change S to 3Ω and repeat the experiment.
(d) He should give up hope of a more accurate measurement with a meter bridge.

3.4 Two cells of emf's approximately 5V and 10V are to be accurately compared using a potentiometer of length 400cm.

(a) The battery that runs the potentiometer should have voltage of 8V.
(b) The battery of potentiometer can have a voltage of 15V and R adjusted so that the potential drop across the wire slightly exceeds 10V.
(c) The first portion of 50 cm of wire itself should have a potential drop of 10V.
(d) Potentiometer is usually used for comparing resistances and not voltages.

3.5 A metal rod of length 10 cm and a rectangular cross-section of 1cm × $\frac{1}{2}$ cm is connected to a battery across opposite faces. The resistance will be

(a) maximum when the battery is connected across 1 cm × $\frac{1}{2}$ cm faces.

(b) maximum when the battery is connected across 10 cm × 1 cm faces.

(c) maximum when the battery is connected across 10 cm × $\frac{1}{2}$ cm faces.

(d) same irrespective of the three faces.

3.6 Which of the following characteristics of electrons determines the current in a conductor?

(a) Drift velocity alone.
(b) Thermal velocity alone.
(c) Both drift velocity and thermal velocity.
(d) Neither drift nor thermal velocity.

MCQ II

3.7 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 charges at a junction.

3.8 Consider a simple circuit shown in Fig 3.2.  stands for a variable resistance R'. R' can vary from R_0 to infinity. r is internal resistance of the battery ($r<<R<<R_0$).

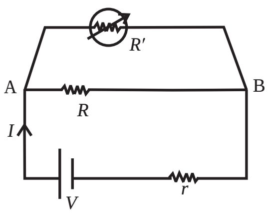

Fig 3.2

(a) Potential drop across AB is nearly constant as R' is varied.
(b) Current through R' is nearly a constant as R' is varied.
(c) Current I depends sensitively on R'.
(d) $I \geq \dfrac{V}{r+R}$ always.

3.9 Temperature dependence of resistivity $\rho(T)$ of semiconductors, insulators and metals is significantly based on the following factors:

(a) number of charge carriers can change with temperature T.
(b) time interval between two successive collisions can depend on T.
(c) length of material can be a function of T.
(d) mass of carriers is a function of T.

3.10 The measurement of an unknown resistance R is to be carried out using Wheatstones bridge (see Fig. 3.25 of NCERT Book). Two students perform an experiment in two ways. The first students takes $R_2 = 10\Omega$ and $R_1 = 5\Omega$. The other student takes $R_2 = 1000\Omega$ and $R_1 = 500\Omega$. In the standard arm, both take $R_3 = 5\Omega$.

Both find $R = \dfrac{R_2}{R_1} R_3 = 10\Omega$ within errors.

(a) The errors of measurement of the two students are the same.
(b) Errors of measurement do depend on the accuracy with which R_2 and R_1 can be measured.
(c) If the student uses large values of R_2 and R_1, the currents through the arms will be feeble. This will make determination of null point accurately more difficult.
(d) Wheatstone bridge is a very accurate instrument and has no errors of measurement.

3.11 In a meter bridge the point D is a neutral point (Fig 3.3).

(a) The meter bridge can have no other neutral point for this set of resistances.

(b) When the jockey contacts a point on meter wire left of D, current flows to B from the wire.

(c) When the jockey contacts a point on the meter wire to the right of D, current flows from B to the wire through galvanometer.

(d) When R is increased, the neutral point shifts to left.

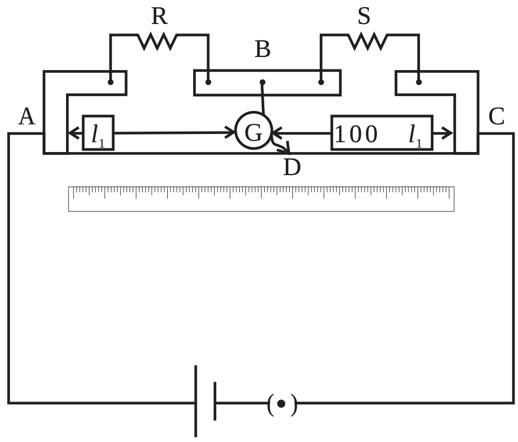

Fig 3.3

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3.12 Is the motion of a charge across junction momentum conserving? Why or why not?

3.13 The relaxation time τ is nearly independent of applied E field whereas it changes significantly with temperature T. First fact is (in part) responsible for Ohm's law whereas the second fact leads to variation of ρ with temperature. Elaborate why?

3.14 What are the advantages of the null-point method in a Wheatstone bridge? What additional measurements would be required to calculate $R_{unknown}$ by any other method?

3.15 What is the advantage of using thick metallic strips to join wires in a potentiometer?

3.16 For wiring in the home, one uses Cu wires or Al wires. What considerations are involved in this?

3.17 Why are alloys used for making standard resistance coils?

3.18 Power P is to be delivered to a device via transmission cables having resistance R_C. If V is the voltage across R and I the current through it, find the power wasted and how can it be reduced.

3.19 AB is a potentiometer wire (Fig 3.4). If the value of R is increased, in which direction will the balance point J shift?

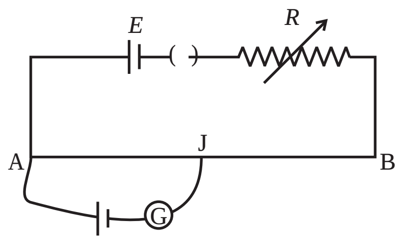

Fig 3.4

3.20 While doing an experiment with potentiometer (Fig 3.5) it was found that the deflection is one sided and (i) the deflection decreased while moving from one end A of the wire to the end B; (ii) the deflection increased. while the jockey was moved towards the end B.

