10^{th} Solved Numerical: Ch: Electricity

EXAMPLE How much work is done in moving a charge of 3 C across two points having a potential difference 15 V?

SOLUTION

Here,

Potential difference (V) = 15 V

Charge (Q) = 3 C

Work done (W) = ? (to be calculated)

We know, $V = \frac{W}{Q}$

Putting the values in the above equation, we get

$$15\text{ V} = \frac{W}{3\text{ C}}$$

$$W = 15\text{ V} \times 3\text{ C}$$

$$W = 45\text{ J}$$

Thus, work done in moving the charge is 45 J.

EXAMPLE How much energy is given to each coulomb of charge passing through a 6 V battery?

SOLUTION

Here,

Potential difference (V) = 6 V

Charge (Q) = 1 C

Work done (W) = ? (to be calculated)

We know, $V = \frac{W}{Q}$

Putting the values in the above equation, we get

$$6\text{ V} = \frac{W}{1\text{ C}}$$

$$W = 6\text{ V} \times 1\text{ C}$$

$$W = 6\text{ J}$$

Thus, work done in moving the charge is 6 J.

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EXAMPLE If 3×10^{-3} J of work is done in moving a particle carrying a charge of 15×10^{-6} C from infinity to a point P, what will be the potential at the point P?

SOLUTION

Here,

Work done (W) = 3×10^{-3} J

Charge (Q) = 15×10^{-6} C

Electric potential (V) = ? (to be calculated)

We know, $V = \frac{W}{Q}$

$$V = \frac{3 \times 10^{-3}\text{ J}}{15 \times 10^{-6}\text{ C}}$$

$$V = \frac{3 \times 10^{3}}{15}\text{ V}$$

$$V = 200\text{ V}$$

Thus, the potential at the point P is 200 V

EXAMPLE 80 J of work is done in moving a charge of 4 C from one terminal of the battery to another. What is the potential difference of the battery?

SOLUTION

Here,

Work done (W) = 80 J

Charge (Q) = 4 C

Potential difference (V) = ? (to be calculated)

We know, $V = \frac{W}{Q}$

Putting the values in the above equation, we get

$$V = \frac{80\text{ J}}{4\text{ C}}$$

$$V = 20\text{ V}$$

Thus, the potential difference of the battery is 20 V

EXAMPLE A current of 0.2 A is drawn by the filament of an electric bulb for 30 minutes. Find the amount of electric charge that flows through the circuit.

SOLUTION Here,

Electric current (I) = 0.2 A

Time (t) = 30 minutes = 1800 s

Amount of electric charge (Q) = ? (to be calculated)

We know, $I = \frac{Q}{t}$

Putting the values in the above equation, we get

$$0.2\text{ A} = \frac{Q}{1800\text{ s}}$$

$$Q = 0.2\text{ A} \times 1800\text{ s}$$

$$Q = 360\text{ C}$$

Thus, the amount of electric charge that flows through the circuit is 360 C.

EXAMPLE 5 C of charge flows through any cross-section of a conductor in 10 seconds. What is the current flowing through the conductor?

SOLUTION Here,

Charge flowing (Q) = 5 C
Time taken (t) = 10 s
Current flowing (I) = ? (to be calculated)

We know, $I = \frac{Q}{t}$

Putting the values in the above equation, we get

$$I = \frac{5\text{ C}}{10\text{ s}} = 0.5\text{ A}$$

Thus, the current flowing through the conductor is 0.5 A.

EXAMPLE A battery of three cells of 2 V each, a 5 Ω resistor, an 8 Ω resistor, a 12 Ω resistor and a plug key are all connected in series. (a) Draw a circuit diagram (b) Find the resultant resistance.

