VERY SHORT ANSWER QUESTIONS

(1 mark)

Previous Years' Questions

Q. 1. Out of two bulbs marked 25 W and 100 W, which has higher resistance?

[CBSE Delhi 2003]

Ans. Resistance of a bulb $R = \frac{V^2}{P} \propto \frac{1}{P}$ for same voltage.

Smaller the power, higher is the resistance. Clearly 25 W bulb has higher resistance.

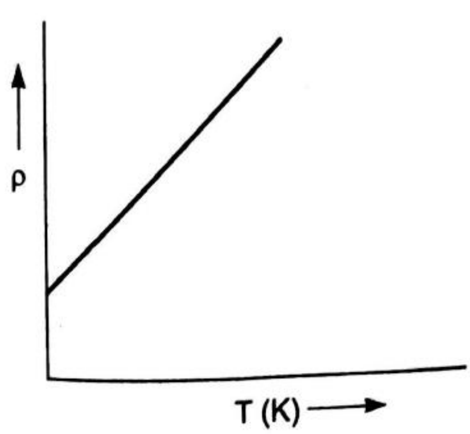
Q. 2. Two materials Si and Cu, are cooled from 300 K to 60 K. What will be the effect on their resistivity?

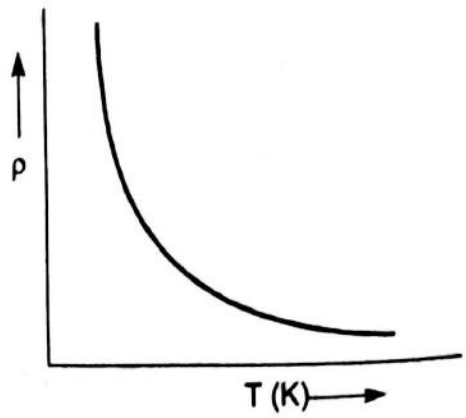
[CBSE (F) 2013]

Semi

Ans. In silicon, the resistivity increases.

In copper, the resistivity decreases.

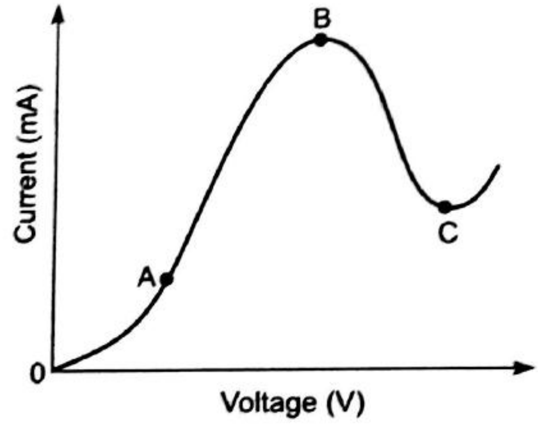




Q. 3. A wire of resistivity ρ is stretched to double its length. What will be its new resistivity? *[CBSE Delhi 2003]*

Ans. New resistivity will be ρ (unchanged) because resistivity is independent of dimensions of conductor.

Q. 4. The graph shown in the figure represents a plot of current versus voltage for a given semiconductor. Identify the region, if any, over which the semiconductor has a negative resistance. **[CBSE (AI) 2013]**



Ans. In region BC *i.e.*, the region showing negative slope.

Concept: In figure draw two horizontal lines, as marked by dotted lines and use the formula:

$$R=\left(\frac{+\Delta V}{-\Delta I}\right) \text{ in the region, B to C = negative resistance.}$$

Q. 5. Two conducting wires X and Y of same diameter but different materials are joined in series across a battery. If the number density of electrons in X is twice that in Y, find the ratio of drift velocity of electrons in the two wires. *[CBSE (AI) 2011]*

Ans. In series current is same,

So, $I_A = I_B = I = neAv_d$

For same diameter, cross-sectional area is same

$$A_A = A_B = A$$

∴ $I_A = I_B \Rightarrow n_x eAv_x = n_y eAv_y$

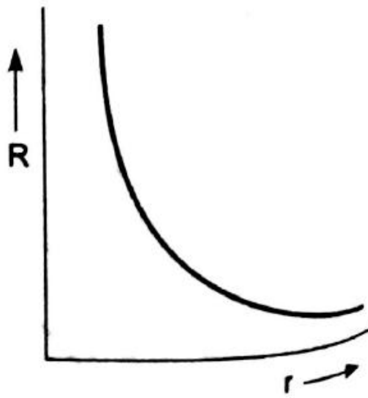
Given $n_x = 2n_y$

$$\Rightarrow \frac{v_x}{v_y} = \frac{n_y}{n_x} = \frac{n_y}{2n_y} = \frac{1}{2}$$

Q. 6. 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. *[CBSE (F) 2013]*

Ans. Resistance of a conductor of length l, and radius r is given by

$$R = \rho\frac{\ell}{\pi r^2}$$



Q. 7. What is the effect of heating of a conductor on the drift velocity of free electrons?

Ans. $$v_d = \frac{eE}{m}\tau$$

By heating a conductor, the collisions of electrons occur more frequently; so relaxation time decreases and hence drift velocity decreases.

Q. 8. Define the term resistivity and write the SI unit. *[CBSE Delhi 2005]*

Ans. The resistivity of the material of a conductor is defined as the resistance offered by a conductor of length 1 m and area of cross-section 1 m^2. Its S.I. unit is ohm × metre (Ωm).

Q. 9. Define electrical conductivity of a conductor and give its SI unit. *[CBSE Delhi 2008, 2005]*

Ans. The reciprocal of resistivity (ρ) of a material is called its conductivity (σ), *i.e.*,

$$\sigma = \frac{1}{\rho}$$

S.I. unit of conductivity is mho m^{-1} (or siemen m^{-1}).

Q. 10. What happens to the power dissipation if the value of electric current passing through a conductor of constant resistance is doubled? *[CBSE Delhi 2003]*

Ans. Power $P = I^2 Rt \propto I^2$

Clearly if current is doubled, the power dissipated becomes 4 times.

