

# Physics

## *NCERT Exemplar Problems*

### Chapter 3

### *Current Electricity*

- 3.1** (b)
- 3.2** (a)
- 3.3** (c)
- 3.4** (b)
- 3.5** (a)
- 3.6** (a)
- 3.7** (b), (d)
- 3.8** (a), (d)
- 3.9** (a), (b)
- 3.10** (b), (c)
- 3.11** (a), (c)
- 3.12** When an electron approaches a junction, in addition to the uniform  $\mathbf{E}$  that it normally faces (which keep the drift velocity  $\mathbf{v}_d$  fixed), there are accumulation of charges on the surface of wires at the junction. These produce electric field. These fields alter direction of momentum.
- 3.13** Relaxation time is bound to depend on velocities of electrons and ions. Applied electric field affects the velocities of electrons by speeds at the order of 1mm/s, an insignificant effect. Change in  $T$ , on the other hand, affects velocities at the order of  $10^2$  m/s. This can affect  $\tau$  significantly.  
[ $\rho = \rho(E, T)$  in which  $E$  dependence is ignorable for ordinary applied voltages.]
- 3.14** The advantage of null point method in a Wheatstone bridge is that the resistance of galvanometer does not affect the balance point and there is no need to determine current in resistances and galvanometer and the internal resistance of a galvanometer.  $R_{\text{unknown}}$  can be calculated

applying Kirchhoff's rules to the circuit. We would need additional accurate measurement of all the currents in resistances and galvanometer and internal resistance of the galvanometer.

**3.15** 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 meter each). This is easily done with the help of centimeter rulings or meter ruler and leads to accurate measurements.

**3.16** 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.

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

**3.18** Power wasted  $P_c = I^2 R_c$

where  $R_c$  is the resistance of the connecting wires.

$$P_c = \frac{P^2}{V^2} R_c$$

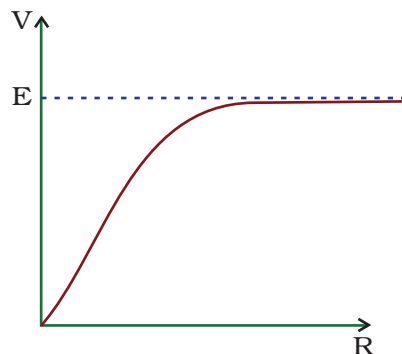
In order to reduce  $P_c$ , power should be transmitted at high voltage.

**3.19** If  $R$  is increased, the current through the wire will decrease and hence the potential gradient will also decrease, which will result in increase in balance length. So J will shift towards B.

**3.20** (i) Positive terminal of  $E_1$  is connected at X and  $E_1 > E$ .

(ii) Negative terminal of  $E_1$  is connected at X.

**3.21**



**3.22** 
$$I = \frac{E}{R + nR}; \frac{E}{R + \frac{R}{n}} = 10I$$

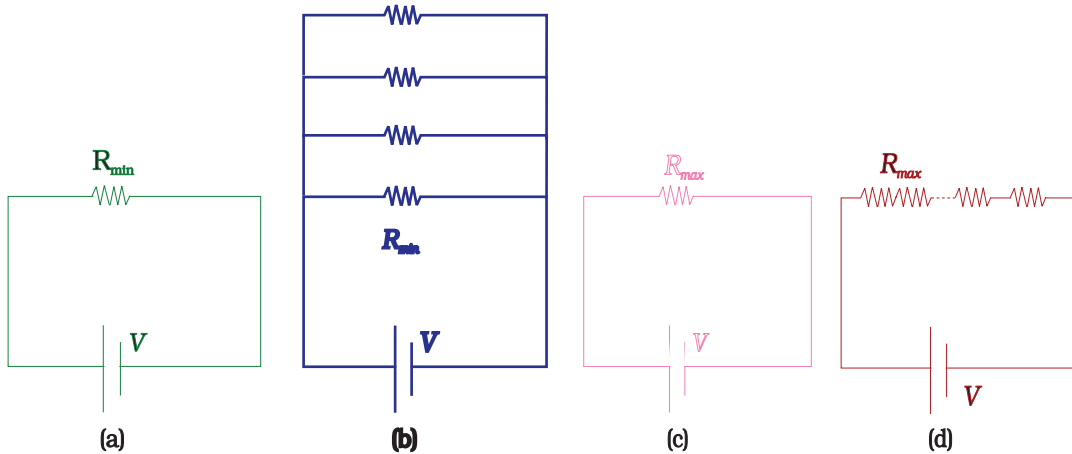
$$\frac{1+n}{1+\frac{1}{n}} = 10 = \frac{1+n}{n+1} n = n$$

