O P JINDAL SCHOOL, SAVITRINAGAR

PRACTICE PAPER (SOLUTION)

CLASS XII PHYSICS **TOPIS : CURRENT ELECTRICITY**

Date : 23/04/20 **MM :50**

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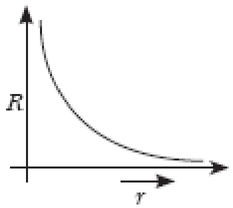
1 Plot a graph showing the variation of resistance of a conducting wire as a function of its radius, keeping the length of the wire and its temperature as constant. 1

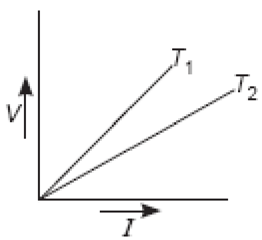
$\because$ $$R = \rho \frac{l}{A} = \rho \frac{l}{\pi r^2}$$

or $$R \propto \frac{1}{r^2}$$

ANS:



2 V–I graph for a metallic wire at two different temperatures T_1 and T_2 is as shown in the figure. Which of the two temperatures is higher and why? 1



ANS: Since, resistance = slope of V-I graph. In the figure, the slope of T_1 is large, so T_1 represents the higher temperature as the resistance increases with the temperature for a conductor

3 The emf of a cell is always greater than its terminal voltage. Why? Give reason. 1

ANS: The current always flows from higher to lower potential. To produce the current to an external circuit, the emf must be greater than the terminal voltage, i.e. the potential difference across the external circuit.

$\varepsilon = V + Ir$

4 You are given three constantan wires P, Q and R of length and area of cross-section (L, A), $\left(2L, \frac{A}{2}\right)$, $\left(\frac{L}{2}, 2A\right)$ respectively. Which has highest resistance? 1

ANS:
$$\text{Given: } P = (L, A), Q = \left(2L, \frac{A}{2}\right), R = \left(\frac{L}{2}, 2A\right)$$
$$\text{As we know } R = \rho\frac{l}{A}$$
$$\therefore \quad R_P = \rho\frac{L}{A}\ ;\ R_Q = \rho\frac{2L.2}{A} = \rho\frac{4L}{A} \quad \text{and} \quad R_R = \rho\frac{L}{2\times 2\,A} = \frac{\rho L}{4A}$$
Hence, Q has the highest resistance.

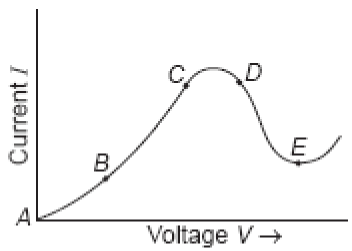
5 Two wires of equal length, one of copper and the other of manganin have the same resistance. Which wire is thicker? 1

ANS:
$$R = \rho_1\frac{l}{A_1}, S = \rho_2\frac{l}{A_2} \quad \therefore \quad \rho_1\frac{l}{A_1} = \rho_2\frac{l}{A_2} \Rightarrow \frac{A_1}{A_2} = \frac{\rho_1}{\rho_2}$$
As the resistivity of manganin (ρ_2) is greater than the resistivity of copper (ρ_1). So, the manganin wire is thicker.

6 State the condition for maximum current to be drawn from a cell. 1

ANS: $I = \frac{E}{R+r}$; when the external resistance, $R = 0$ (i.e. cell is short-circuited), then the maximum current will be drawn from a cell.

7 Graph showing the variation of current versus voltage for a material GaAs is shown in the figure. Identify the region of
(i) negative resistance,
(ii) where Ohm's law is obeyed.



1

ANS: (i) *DE* is the negative resistance region.
(ii) Ohm's law is obeyed in the region *AB*.

8 Define the term 'electrical conductivity' of a metallic wire. Write its SI unit. 1

ANS: Electric conductivity (σ) is defined as the reciprocal of electric resistivity.

i.e. $\sigma = \frac{1}{\rho}$

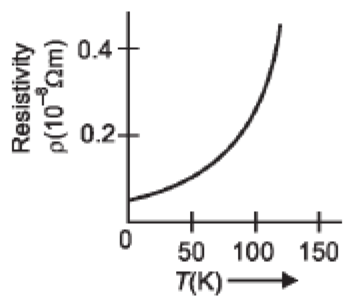
Its SI unit is $\Omega^{-1}\ m^{-1}$, mho m^{-1} or siemen m^{-1}.