Q. 11. Two heated wires of the same dimensions are first connected in series and then in parallel to a source of supply. What will be the ratio of heat produced in the two cases? *[CBSE Delhi 2003]*

Ans. For same voltage $Q = \frac{V^2}{R} t \propto \frac{1}{R}$

$$\frac{Q_{series}}{Q_{parallel}} = \frac{R_{parallel}}{R_{series}} = \frac{(R\,.\,R)/(R+R)}{R+R} = \frac{R/2}{2R} = \frac{1}{4}$$

Q. 12. A carbon resistor is marked in colour bands of red, black, orange and silver. What is the resistance and tolerance value of the resistor? *[CBSE (AI) 2002]*

Ans. From colour-code table

Red	Black	Orange	Silver
↓	↓	↓	↓
2	0	3	±10%

$$R = 20 \times 10^3\ \Omega \pm 10\% = 20\ \text{k}\Omega \pm 10\%$$

Q. 13. The metallic conductor is at temperature θ_1. The temperature of metallic conductor is increased to θ_2. How will the product of its resistivity and conductivity change? *[CBSE Delhi 2002C]*

Ans. Product $\rho\sigma = \rho\,.\,\frac{1}{\rho}\left(\text{since } \sigma = \frac{1}{\rho}\right)$

= independent of temperature.

Q. 14. Write an expression for the resistivity of a metallic conductor showing its variation over a limited range of temperature. *[CBSE Delhi 2008C]*

Ans. If ρ_1 is the resistivity of temperature T_1 and ρ_2 that at temperature T_2, then

$$\rho_2 = \rho_1 [1 + \alpha (T_2 - T_1)]$$

where α is temperature coefficient of resistivity.

Q. 15. Two wires one of manganin and the other of copper have equal length and equal resistance. Which one of these wires will be thicker? *[CBSE (AI) 2012]*

Ans. Resistance $R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$

Resistivity ρ of manganin is much greater than that of copper, therefore to keep same resistance R, for same length of wire, the manganin wire must be thicker.

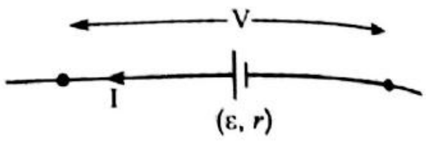
Q. 16. Specific resistance of copper, silver and constantan are 1.18×10^{-6}, 1×10^{-6}, 45×10^{-6} ohm cm respectively. Which is the best electrical conductor and why?

Ans. Smaller the resistivity of a substance, larger is its conductivity. The resistivity of silver is least so silver is the best conductor.

Q. 17. Name the device used for measuring the internal resistance of a secondary cell.

Ans. Potentiometer.

Q. 18. A cell of emf '*E*' and internal resistance '*r*' draws a current '*I*'. Write the relation between terminal voltage '*V*' in terms of *E*, *I* and *r*. ***[CBSE Delhi 2013]***

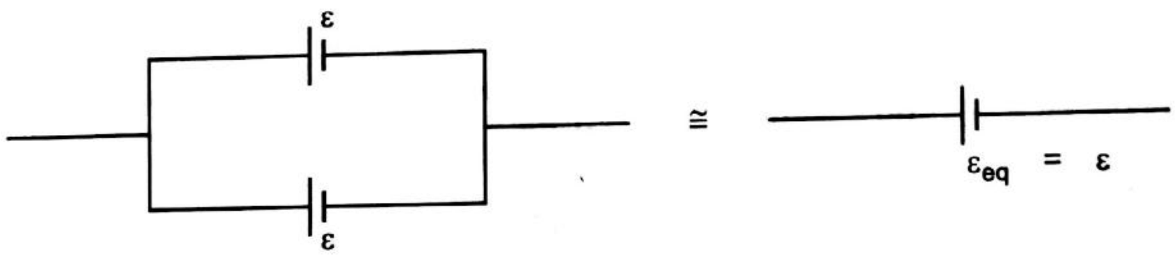


Ans. The terminal voltage V < E, so V = E − Ir

Q. 19. Two identical cells, each of emf E, having negligible internal resistance, are connected in parallel with each other across an external resistance R. What is the current through this resistance? ***[CBSE (AI) 2013]***

Ans. Current, $I = \frac{E}{R}$

Concept: (*i*) emf of combination of two (or more cells) remain same.



(*ii*) Internal resistance is negligible *i.e.*, zero.

So, $I = \frac{\varepsilon_{eq}}{R + r_{eq}} = \frac{\varepsilon}{R}$ $(r_{eq} = 0)$

Q. 20. Why do we prefer a potentiometer to measure the emf of a cell rather than a voltmeter?

Ans. A voltmeter draws current from a cell, therefore voltmeter measures terminal potential difference rather than emf, while a potentiometer at balance, does not draw any current from the cell; so the cell remains in open circuit. Hence potentiometer reads the actual value of emf.

Q. 21. A (*i*) series (*ii*) parallel combination of two given resistors is connected, one by one, across a cell. In which case will the terminal potential difference, across the cell have a higher value?

Ans. Terminal potential difference across a cell

$$V = \varepsilon - Ir$$

(*i*) In series arrangement, current, $I_S = \frac{E}{R_1 + R_2 + r}$

(*ii*) In parallel arrangement, current, $I_p = \frac{E}{\frac{R_1 R_2}{R_1 + R_2} + r}$

Obviously, $I_P > I_S$, so $V_P < V_S$.

That is **series arrangement will have higher terminal potential difference.**

Q. 22. The emf of a cell always greater than its terminal voltage. Why? Give reason.

[CBSE Delhi 2013]

Ans. (i) In an open circuit, the emf of a cell and terminal voltage are same.

(ii) In closed circuit, a current is drawn from the source, so, V = E –Ir, it is true/valid, because each cell has some finite resistance.

Q. 23. Define the current sensitivity of a galvanometer. Write its SI unit. *[CBSE (AI) 2013]*

Ans. Ratio of deflection produced in the galvanometer to the current flowing through it.

$$\text{Current sensitivity } S_i = \frac{\theta}{I}$$

SI unit of current sensitivity S_i is division/ampere or radian/ampere.