$$\therefore n = 10.$$

**3.23** 
$$\frac{1}{R_p} = \frac{1}{R_1} + \dots + \frac{1}{R_n}, \quad \frac{R_{\min}}{R_p} = \frac{R_{\min}}{R_1} + \frac{R_{\min}}{R_2} + \dots + \frac{R_{\min}}{R_n} > 1$$

and  $R_s = R_1 + \dots + R_n \geq R_{\max}$ .

In Fig. (b),  $R_{\min}$  provides an equivalent route as in Fig. (a) for current. But in addition there are  $(n-1)$  routes by the remaining  $(n-1)$  resistors. Current in Fig. (b) > current in Fig. (a). Effective Resistance in Fig. (b) <  $R_{\min}$ . Second circuit evidently affords a greater resistance. You can use Fig. (c) and (d) and prove  $R_s > R_{\max}$ .

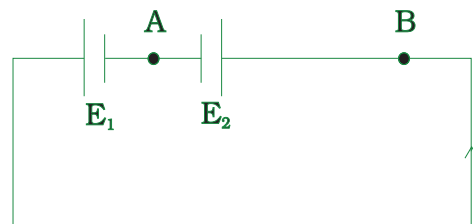


**3.24** 
$$I = \frac{6 - 4}{2 + 8} = 0.2 \text{ A}$$

P.D. across  $E_1 = 6 - 0.2 \times 2 = 5.6 \text{ V}$

P.D. across  $E_2 = V_{AB} = 4 + 0.2 \times 8 = 5.6 \text{ V}$

Point B is at a higher potential than A



**3.25** 
$$I = \frac{E + E}{R + r_1 + r_2}$$

$$V_1 = E - Ir_1 = E - \frac{2E}{r_1 + r_2 + R} r_1 = 0$$

or 
$$E = \frac{2Er_1}{r_1 + r_2 + R}$$

$$1 = \frac{2r_1}{r_1 + r_2 + R}$$

$$r_1 + r_2 + R = 2r_1$$

$$R = r_1 - r_2$$

**3.26** 
$$R_A = \frac{\rho l}{\pi(10^{-3} \times 0.5)^2}$$

$$R_B = \frac{\rho l}{\pi[(10^{-3})^2 - (0.5 \times 10^{-3})^2]}$$

$$\frac{R_A}{R_B} = \frac{(10^{-3})^2 - (0.5 \times 10^{-3})^2}{(.5 \times 10^{-3})^2} = 3 : 1$$

**3.27** We can think of reducing entire network to a simple one for any branch  $R$  as shown in Fig.

Then current through  $R$  is  $I = \frac{V_{eff}}{R_{eff} + R}$

Dimensionally  $V_{eff} = V_{eff}(V_1, V_2, \dots, V_n)$  has a dimension of voltage and  $R_{eff} = R_{eff}(R_1, R_2, \dots, R_m)$  has a dimension of resistance. Therefore if all are increased  $n$ -fold

$$V_{eff}^{new} = nV_{eff}, R_{eff}^{new} = nR_{eff}$$

and  $R^{new} = nR$ .

Current thus remains the same.