9 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? 1

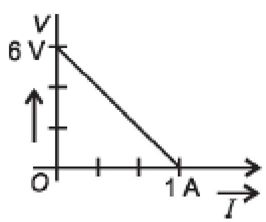
ANS: No. As the collision is a random process, the electrons cannot get deflected in the same direction.

10 Show variation of resistivity of copper as a function of temperature in a graph. 1

ANS:



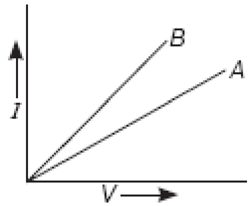
11 The plot of the variation of potential difference across a combination of three identical cells in series, versus current is as shown here. What is the emf of each cell? 1



When $I = 0$, $V_{max} = E = 6$ V

ANS: Thus, an emf of each cell $= \frac{6}{3} = 2$ volts.

12 Out of V – I graph for parallel and series combination of two metallic resistors, which one represents parallel combination of resistors? Justify your answer.



1

ANS: The resistance of parallel combination is less than of series combination of a given set of resistors. Hence, B represents a parallel combination, since $\frac{I}{V}$ is more.

Hence, the resistance, i.e. $\frac{V}{L}$ is less.

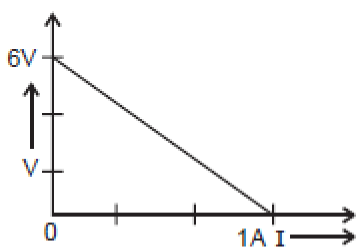
or

As slope of A < slope of B and resistance (R) = $\frac{1}{\text{Slope}}$

$R_A > R_B$

Hence, B will represent the parallel combination.

13 The plot of the variation of potential difference across a combination of three identical cells in series, versus current is shown below. What is the emf and internal resistance of each cell?



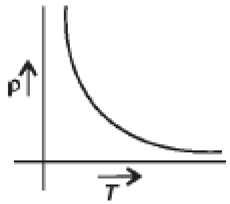
1

ANS: When $I = 0$, $E = V$

Thus, emf of each cell = $\frac{6}{3}$ = 2V

14 Plot a graph showing temperature dependence of resistivity for a typical semiconductor. How is this behaviour explained? 1

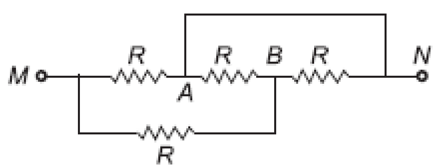
ANS: In case of semiconductors, n (no. density of free electrons) increases with temperature. Therefore, resistivity decreases. The decrease in resistivity due to increase in n dominates the increase in resistivity due to decrease in τ.
Therefore, the resistivity of semiconductor decreases with the increase in temperature.



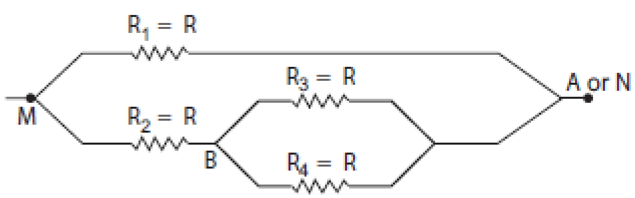
15 Nichrome and copper wires of same length and area of cross section are connected in series, current is passed through them why does the nichrome wire get heated first? 2

ANS: As, in series, $H \propto R$ [where H = Heat produced and R = resistance] and the resistance of nichrome wire is more than the resistance of copper wire of same dimensions. Hence, the nichrome wire will heat up more.

16 Calculate the resistance across the points M and N in the given figure. 2



ANS: In this case, points A and N are at same potential, but points M and B are at different potentials. The above circuit can therefore be redrawn.