Q. 24. A resistance R is connected across a cell of emf ε and internal resistance r. A potentiometer now measures the potential difference between the terminals of the cell as V. Write the expression for 'r' in terms of ε, V and R. *[CBSE Delhi 2011]*

Ans. $r = \left(\frac{\varepsilon}{V} - 1\right) R$

Q. 25. The applied p.d. across a given resistance is altered so that heat produced per second increases by a factor of 16. By what factor does the applied p.d. change?

Ans. Power $P = \frac{V^2}{R} \Rightarrow V \propto \sqrt{P}$ for given resistance. Hence, for making power 16-times, voltage should be made 4-times.

Q. 26. Two electric bulbs are marked 220 V, 60 W and 220 V, 100 W respectively. Which of the two has the greater resistance?

Ans. Power $P = \frac{V^2}{R} \Rightarrow R \propto \frac{1}{P}$ for same voltage. Smaller the power, larger the resistance; so 60 W bulb has greater resistance.

Q. 27. Two electric bulbs whose resistances are in the ratio 1 : 2 are connected in parallel to a source of constant voltage. What will be the ratio of power dissipation in these wires?

Ans. Power $P = \frac{V^2}{R} \propto \frac{1}{R}$ for same voltage

$$\frac{P_1}{P_2} = \frac{R_2}{R_1} = \frac{2}{1}.$$

Thus ratio of power dissipated is 2 : 1.

Q. 28. State the condition under which the terminal p.d. across a battery and its emf are equal.

[CBSE (AI) 2004]

Ans. The terminal p.d. across a battery is equal to its emf when battery is in open circuit, *i.e.,* when no current is being drawn from the cell.

Q. 29. A toaster produces more heat than a light bulb when connected in parallel to a 220 V mains. Which of the two has greater resistance?

Ans. Heat produced $P \propto \frac{1}{R}$ for the same voltage. Hence, light bulb has greater resistance.

Q. 30. Two heating coils, one of fine wire and other of thick wire, made of the same material and of the same length is connected one by one to a source of electricity. Which coil will produce heat at a greater rate?

Ans. $Q \propto \frac{1}{R}$ or, $R = \frac{\rho l}{\pi r^2}$

$\therefore \quad Q \propto \frac{\pi r^2}{\rho l}$

Clearly, thick wire will produce heat at a greater rate.

Q. 31. Two 120 V light bulbs, one of 25 W and the other of 200 W were connected in series across a 240 V line. One bulb burnt out almost instantaneously. Which one was burnt and why? *[CBSE (AI) 2004]*

Ans. Resistance of bulb $R = \frac{V^2}{P} \propto \frac{1}{P}$; so 25 W bulb has higher resistance. In series current remains the same; so p.d. across 25 W bulb will be more than that across 200 W bulb; so 25 W bulb was burnt out immediately.

Other Important Questions

Q. 32. What is the advantage of using thick metallic strips to join wires in a potentiometer? *[NCERT Exemplar]*

Ans. The metal strips have low resistance and need not be counted in the potentiometer length l_1 of the null point. One measures only their lengths along the straight segments (of lengths 1 metre each). This is easily done with the help of centimeter rulings or meter ruler and leads to accurate measurements.

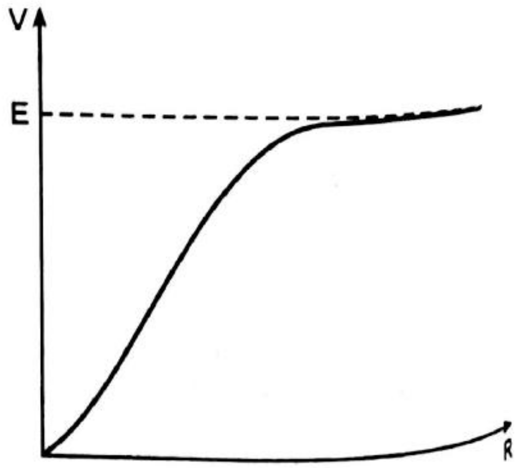
Q. 33. For wiring in the home, one uses Cu wires or Al wires. What considerations are involved in this? *[NCERT Exemplar]*

Ans. Two considerations are required: (*i*) cost of metal, and (*ii*) good conductivity of metal. Cost factor inhibits silver. Cu and Al are the next best conductors.

Q. 34. Why are alloys used for making standard resistance coils? *[NCERT Exemplar]*

Ans. Alloys have low value of temperature co-efficient (less temperature sensitivity) of resistance and high resistivity.

Q. 35. 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*. *[NCERT Exemplar]*



Ans. $I = \frac{V}{R} = \frac{E}{R+r}$

$\therefore \quad V = \frac{ER}{R+r} = \frac{E}{1+\frac{r}{R}}$

When, $R = 0, V = 0$

And $R = \infty, V = \infty.$

Q. 36. You always specify the direction of current with an arrow; then why is the current a scalar quantity?

Ans. Current is a scalar quantity because it does not obey the laws of vector addition.

Q. 37. What are the charge carriers for current flow in a metallic conductor?

Ans. Free electrons are the charge carriers for current flow in a metallic conductor.

Q. 38. Is current density a scalar or a vector quantity?

Ans. Current density is a vector quantity.

Q. 39. A steady current is flowing in a cylindrical conductor. Does electric field exist within the conductor?

Ans. Yes, electric field exists within the conductor because it is the electric field which imparts acceleration to electrons for the flow of current.

Q. 40. When a straight wire of resistance R is bent in U-shape, does its resistance change?

Ans. No, the resistance remains same, because length and cross-sectional area of the wire remain unchanged.

Q. 41. If the radius of a copper wire is doubled, will its specific resistance increase, decrease or remain same?

Ans. The specific resistance of a wire depends on the material (at a given temperature), therefore by changing the radius, the specific resistance of copper remains unchanged.

Q. 43. On increasing the current drawn from a cell, the potential difference across its terminals is lowered, why?

Ans. The terminal potential difference $V = E - Ir$. Clearly if I is increased, the terminal potential difference falls.

