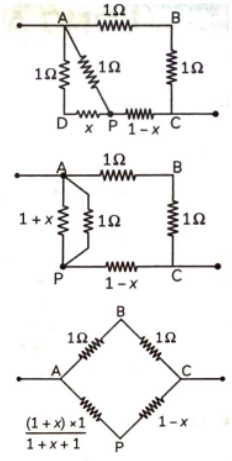
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Answers Key:

3 Marks

1. Given, resistance of heating element at temperature 27°C,
   R_{27} = 100 Ω
   Resistance of heating element at temperature t°C,
   R_t = 117 Ω
   α=1.70 $\times 10^{-4}$ °C^{-1}, t = ?
   By using the formula of temperature coefficient of resistance,
   $\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}$ ...(i)
   Here, $R_1 = R_t$, $R_1 = R_{27}$, t_2 = t and t_1 = 27°C
   Such that, $\alpha = \frac{R_t - R_{27}}{R_{27}(t - 27)}$
   Substituting given values in Eq. (i), we get
   $$1.70 \times 10^{-4} = \frac{117 - 100}{100(t - 27)}$$
   $$\text{or} \quad t - 27 = \frac{17}{100 \times 1.70 \times 10^{-4}}$$
   or t = 1000 + 27 = 1027°C
2. When the current through the element is very small, heating effects can be ignored and the temperature T_1 of the element is the same as room temperature. When the toaster is connected to the supply, its initial current will be slightly higher than its steady value of 2.68 A. But due to heating effect of the current, the temperature will rise. This will cause an increase in resistance and a slight decrease in current. In a few seconds, a steady state will be reached when temperature will rise no further, and both the resistance of the element and the current drawn will achieve steady values. The resistance R_2 at the steady temperature T_2 is
   $R_2 = \frac{230\ V}{2.68\ A} = 85.8\Omega$
   Using the relation
   $R_2 = R_1 [1 + \alpha (T_2 - T_1)]$
   with α = 1.70 x 10^{-4} °C^{-1}, we get
   $T_2 - T_1 = \frac{(85.8 - 75.3)}{(75.3) \times 1.70 \times 10^{-4}} = 820°C$
   that is, T_2 = (820 + 27.0) °C = 847 °C
   Thus, the steady temperature of the heating element (when heating effect due to the current equals heat loss to the surroundings) is 847 °C.



3. As the points B and P are at the same potential,
   $\frac{1}{1} = \frac{\frac{(1+x)}{(2+x)}}{(1-x)}$
   $\Rightarrow \quad x = (\sqrt{2} - 1)$ ohm
4. Consider a current I_3 starting from the 45 V cell. It gets divided into two currents of I_1 and l_2 Such that they divide at junction a and come together to re form the current I_3 at junction d due to junction rule.
   Now let us write down the loops we will be following, shown by the two curved arrows. These arrows can be made clockwise or counter-clockwise as per our convenience.
   Now in the upper loop,
   $40I_3 + 30I_1 + 1I_3 - 45 = 0$
   In the lower loop
   $I_3 + 40l_3 + 1I_2 + 20I_2 - 80 = 0$
   As can be noted we follow the following rule:
   (1) If the loop and the current are in the same direction then IR will be positive else negative.
   (2) If the loop points from the negative end of the cell to the positive end then E = -ve.
   So now that we have two equations we still need a third equation since we have three variables. The third equation can be taken up as
   $I_3 = I_1 + l_2$
5. $(V_A - V_B) = E_1 - i_1r_1$

$(V_C - V_D) = E_2 - i_2r_2$

$i_1 = \frac{E_1 - V}{r_1}$,

$i_2 = \frac{E_2 - V}{r_2}$

$i = i_1 + i_2$

$\Rightarrow = \frac{E_1 - V}{r_1} + \frac{E_2 - V}{r_2}$

$i = \frac{(E_1 - V)r_2 + (E_2 - V)r_1}{r_1 r_2}$

$V = \frac{E_1 r_2 + E_2 r_1}{(r_1 + r_2)} - \left(\frac{r_1 r_2}{r_1 + r_2}\right) i$

Comparing it with, V = E - iR

We get,

$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$

$r_{eq} = \frac{r_1 r_2}{r_1 + r_2} = \frac{1}{r_1} + \frac{1}{r_2}$

$E_{eq} = \frac{E_1}{\frac{r_1}{r_1} + \frac{r_2}{r_1}}$

6. (A) Heat produced,

$H = \frac{V^2}{R} t$

$\Rightarrow H \alpha V^2$

$\frac{H'}{H} = \frac{V'^2}{V^2}$

$\frac{9H}{H} = \frac{V'^2}{V^2}$

$V'^2 = 9V^2$

$V' = 3V$

So, potential difference is increased by a factor of 3.