SOLUTION

(a)

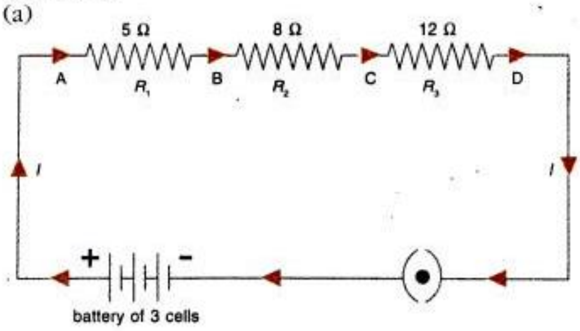

Fig. 4.27

(b) Here, R_1 = 5 Ω, R_2 = 8 Ω, R_3 = 12 Ω

We know,

Total resistance (in series)

$$R = R_1 + R_2 + R_3$$

$$\therefore \quad R = 5\ \Omega + 8\ \Omega + 12\ \Omega$$

$$R = 25\ \Omega$$

Thus, the resultant resistance is equal to 25 Ω.

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EXAMPLE What will be the resistance of a metal wire of length 2 m and area of cross-section 1.25×10^{-6} m², if the resistivity of the metal is 1.6×10^{-8} Ω m?

SOLUTION

We know

$$\rho = \frac{R \times A}{l}$$

Here, Resistance (R) = ? (to be calculated)
Area of cross-section (A) = 1.25×10^{-6} m²
Length (l) = 2 m
Resistivity of the metal (ρ) = 1.6×10^{-8} Ω m

So, putting these values in the above formula, we get

$$1.6 \times 10^{-8}\ \Omega\text{ m} = \frac{R \times 1.25 \times 10^{-6}\text{ m}^2}{2\text{ m}}$$

or $$R = \frac{2\text{ m} \times 1.6 \times 10^{-8}\ \Omega\text{ m}}{1.25 \times 10^{-6}\text{ m}^2}$$

or $$R = \frac{2 \times 1.6 \times 10^{-8+6}\ \Omega}{1.25}$$

or $$R = \frac{2 \times 1.6 \times 10^{-2}\ \Omega}{1.25}$$

or $$R = 2.56 \times 10^{-2}\ \Omega$$

Thus, the resistance of the metal wire is 2.56×10^{-2} Ω

Example **An electric bulb draws a current of 0.2 A when the voltage is 220 volts. Calculate the amount of electric charge flowing through it in one hour. [Delhi 2004 C]**

Ans. I = 0.2 A, V = 220 volt t = 1 h = 3600 s

We know, $I = \frac{q}{t}$ $\quad q = I \times t = 0.2 \times 3600$

= 720 coulomb

Example **A bulb is rated at 5.0 volt, 100 mA. Calculate its (*i*) power and (*ii*) resistance.**

Ans. (*i*) V = 5.0 volt,

I = 100 mA

Power = VI = $5 \times 100 \times 10^{-3}$

= 0.5 watt

(*ii*) Resistance = $R = \frac{V}{I}$

$$= \frac{5}{100 \times 10^{-3}} = \frac{5000}{100} = 50\ \Omega$$

Example Calculate the amount of charge that would flow in 30 minutes through the element of an electric bulb drawing a current of 0.4 A.

Ans. $t = 30 \text{ min} = 30 \times 60 = 1800 \text{ s}$

$I = 0.4 \text{ A}$

$q = It = 0.4 \times 1800 = 720 \text{ coulomb}$

Example Two resistors with resistances 10 ohm and 15 ohm are to be connected to a battery of emf 5 V so as to obtain

(*i*) maximum current

(*ii*) minimum current

(*a*) How will you connect the resistances in each case ?

(*b*) Calculate the strength of total current in the circuit in the two cases.

Ans. (*a*) (*i*) Resistance has to be small, so parallel connection.

(*ii*) Series connection will have maximum resistance, so minimum current.

(*b*) $$I_{min} = \frac{5}{10+15} = \frac{1}{5} \text{ A}$$

$$I_{max} = \frac{5}{\frac{150}{25}} = \frac{5}{6} \text{ A}$$

Example An electric iron has a rating of 750 W, 220 V. Calculate (*i*) current passing through it, and (*ii*) its resistance, when in use.