Q. 44. Is it possible that the terminal potential difference across the cell be zero? If yes, state the condition.

Ans. Yes, terminal potential difference $V = IR$. If external resistance $R = 0, V = 0$; *i.e.* terminal potential difference is zero, when cell is short circuited.

Q. 45. State the condition for maximum current to be drawn from the cell.

Ans. Current drawn from a cell of emf E and internal resistance r in an external resistance R is

$$I = \frac{E}{R + r}$$

Clearly, for maximum current, the external resistance R should be zero *i.e.*, for maximum current the terminals of a cell must be short circuited.

Q. 46. When is a Wheatstone's bridge most sensitive?

Ans. The Wheatstone's bridge is most sensitive when all the four resistances of bridge are equal.

Q. 47. A 25 watt and a 100 watt bulbs are joined in a series and connected to mains. Which bulb will glow brighter ?

Ans. The resistance of bulb, $R = V^2/P \propto 1/P$ for same V. Obviously the resistance of 25 watt bulb is 4 times that of 100 watt bulb. In series current I is the same, therefore Joule-heat produced (I^2R) is proportional to resistance R. Hence the bulb having higher resistance (i.e., 25 watt bulb) glows brighter than 100 watt bulb when connected in series.

SHORT ANSWER QUESTIONS

(2, 3 marks)

Previous Years' Questions

Q. 1. Define the terms (*i*) drift velocity, (*ii*) relaxation time.

A conductor of length L is connected to a dc source of emf ε. If this conductor is replaced by another conductor of same material and same area of cross-section but of length 3L, how will the drift velocity change? *[CBSE Delhi 2011, (AI) 2013]*

Ans. (*i*) **Drift Velocity:** When a potential difference is applied across a conductor, the free electrons drift towards the direction of positive potential. The small average velocity of free electrons along the direction of positive potential is called the drift velocity.

(*ii*) **Relaxation Time:** The time of free travel of a free electron between two successive collisions of electron with lattice ions/atoms is called the **relaxation time.**

Drift velocity, $v_d = \frac{e\tau}{m}\frac{\varepsilon}{L} \alpha \frac{1}{L}$

When length L is made 3L, drift velocity becomes **one-third.**

Q. 2. How does drift velocity of electrons in a metallic conductor vary with the rise of temperature? *[CBSE Delhi 2002]*

Ans. Drift velocity $v_d = \frac{e\,\tau}{m} E$, where E is electric field strength. With rise of temperature, the rate of collision of electrons with ions of lattice increases, so relaxation time decreases. As a result the drift velocity of electrons decreases with the rise of temperature.

Q. 3. Write the mathematical relation between mobility and drift velocity of charge carriers in a conductor. Name the mobile charge carriers responsible for conductors of electric current in (*i*) an electrolyte (*ii*) an ionised gas.

Ans. The mathematical relation between mobility and drift velocity of charge carriers in a conductor is given by

$$\mu = \frac{|v_d|}{E} = \frac{\text{magnitude of the drift velocity}}{\text{electric field}}$$

(*i*) In electrolyte, the mobile charge carriers are both positive and negative ions.

(*ii*) In an ionised gas, the mobile charge carriers are electrons and positive ions.

Q. 4. (*a*) **You are required to select a carbon resistor of resistance 47 $k\Omega \pm 10\%$ from a large collection. What should be the sequence of colour bands used to code it?**

(*b*) **Write the characteristics of manganin which make it suitable for making standard resistance.** *[CBSE (F) 2011]*

Ans. (*a*) Resistance $= 47\ \text{k}\Omega \pm 10\% = 47 \times 10^3\,\Omega \pm 10\%$

Sequence of colour should be :

Yellow, Violet, Orange and Silver

(*b*) (*i*) Very low temperature coefficient of resistance.

(*ii*) High resistivity

Q. 5. How does the resistivity of (*i*) a conductor and (*ii*) a semiconductor vary with temperature? Give reason for each case. *[CBSE (AI) 2005]*

Ans. (*i*) The resistivity of a conductor increases with increase of temperature.

Reason: When temperature increases, the rate of collisions of free electrons of conductor with ions of lattice increases, so relaxation time decreases. As a result, the resistivity $\left(\rho = \frac{m}{ne^2\tau} \propto \frac{1}{\tau}\right)$ increases.

(*ii*) The resistivity of a semiconductor decreases with the rise of temperature.

Reason: When temperature increases, the covalent bonds between valence electrons of atoms of semiconductor break, so more charge carriers (electrons and holes) becomes free. In other words the number density of charge carriers increases $\left(\rho \propto \frac{1}{n}\right)$, so resistivity of semiconductor decreases with the rise of temperature.

Q. 6. Write the mathematical relation for the resistivity of a material in terms of relaxation time, number density, and mass and charge of charge carriers in it. Explain using this relation, why the resistivity of a metal increases and that of a semiconductor decreases with rise in temperature. ***[CBSE Delhi 2007]***

Ans. Resistivity of a **material,** $\rho = \frac{m}{ne^2\tau}$

where m is mass, e is charge on charge carrier, n is number density and τ is relaxation time.

For a metallic conductor : When temperature of a metal increases, the number of collisions of electrons with ion-lattice increases, so relaxation time decreases, as resistivity $\rho \propto \frac{1}{\tau}$, so resistivity of material increases with rise of temperature.

For a semiconductor : When the temperature of a semiconductor increases, the covalence bonds break and charge carriers (electrons and holes) become free *i.e.,* charge carrier density (n) increases with rise of temperature, so resistivity of a semiconductor decreases with rise of temperature.