**3.28** Applying Kirchhoff's junction rule:

$$I_1 = I + I_2$$

Kirchhoff's loop rule gives:

$$10 = IR + 10I_1 \dots (i)$$

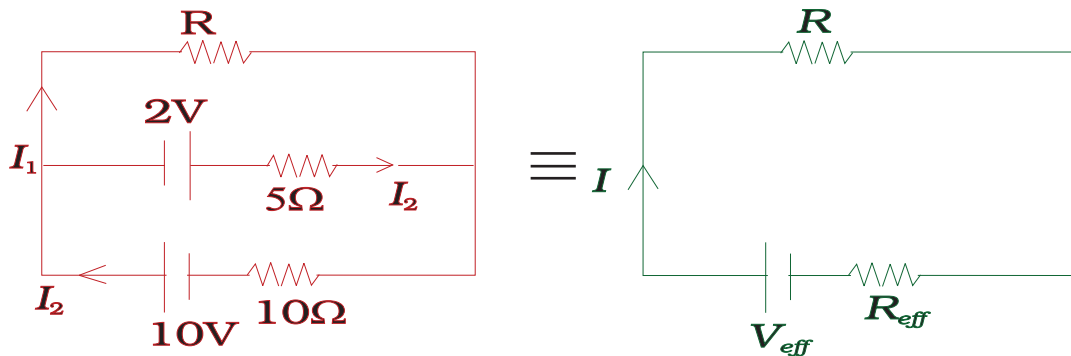
$$2 = 5I_2 - RI = 5(I_1 - I) - RI$$

$$4 = 10I_1 - 10I - 2RI \dots (ii)$$

$$(i) - (ii) \Rightarrow 6 = 3RI + 10I \text{ or, } 2 = I \left( R + \frac{10}{3} \right)$$

$2 = (R + R_{eff})I$  Comparing with  $V_{eff} = (R + R_{eff})I$  and  $V_{eff} = 2V$

$$R_{eff} = \frac{10}{3} \Omega.$$



**3.29** Power consumption = 2units/hour = 2KW = 2000J/s

$$I = \frac{P}{V} = \frac{2000}{220}; \quad 9 \text{ A}$$

Power loss in wire =  $RI^2$  J/s

$$= \rho \frac{l}{A} I^2 = 1.7 \times 10^{-8} \times \frac{10}{\pi \times 10^{-6}} \times 81 \text{ J/s}$$

$$\square 4 \text{ J/s}$$

$$= 0.2\%$$

$$\text{Power loss in Al wire} = 4 \frac{\rho_{Al}}{\rho_{Cu}} = 1.6 \times 4 = 6.4 \text{ J/s} = 0.32\%$$

**3.30** Let  $R'$  be the resistance of the potentiometer wire.

$$\frac{10 \times R'}{50 + R'} < 8 \Rightarrow 10R' < 400 + 8R'$$

$$2R' < 400 \text{ or } R' < 200\Omega.$$

$$\frac{10 \times R'}{10 + R'} > 8 \Rightarrow 2R' > 80 \Rightarrow R' > 40$$

$$\frac{10 \times \frac{3}{4} R'}{10 + R'} < 8 \Rightarrow 7.5R' < 80 + 8R'$$

$$R' > 160 \Rightarrow 160 < R' < 200.$$

Any  $R'$  between  $160\Omega$  and  $200\Omega$  will achieve.

Potential drop across 400 cm of wire  $> 8V$ .

Potential drop across 300 cm of wire  $< 8V$ .

$$\phi \times 400 > 8V \quad (\phi \rightarrow \text{potential gradient})$$

$$\phi \times 300 < 8V$$

$$\phi > 2V/m$$

$$< 2\frac{2}{3} \text{ V/m.}$$

**3.31** (a)  $I = \frac{6}{6} = 1 \text{ A} = nev_d A$

$$v_d = \frac{1}{10^{29} \times 1.6 \times 10^{-19} \times 10^{-6}} = \frac{1}{1.6} \times 10^{-4} \text{ m/s}$$

$$\begin{aligned} K.E &= \frac{1}{2} m_e v_d^2 \times nAl \\ &= \frac{1}{2} \times 9.1 \times 10^{-31} \times \frac{1}{2.56} \times 10^{-8} \times 10^{29} \times 10^{-6} \times 10^{-1} ; 2 \times 10^{-17} \text{ J} \end{aligned}$$

(b) Ohmic loss  $= RI^2 = 6 \times 1^2 = 6 \text{ J/s}$

All of KE of electrons would be lost in  $\frac{2 \times 10^{-17}}{6} \text{ s} ; 10^{-17} \text{ s}$