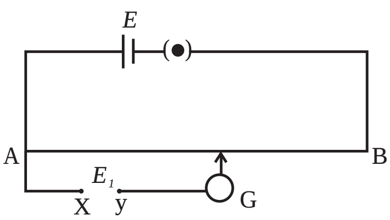

Fig 3.5

(i) Which terminal +or –ve of the cell E_1, is connected at X in case (i) and how is E_1 related to E?

(ii) Which terminal of the cell E_1 is connected at X in case (ii)?

3.21 A cell of emf E and internal resistance r is connected across an external resistance R. Plot a graph showing the variation of P.D. across R, verses R.

SA

3.22 First a set of n equal resistors of R each are connected in series to a battery of emf E and internal resistance R. A current I is observed to flow. Then the n resistors are connected in parallel to the same battery. It is observed that the current is increased 10 times. What is 'n'?

3.23 Let there be n resistors R_1 . ...R_n with R_{max} = max (R_1......... R_n) and R_{min} = min {R_1 ..... R_n}. Show that when they are connected in parallel, the resultant resistance $R_P < R_{min}$ and when they are connected in series, the resultant resistance $R_S > R_{max}$. Interpret the result physically.

3.24 The circuit in Fig 3.6 shows two cells connected in opposition to each other. Cell E_1 is of emf 6V and internal resistance 2Ω; the cell E_2 is of emf 4V and internal resistance 8Ω. Find the potential difference between the points A and B.

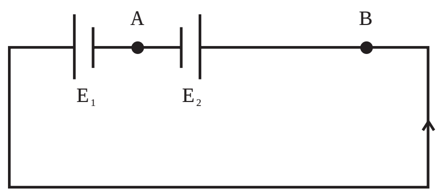

Fig 3.6

3.25 Two cells of same emf E but internal resistance r_1 and r_2 are connected in series to an external resistor R (Fig 3.7). What should be the value of R so that the potential difference across the terminals of the first cell becomes zero.

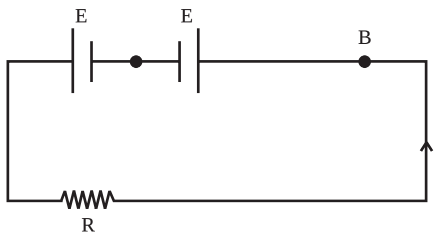

Fig. 3.7

3.26 Two conductors are made of the same material and have the same length. Conductor A is a solid wire of diameter 1mm. Conductor B is a hollow tube of outer diameter 2mm and inner diameter 1mm. Find the ratio of resistance R_A to R_B.

3.27 Suppose there is a circuit consisting of only resistances and batteries. Suppose one is to double (or increase it to n-times) all voltages and all resistances. Show that currents are unaltered. Do this for circuit of Example 3.7 in the NCERT Text Book for Class XII.

LA

3.28 Two cells of voltage 10V and 2V and internal resistances 10Ω and 5Ω respectively, are connected in parallel with the positive end of 10V battery connected to negative pole of 2V battery (Fig 3.8). Find the effective voltage and effective resistance of the combination.

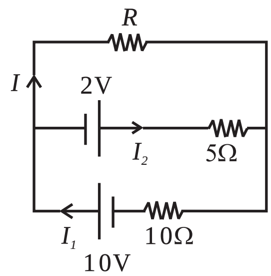

Fig 3.8

3.29 A room has AC run for 5 hours a day at a voltage of 220V. The wiring of the room consists of Cu of 1 mm radius and a length of 10 m. Power consumption per day is 10 commercial units. What fraction of it goes in the joule heating in wires? What would happen if the wiring is made of aluminium of the same dimensions?

$[\rho_{cu} = 1.7 \times 10^{-8}_{\Omega m}$, $\rho_{Al} = 2.7 \times 10^{-8}\,\Omega m]$

3.30 In an experiment with a potentiometer, V_B = 10V. R is adjusted to be 50Ω (Fig. 3.9). A student wanting to measure voltage E_1 of a battery (approx. 8V) finds no null point possible. He then diminishes R to 10Ω and is able to locate the null point on the last (4[th]) segment of the potentiometer. Find the resistance of the potentiometer wire and potential drop per unit length across the wire in the second case.

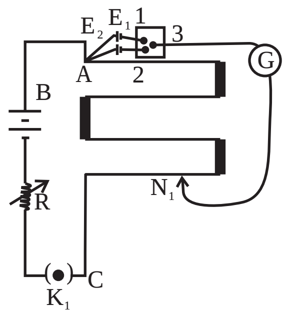

Fig 3.9

3.31 (a) Consider circuit in Fig 3.10. How much energy is absorbed by electrons from the initial state of no current (ignore thermal motion) to the state of drift velocity?

(b) Electrons give up energy at the rate of RI^2 per second to the thermal energy. What time scale would one associate with energy in problem (a)? n = no of electron/volume = $10^{29}/m^3$, length of circuit = 10 cm, cross-section = A = $(1mm)^2$

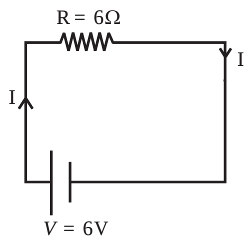

Fig 3.10