Q. 7. Define resistivity of a conductor. Plot a graph showing the variation of resistivity with temperature for a metallic conductor. How does one explain such a behaviour, using the mathematical expression of the resistivity of a material. ***(CBSE Delhi 2008)***

Ans. We know that, $R = \rho \frac{l}{A}$

If $l = 1, A = 1 \Rightarrow \rho = R$

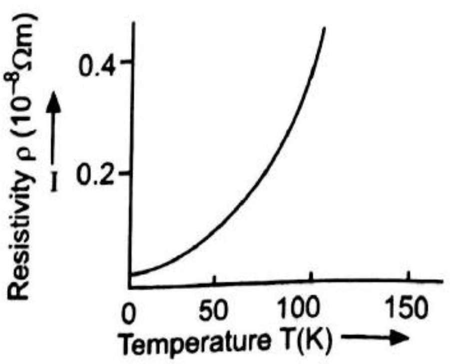
Thus, resistivity of a material is numerically equal to the resistance of the conductor having unit length and unit cross-sectional area.

The resistivity of a material is found to be dependent on the temperature. Different materials do not exhibit the same dependance on temperatures. Over a limited range of temperatures, that is not too large, the resistivity of a metallic conductor is approximately given by,

$$\rho_T = \rho_0 [1 + \alpha (T - T_0)] \qquad ...(i)$$

where ρ_T is the resistivity at a temperature T and ρ_0 is the same at a reference temperature T_0. α is called the *temperature co-efficient of resistivity.*

The relation of Eq. (i) implies that a graph of ρ_T plotted against T would be a straight line. At temperatures much lower than 0°C, the graph, however, deviates considerably from a straight line (Fig.).



Resistivity ρ_T of metallic conductor as a function of temperature T.

Q. 8. Using the mathematical expression for the conductivity of a material, explain how it varies with temperature for (*i*) semiconductor (*ii*) good conductors. *[CBSE (AI) 2008]*

Ans. Conductivity of a material, $\sigma = \frac{ne^2\tau}{m}$

where m = mass of charge carrier, e = charge on each carrier

τ = relaxation time n = number density of charge carriers

(*i*) **In the case of a semiconductor;** when temperature increases, covalent bonds break and charge carriers (electrons and holes) become free *i.e.*, n increases, so conductivity increases with rise of temperature.

(*ii*) **In the case of good conductors;** when temperature increases, the number of collisions of electrons with ion-lattice increases, so relaxation time decreases, so conductivity of good conductor decreases with rise of temperature.

Q. 9. A conductor of length '*l*' is connected to a dc source of potential '*V*'. If the length of the conductor is tripled by gradually stretching it, keeping '*V*' constant, how will (*i*) drift speed of electrons and (*ii*) resistance of the conductor be affected? Justify your answer. *[CBSE (F) 2012]*

Ans. (*i*) We know that $v_d = -\frac{eV\tau}{ml} \propto \frac{1}{l}$

When length is tripled, the drift velocity becomes one-third.

(*ii*) $R = \rho\frac{l}{A}, \quad l' = 3l$

New resistance

$$R' = \rho\frac{l'}{A'} = \rho \times \frac{3l}{A/3} = 9R$$

$$R' = 9R$$

Hence, the new resistance will be 9 times the original.

Q. 10. A cylindrical metallic wire is stretched to increase its length by 10%. Calculate the percentage increase in its resistance. *[CBSE Delhi 2007]*

Ans. When the same wire is stretched, its length increases but cross-sectional area decreases. The change in resistance is due to both increase in length and decrease in cross-sectional area.

Volume $V = lA = \text{constant}$, $A = \frac{V}{l} = \text{constant}$

$$\therefore \quad R = \frac{\rho l}{A} = \frac{\rho l^2}{V} \propto l^2$$

$$\therefore \quad \frac{R'}{R} = \left(\frac{l'}{l}\right)^2$$

Given $\quad l' = l + \frac{10}{100}l = 1.1\,l \Rightarrow \frac{l'}{l} = 1.1$

$$\therefore \quad \frac{R'}{R} = (1.1)^2 = 1.21$$

% increase in resistance

$$\frac{R'-R}{R} \times 100\% = \left(\frac{R'}{R} - 1\right) \times 100\% = (1.21 - 1) \times 100\% = \mathbf{21\%}$$

Q. 11. Two heating elements of resistance R_1 and R_2 when operated at a constant supply of voltage, V, consume powers P_1 and P_2 respectively. Deduce the expressions for the power of their combination when they are, in turn, connected in (*i*) series and (*ii*) parallel across the same voltage supply. ***[CBSE (AI) 2011]***

Ans. (*i*) **In series combinations**

Net resistance, $R = R_1 + R_2$ ...(*i*)

As heating elements are operated at same voltage V, we have

$$R = \frac{V_2}{P}, \quad R_1 = \frac{V^2}{P_1} \text{ and } R_2 = \frac{V^2}{P_2}$$

$\therefore$ From equation (*i*)

$$\frac{V^2}{P} = \frac{V^2}{P_1} + \frac{V^2}{P_2} \Rightarrow \frac{1}{P} = \frac{1}{P_1} + \frac{1}{P_2}$$

(*ii*) **In parallel combination**

Net resistance $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

$$= \frac{P}{V^2} = \frac{P_1}{V^2} + \frac{P_2}{V^2}$$

$$\Rightarrow \quad P = P_1 + P_2$$

Q. 12. A cell of emf E and internal resistance r is connected to two external resistances R_1 and R_2 and a perfect ammeter. The current in the circuit is measured in four different situations: ***[CBSE Delhi 2012]***

(*i*) without any external resistance in the circuit.

(*ii*) with resistance R_1 only

(*iii*) with R_1 and R_2 in series combination

(*iv*) with R_1 and R_2 in parallel combination.

The currents measured in the four cases are 0.42 A, 1.05 A, 1.4 A and 4.2 A, but not necessarily in that order. Identify the currents corresponding to the four cases mentioned above.

Ans. (*i*) $i = \frac{\varepsilon}{r}$

where $\varepsilon = emf$

r = Internal resistance

In this situation, effective resistance of circuit is minimum so current is maximum.

So, $i = 4.2$ A

(*ii*) $i = \frac{\varepsilon}{R_1 + r}$

Here, effective resistance is more than (*i*) and (*iv*) but less than (*iii*).