(B) Current,

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

$I = \frac{12}{4 + 2} = \frac{12}{6} = 2\ A$

Ammeter reading = 2 A

Potential difference,

V = E - Ir

V = 12 - 2 x 2

= 12 - 4

V = 8V

Voltmeter reading = 8V.

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2 Marks

7. Emf of the battery, E = 12 V

Internal resistance of the battery, r = 0.4 Ω

Maximum current drawn from the battery = I

According to Ohm's law,

E = Ir

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

$= \frac{12}{0.4} = 30A$

The maximum current drawn from the given battery is 30 A.

8. (a) Electric field is established throughout the circuit, almost instantly (with the speed of light) causing at every point a local electron drift. Establishment of a current does not have to wait for electrons from one end of the conductor travelling to the other end. However, it does take a little while for the current to reach its steady value.

(b) Each 'free' electron does accelerate, increasing its drift speed until it collides with a positive ion of the metal. It loses its drift speed after collision but starts to accelerate and increases its drift speed again only to suffer a collision again and so on. On the average, therefore, electrons acquire only a drift speed.

(c) Simple, because the electron number density is enormous, ~10^{29} m^{-3}.

(d) By no means. The drift velocity is superposed over the large random velocities of electrons.

(e) In the absence of electric field, the paths are straight lines; in the presence of electric field, the paths are, in general, curved.

9. Drift velocity, $V_d = \frac{eE\tau}{m}$

Now, $E = \frac{V}{l}$

where V is potential difference. If the length of the conductor is doubled then drift velocity will be halved.

Resistance of conductor is directly proportional to the length, therefore on doubling the length, resistance will become two times.

10. Here. E_1 = 6 V, E_2 = 4 V, r_1 = 2 Ω and r_2 = 8 Ω

Equivalent emf of two cells = (6 - 4)V = 2 V,

Equivalent resistance = (2 + 8) Ω = 10 Ω,

Then the electric current is given by:

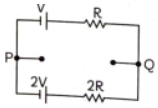
$I = \frac{V}{R} = 0.2$ A

Here, E_1 = V- lr_1 = 6 - 0.2 x 2 = 6 - 0.4 = 5.6 V

Similarly. E_2 = V+ Ir_2 = 4 + 0.2 x 8 = 4 + 1.6 = 5.6 V

The potential between points A and B will be E_2 = 5.6 V. As current is flowing from B to A. Here potential at B is larger than A.

11. In steady-state condition, no current flows through the capacitor i.e., C behaves as an open circuit. Hence, the circuit becomes,



This circuit can be considered a parallel combination of two cells of emf V and 2V with resistances R and 2R. Equivalent resistance for this circuit is,

$R_{eq} = \frac{R \times 2R}{R+2R} = \frac{2R}{3}$

(A) Equivalent emf of the cell is

$$V_{PQ} = R_{eq}\left(\frac{2V}{2R} + \frac{V}{R}\right)$$
$$= \frac{2R}{3} \times \frac{2V}{R} = \frac{4V}{3}$$

(B) Applying KVL for capacitor branch, we get,

$V_{PQ} + V_C - V = 0$

$V_C = -\frac{4V}{3} + V = -\frac{V}{3}$

12. Given: $E_1 = 10$ V; $E_2 = 200$ V, r = 38 Ω

Net emf,

$E = E_2 - E_1$

(∵ Two cells being in opposition)

E = 200V - 10 V = 190 V

∴ Current, I = $\frac{\text{Netemf}}{\text{Resistance}}$

$I = \frac{190\ V}{38\Omega} = 5$ A.

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