$\because$ R_3 and R_4 are in parallel

$$\therefore \qquad R_{34} = \frac{R_3 \times R_4}{R_3 + R_4} = \frac{R \times R}{R + R} = \frac{R^2}{2R} = \frac{R}{2}$$

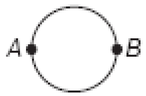
$\because$ R_{34} and R_2 are in series

$$\therefore \qquad R_{234} = R_{34} + R_2 = \frac{R}{2} + R = \frac{3R}{2}$$

$\because$ R_{234} and R_1 are in parallel, so equivalent resistance is calculated as

$$R_{eq} = \frac{R_{234} \times R_1}{R_{234} + R_1} = \frac{\frac{3R}{2} \times R}{\frac{3R}{2} + R} = \frac{\frac{3R^2}{2}}{\frac{5R}{2}} = \frac{3R}{5}$$

17 A uniform wire of resistance *R* ohm is bent into a circular loop as shown in the figure. Compute effective resistance between diametrically opposite points *A* and *B*. 2



ANS: Resistance of each semicircular part (R') = $\frac{1}{2}$ × resistance of circular part = $\frac{R}{2}$

Since both the parts of circular wire are connected in parallel

$$\therefore \qquad R_{AB} = \frac{R'}{2} = \frac{R/2}{2} = \frac{R}{4}$$

18 Name two factors on which the resistivity of a given material depends. A carbon resistor has a value of 62 kΩ with a tolerance of 5%. Give the colour code for the resistor. 2

ANS: (i) Temperature

(ii) Nature of the material.

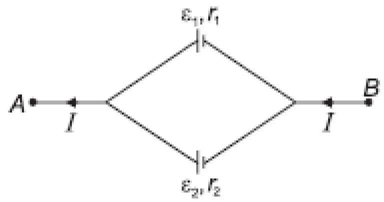
The colour code for the carbon resistor is blue, red, orange and gold.

19 Two cells of emfs ε_1, ε_2 and internal resistances r_1 and r_2 respectively are connected in parallel as shown in the figure. Deduce the expression for 3

(i) the equivalent emf of the combination,

(ii) the equivalent resistance of the combination, and

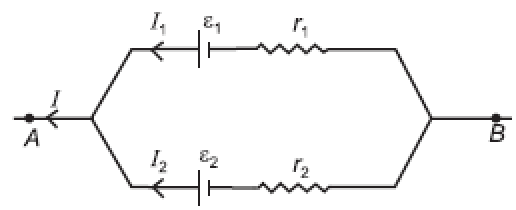
(iii) the potential difference between the points *A* and *B*.



We know $V = \varepsilon_1 - I_1 r_1$

So, $$I_1 = \frac{\varepsilon_1 - V}{r_1}$$

Similarly, $$I_2 = \frac{\varepsilon_2 - V}{r_2}$$



ANS:

As the cells are in parallel, the potential difference across the cells is same,

i.e. V1 = V2 = V

Now, $$I = I_1 + I_2$$

$$\therefore \quad I = \left(\frac{\varepsilon_1 - V}{r_1}\right) + \left(\frac{\varepsilon_2 - V}{r_2}\right) \Rightarrow I = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right) \quad \ldots(a)$$

$$I = \left(\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 . r_2}\right) - V\left(\frac{r_1 + r_2}{r_1 . r_2}\right) \Rightarrow V = \left(\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}\right) - I\left(\frac{r_1 r_2}{r_1 + r_2}\right) \ldots(b)$$

$$\therefore \quad V = \varepsilon_{eq} - I\, r_{eq}$$

(i) The expression for the equivalent emf of the combination

$$\varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} \quad \ldots(c)$$

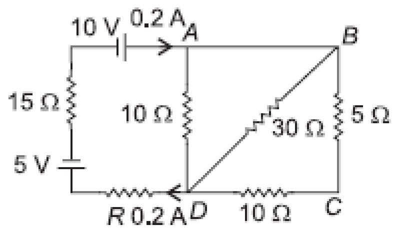
(ii) Expression for the equivalent resistance of the combination

$$r_{eq} = \frac{r_1 r_2}{r_1 + r_2} \quad \ldots(d)$$

(iii) Expression for the potential difference between the points *A* and *B*.