So, $i = 1.05$ A

(*iii*) $i = \frac{\varepsilon}{r + R_1 + R_2}$

In this situation effective resistance is maximum so current is minimum.

So, $i = 0.42$ A

(iv) $i = \dfrac{\varepsilon}{r + \dfrac{R_1 R_2}{R_1 + R_2}}$

In this situation, the effective resistance is more than (*i*) but less than (*ii*) and (*iii*).

Hence, $i = 1.4$ A

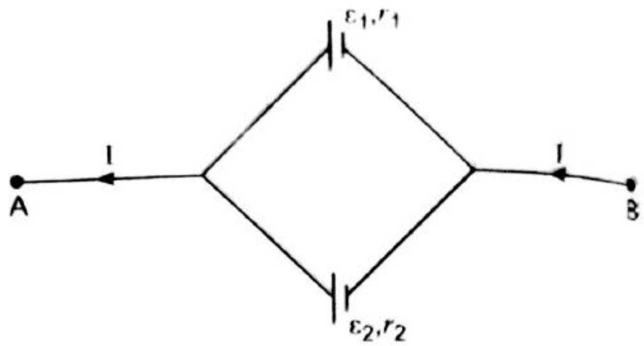
Q. 13. Two cells of emfs $\varepsilon_1, \varepsilon_2$ and internal resistance r_1 and r_2 respectively are connected in parallel as shown in the figure. ***[CBSE (F) 2012]***

Deduce the expressions for

(*i*) the equivalent e.m.f. of the combination,

(*ii*) the equivalent resistance of the combination, and

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



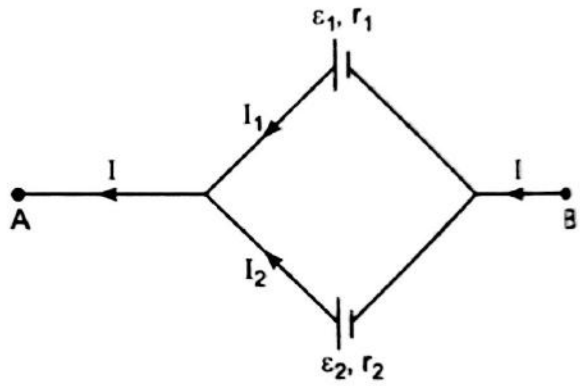
Ans. Here, $I = I_1 + I_2$ ...(*i*)

Let V = Potential difference between A and B.

For cell ε_1

Then, $V = \varepsilon_1 - I_1 r_1 \Rightarrow I_1 = \dfrac{\varepsilon_1 - V}{r_1}$

Similarly, for cell ε_2 $\quad I_2 = \dfrac{\varepsilon_2 - V}{r_2}$



Putting these values in equation (*i*)

$$I = \frac{\varepsilon_1 - V}{r_1} + \frac{\varepsilon_2 - V}{r_2}$$

or

$$I = \left(\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

or

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

Comparing the above equation with the equivalent circuit of emf 'ε_{eq}' and internal resistance 'r_{eq}' then,

$$V = \varepsilon_{eq} - I r_{eq} \quad ...(iii)$$

Then

(*i*) $\varepsilon_{eq} = \dfrac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}$ (*ii*) $r_{eq} = \dfrac{r_1 r_2}{r_1 + r_2}$

(*iii*) The potential difference between A and B

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

Q. 14. State Kirchhoff's rules of current distribution in an electrical network.

[CBSE Delhi 2013, 200

Ans. Kirchhoff's Laws:

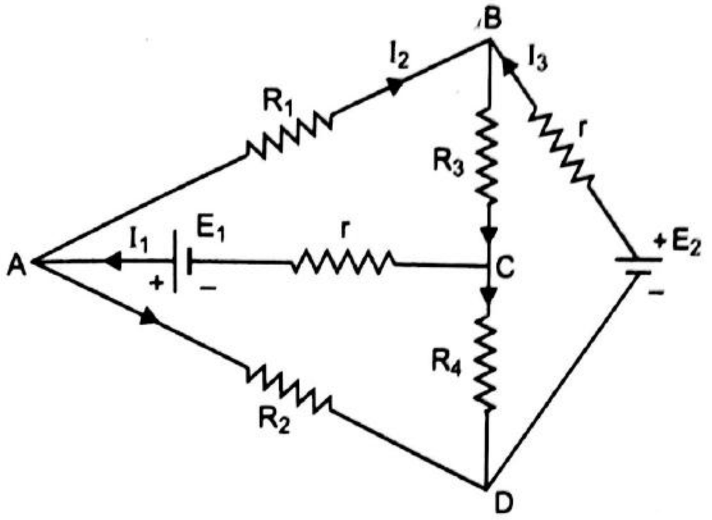
(*i*) The algebraic sum of currents meeting at any junction is zero, *i.e.*,

$$\Sigma I = 0$$

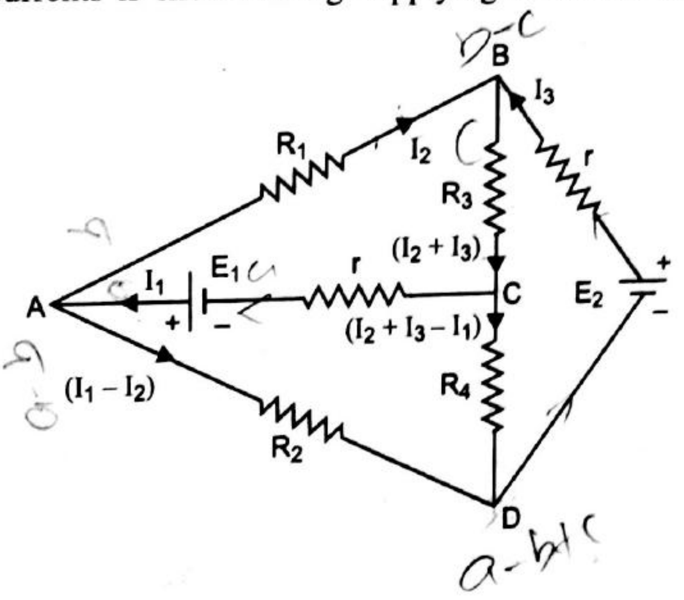
(ii) The algebraic sum of potential differences across circuit elements of a closed circuit is zero, *i.e.,*

$$\Sigma V = 0$$

Q. 15. Use Kirchhoff's rules to write the three equations that may be used to obtain the values of three unknown currents in the branches (shown) of the given circuit. *[CBSE (AI) 2008C]*