$$V = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} - \left(\frac{r_1 r_2}{r_1 + r_2}\right) I$$

20 Calculate the value of the resistance *R* in the circuit shown in the figure so that the current in the circuit is 0.2 A. What would be the potential difference between points *A* and *D*? 4



ANS: Resistance in the arm *BCD* of the circuit,

$R_1 = 5 + 10 = 15\ \Omega$

Resistance between points *B* and *D*, $R_{BD} = \dfrac{30 \times 15}{45} = 10\ \Omega$

Resistance between the points *A* and *D*, $R_{AD} = \dfrac{10 \times 10}{10+10} = \dfrac{100}{20} = 5\ \Omega$

Now, the circuit reduces to the form as shown.

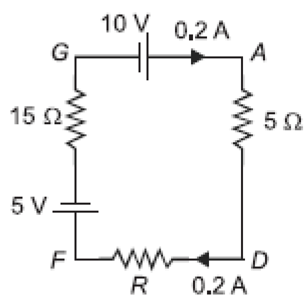
From the loop *ADFGA*,

$5 \times 0.2 + R \times 0.2 + 15 \times 0.2 = 5 \Rightarrow 0.2R + 4 = 5$

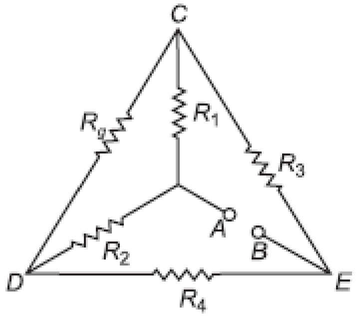
$0.2R = 1 \Rightarrow R = \dfrac{1}{0.2} = 5\ \Omega$

Potential difference between the points *A* and *D*,

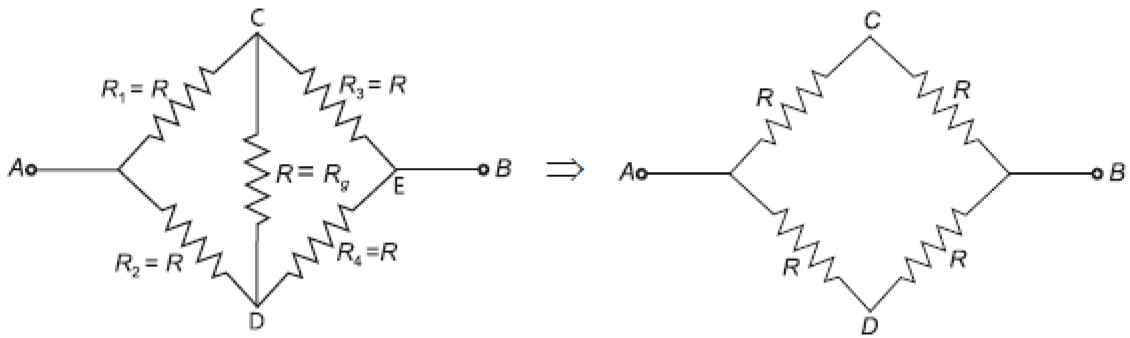
$V_{AD} = 5 \times 0.2 = 1$ V



21 (i) Calculate the equivalent resistance of the given electrical network between points *A* and *B*.
(ii) Also calculate the current through *CD* and *ACB*, if a 10 V dc source is connected between *A* and *B*, and the value of *R* is assumed as 2 Ω. 4



ANS: (i) The given circuit can be redrawn as shown in the figure.



As $$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$

The circuit is a balanced wheatstone bridge.

$\therefore$ $V_C = V_D$ and $I_{CD} = 0$

Hence, an equivalent circuit is redrawn as shown.

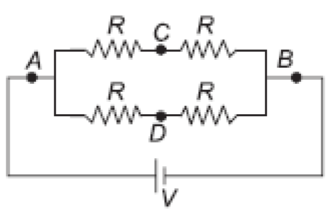
Thus, $$R_{AB} = \frac{(2R)(2R)}{4R} = R\,\Omega$$

(ii) Being a balanced wheatstone bridge, $I_{CD} = 0$

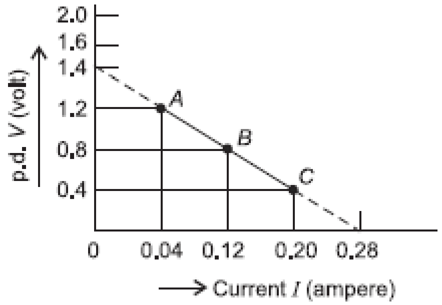
Given: $R = 2\ \Omega$, $V_{AB} = 10$ V

$R_{ACB} = 4\ \Omega$

$$I_{ACB} = \frac{10}{4} = 2.5\text{ A}$$



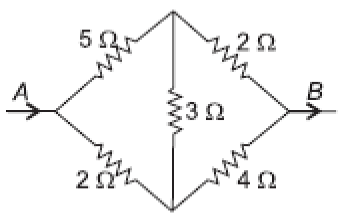
22 A straight line plot showing the terminal potential difference (V) of a cell as a function of current (I) drawn from it is shown in the figure.
Using this plot, determine (i) the emf, and (ii) internal resistance of the cell. 4



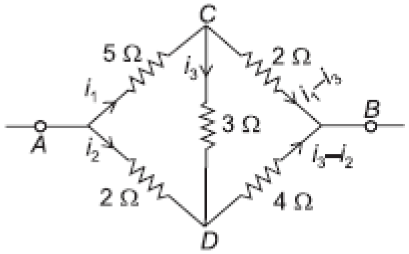
ANS: We know that $E - V = Ir$
(i) Clearly, where $I = 0$, $E = V = 1.4$ V (from the graph)
(ii) Also, when $V = 1.2$ V, $I = 0.04$ A

$$r = \frac{E - V}{I} = \frac{1.4 - 1.2}{0.04} = \frac{0.20}{0.04} = 5\,\Omega$$

23 In the arrangement of conductors, find the equivalent resistance between A and B. 4



ANS: Kirchhoff 's second rule for the loop $ACDA$,
$5i_1 + 3i_3 - 2i_2 = 0$
or $5i_1 - 2i_2 + 3i_3 = 0$ ...(i)
Kirchhoff 's second rule for the loop $CBDC$,
$2(i_1 - i_3) - 4\,(i_3 + i_2) - 3i_3 = 0$
$2i_1 - 2i_3 - 4i_3 - 4i_2 - 3i_3 = 0$
$2i_1 - 4i_2 - 9i_3 = 0$ ...(ii)
From equations (i) and (ii), we get



$$\frac{i_1}{18+12} = \frac{i_2}{6+45} = \frac{i_3}{-20+4}$$

$$\frac{i_1}{30} = \frac{i_2}{51} = \frac{i_3}{-16} = k$$

$$i_1 = 30\,k \,;\, i_2 = 51\,k \,;\, i_3 = -16\,k$$

Let the equivalent resistance between *A* and *B* be *R*, then

$V = R\,(i_1 + i_2)$

where, *V* is the potential difference between *A* and *B*.

Also, $V = V_{AC} + V_{CB} = 5i_1 + 2\,(i_1 - i_3)$

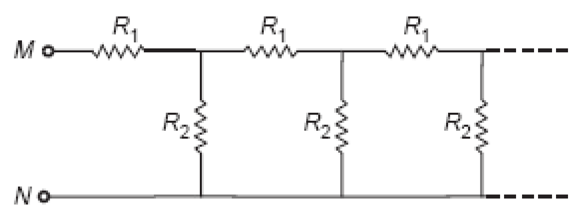
$V = 7i_1 - 2i_3$

$R(i_1 + i_2) = 7i_1 - 2i_3$

$$R = \frac{7i_1 - 2i_3}{i_1 + i_2} = \frac{7 \times 30\,k - 2\,(-16\,k)}{30\,k + 51\,k}$$

$$R \approx 3\,\Omega$$

24 The figure shows an infinite circuit which is formed by the repetition of same chain consisting R1 and R2. If R1 = 4W and R2 = 3W, then calculate the resistance between the points M and N.