Ans. The distribution of currents is shown in fig. Applying Kirchhoff's II law in loop *ABCA.*



$$-I_2R_1 - (I_2 + I_3)R_3 - I_1r + E_1 = 0$$

$$\Rightarrow \quad I_1r + I_2(R_1 + R_3) + I_3R_3 = E_1 \qquad ...(i)$$

Applying Kirchhoff's II law to loop *ACDA*

$$-E_1 + I_1r - (I_2 + I_3 - I_1)R_4 + (I_1 - I_2)R_2 = 0$$

$$\Rightarrow \quad I_1(r + R_2) - (R_2 + R_4)I_2 - I_3R_4 = E_1 \qquad ...(ii)$$

In loop BE_2DB

$$I_3r - E_2 + (I_2 + I_3 - I_1)R_4 + (I_2 + I_3)R_3 = 0$$

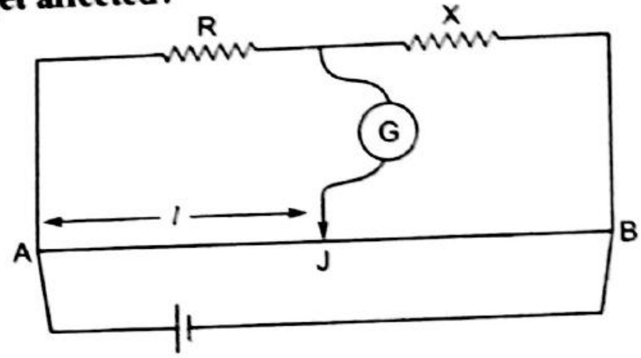
$$\Rightarrow \quad -I_1R_4 + I_2(R_3 + R_4) + I_3(r + R_3 + R_4) = E_2 \qquad ...(iii)$$

Equations (*i*), (*ii*) and (*iii*) are required equations.

Q. 16. In the meter bridge experiment, balance point was observed at J with $AJ = l$.

(i) The values of R and X were doubled and then interchanged. What would be the new position of balance point?

(ii) If the galvanometer and battery are interchanged at the balance position, how will the balance point get affected? **[CBSE (AI) 2011]**



Ans. (i) $\frac{R}{X} = \frac{rl}{r(100-l)}$

$\Rightarrow \quad \frac{R}{X} = \frac{l}{100-l}$ ...(i)

When both R and X are doubled and then interchanged, the new balance length becomes l' given by

$$\frac{2X}{2R} = \frac{l'}{(100-l')}$$

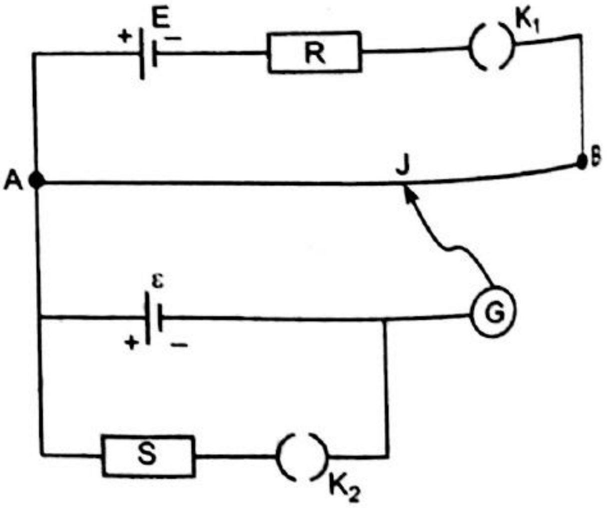
$\Rightarrow \quad \frac{X}{R} = \frac{l'}{100-l'}$ ...(ii)

From (i) and (ii), $\frac{100-l}{l} = \frac{l'}{100-l'}$

$\Rightarrow \quad l' = (100-l)$

(ii) If galvanometer and battery are interchanged, there is no effect on the balance point.

Q. 17. Two students 'X' and 'Y' perform an experiment on potentiometer separately using the circuit given: **[CBSE (F) 2012]**



Keeping other parameters unchanged, how will the position of the null point be affected it

(i) 'X' increases the value of resistance R in the set-up by keeping the key K_1 closed and the key K_2 open?

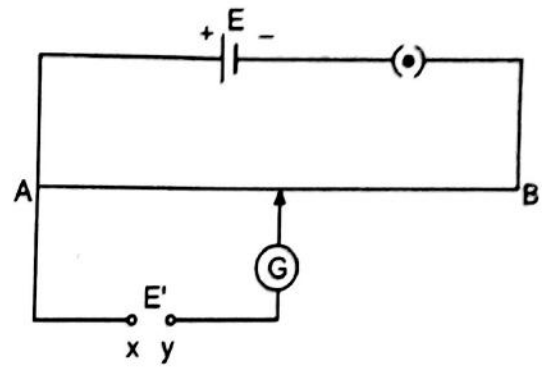
(ii) 'Y' decreases the value of resistance S in the set-up, while the key K_2 remain open and the key K_1 closed?

Justify.

Ans. (i) By increasing resistance R the current through AB decreases, so potential gradient decreases. Hence a greater length of wire would be needed for balancing the same potential difference. So the null point would shift towards B.

(ii) By decreasing resistance S, the current through AB remains the same, potential gradient does not change. As K_2 is open so there is no effect of S on null point.

Q. 18. For the potentiometer circuit shown in the given figure, points X and Y represent the two terminals of an unknown emf E'. A student observed that when the jockey is moved from the end A to the end B of the potentiometer wire, the deflection in the galvanometer remains in the same direction.



What may be the two possible faults in the circuit that could result in this observation?