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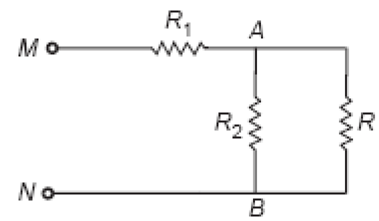
ANS: Let the total resistance of this infinite chain be R, clearly the total resistance to the right of AB can be assumed to be equal to R



$$R = \frac{R R_2}{R + R_2} + R_1$$

$$R^2 + RR_2 = RR_2 + RR_1 + R_1R_2$$

$$R^2 - RR_1 - R_1R_2 = 0$$

$$R^2 - 4R - 12 = 0$$

$$(R - 6)(R + 2) = 0$$

$$R \neq 2, \text{ Hence } R = 6\Omega$$

because the chain is infinite. Hence we can redraw the circuits as follows.

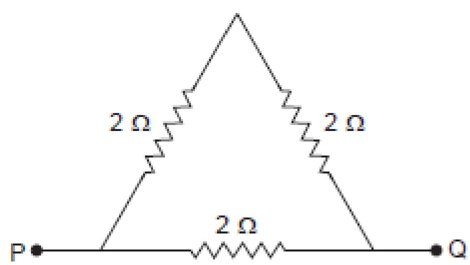
25 A Daniel cell is balanced on 125 cm length of a potentiometer wire. Now the cell is short-circuited by a resistance 2 ohm and the balance is obtained at 100 cm. The internal resistance of the Daniel cell is 1

(a) 0.5 ohm (b) 1.5 ohm

(c) 1.25 ohm (d) 4/5 ohm

ANS: $(a)\ r = \left(\frac{l_1 - l_2}{l_2}\right) R = \left(\frac{25}{100}\right) 2 = 0.5\ \Omega$

26 Three resistors each of 2 ohm are connected together in a triangular shape. The resistance between any two vertices will be 1

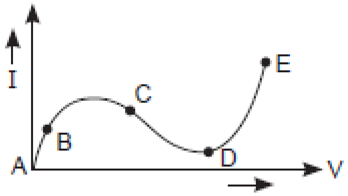


(a) 4/3 ohm (b) 3/4 ohm

(c) 3 ohm (d) 6 ohm

ANS: (a) Equivalent resistance of the combination $\frac{(2+2)\times 2}{2+2+2} = \frac{8}{6} = \frac{4}{3}\Omega$

27 From the graph between current I and voltage V shown below, identify the portion corresponding to negative resistance 1

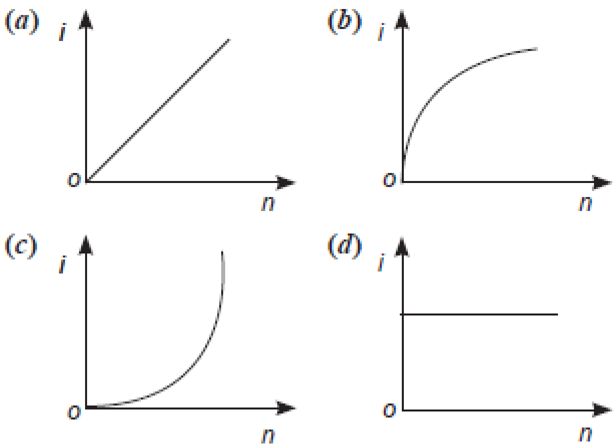


(a) AB (b) BC

(c) CD (d) DE

ANS: (c) For portion CD slope of the curve is negative i.e. resistance be negative.

28 A battery consists of a variable number ‘n’ of identical cells having internal resistances connected in series. The terminals of battery are short circuited and the current i is measured. Which of the graph below shows the relationship between i and n? 1



ANS: (d) $I = \frac{nE}{nr} = \frac{E}{r}$. current is independent of n.

29 A cell of e.m.f. 1.5V having a finite internal resistance is connected to a load resistance of 2Ω. For maximum power transfer the internal resistance of the cell should be ___________. 1

ANS: 2 Ω. For maximum power, external resistance = internal resistance.