If the galvanometer deflection at the end B is (*i*) more, (*ii*) less than at the end A, which of the two faults, listed above, would be there in the circuit? Give reason in support of your answer in each case. ***[CBSE (AI) 2007]***

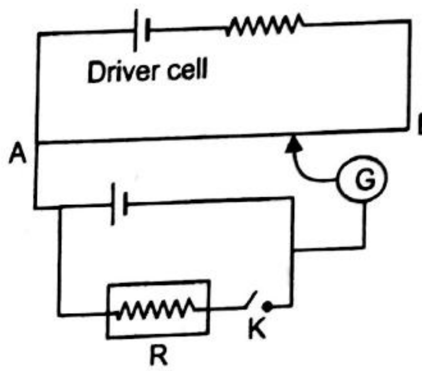
Ans. The two possible faults in the circuit may be (*i*) emf E' is greater than emf E.

(*ii*) Terminal X of unknown emf is negative (while it must be positive).

If galvanometer deflection at end B is more than that at end A, then terminal X is negative, because in this case net current in galvanometer along AB due to both cells is additive.

If galvanometer deflection at end B is less than that at end A, then $E' > E$, because net current in galvanometer due to both cells' emfs E and E' is subtractive.

Q. 19. The following circuit shows the use of potentiometer to measure the internal resistance of a cell



(*i*) When the key K is open, how does the balance point change, if the current from the driver cell decreases.

(*ii*) When the key K is closed, how does the balance point change if R is increased keeping current from the driver cell constant?

Ans. (*i*) When current through driver cell decreases, the potential gradient across potentiometer wire decreases; so the balancing length $l = \frac{E}{k}$ increases, so balance point is shifted to the right.

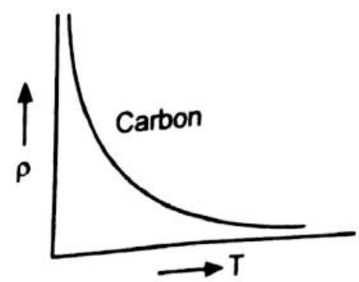
(*ii*) With increase of R, the terminal p.d. across cell E increases and hence balancing length $l = \frac{V}{k} \propto V$ increases. So the balance point is shifted to the right.

Q. 20. Sketch a graph showing the variation of resistivity of carbon with temperature.

OR

Plot a graph showing temperature dependence of resistivity for a typical semiconductor. How is this behaviour explained? ***[CBSE Delhi 2012, (F) 2011]***

Ans. The resistivity of a typical semiconductor (carbon) decreases with increase of temperature. The graph is shown in figure.



Explanation: In semiconductor the number density of free electrons (n) increases with increase in temperature (T) and consequently the relaxation period decreases. But the effect of increase in n has higher impact than decrease of τ. So, resistivity decreases with increase in temperature.

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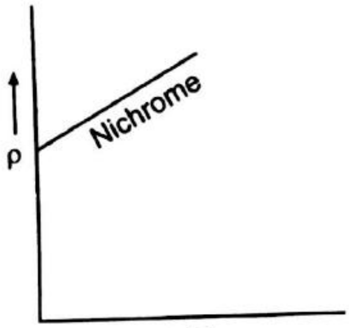
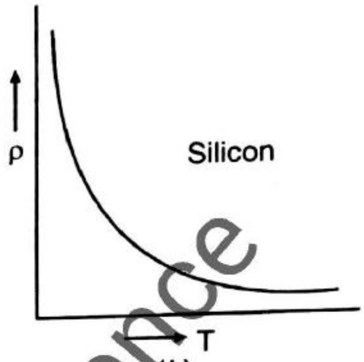
Q. 21. **Draw the graphs showing the variation of resistivity with temperature for (*i*) nichrome and (*ii*) silicon.**

Ans. The variation of resistivity of nichrome and silicon with temperature are shown in figures (*a*) and (*b*).



(*a*)

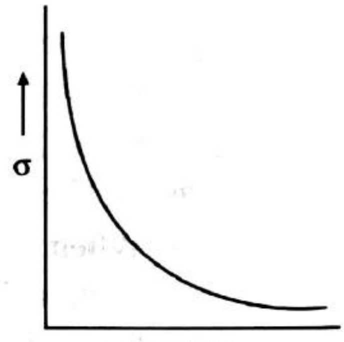


(*b*)

Q. 22. Explain the variation of conductivity with temperature for (*i*) a metallic conductor and (*ii*) ionic conductors. *[CBSE Delhi 2008, 2004 C, (AI) 2004]*

Ans. (*i*) Conductivity of a metallic conductor $\sigma = \frac{1}{\rho} = \frac{ne^2\tau}{m}$.

With rise of temperature, the collision of electrons with fixed lattice ions/atoms increases so that relaxation time (τ) decreases. Consequently, the conductivity of metals decreases with rise of temperature. Figure represents the variation of conductivity of metal with temperature. Initially the variation of conductivity with temperature is linear and then it is non-linear.



(*ii*) **Conductivity of ionic conductor increases with increase of temperature** because with increase of temperature, the ionic bonds break releasing positive and negative ions which are charge carriers in ionic conductors.

Other Important Questions

Q. 23. Electrons are continuously in motion within a conductor but there is no current in it unless some source of potential is applied across its ends. Give reason.

Ans. In the absence of any external source the motion of electrons in a conductor is random and electrons collide continuously with the positive ions of metal. This causes a random change in direction. The average velocity of random motion of electrons in any direction is zero, hence current is zero.

Q. 24. What is the change in resistance of an Eureka wire when its radius is halved and the length is reduced to one-fourth of its original value.

Ans. We have $$R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2} \quad ...(i)$$

New radius $r' = r/2$

New length $l' = l/4$

$$\therefore \quad \text{New resistance } R' = \frac{\rho l'}{\pi r'^2} = \frac{\rho (l/4)}{\pi (r/2)^2} = \frac{\rho l}{\pi r^2} \quad ...(ii)$$

∴ Comparing (*i*) and (*ii*), we note that the resistance of wire remains unchanged.