Ans. (*i*) $$\text{Current} = \frac{\text{Power}}{\text{Voltage}} = \frac{750}{220} = 3.41 \text{ A}$$

(*ii*) $$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}} = \frac{220}{3.41} = 64.5\,\Omega$$

Example An electric iron has a rating of 1000 W, 220 V. When in use calculate for it

(*i*) current passing through it,

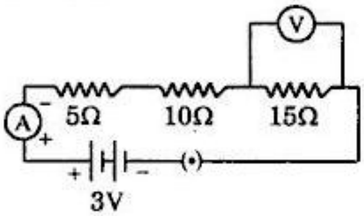
(*ii*) its resistance [Delhi 2007]

Ans. (*i*) $\text{Power} = \text{Current} \times \text{Voltage}$

$$\therefore \text{Current} = \frac{\text{Power}}{\text{Voltage}} = \frac{1000}{220} \text{ A} = 4.545 \text{ A}$$

(*ii*) $$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}} = \frac{220}{4.545}\,\Omega = 48.4\,\Omega$$

Example What are the likely readings of the ammeter and the voltmeter in the circuit shown here ?



Ans. The ammeter reading would be

$$\frac{3}{5+10+15} \text{ A} = \frac{3}{30} \text{ A} = 0.1 \text{ A}$$

The voltmeter reading would be

$0.1 \times 15 \text{ V} = 1.5 \text{ V}$

Example A 220 V line supplies a total current of 5 A to N resistors (each of value 176 Ω) connected in parallel. What is the value of N ?

Ans. The total resistance of the parallel combination of N resistors

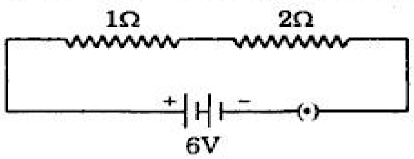
$$= \frac{220 \text{ V}}{5 \text{ A}} = 44 \text{ ohm}$$

$$\therefore \frac{1}{44} = \frac{1}{176} + \frac{1}{176} + \ldots \text{ N times}$$

$$= \frac{N}{176}$$

$$\therefore N = \frac{176}{44} = 4$$

Example Calculate the power used in the 2 Ω resistor in the circuit shown here.



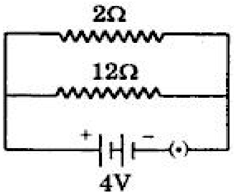
Ans. Current through the circuit

$$= \frac{6 \text{V}}{(1+2)\,\Omega} = 2 \text{A}$$

$\therefore$ Power used in the 2Ω resistor

$$= I^2R = (2)^2 \times 2 \text{ watt} = 8 \text{W}$$

Example **Calculate the power used in the 2 Ω resistor in the circuit shown here.**



Ans. Current through the 2 Ω resistor

$$= \frac{4V}{2\,\Omega} = 2\text{ A}$$

∴ Power used in the 2 Ω resistor

$$= I^2R$$

$$= (2)^2 \times 2 \text{ watt} = 8W$$

Example **When N identical electric bulbs, each rated as 11 W, 220 V are connected in parallel across a 220 V supply line, the total current drawn is 5A. What is the value of N ?**

Ans. Resistance of each bulb

$$= \frac{220 \times 220}{11} \text{ ohm}$$

$$= 4400 \text{ ohm}$$

∴ Resistance of the parallel combination of

$$\text{N such bulbs} = \frac{4400}{N} \text{ ohm}$$

$$\therefore \quad \frac{4400}{N} = \frac{220}{5}$$

$$\text{or} \quad N = \frac{4400 \times 5}{220} = 100$$

∴ 100 bulbs are needed in this case.

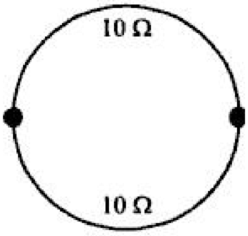
Example **An electric heater of resistance 8Ω draws 15A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.**

Ans. Rate of development of heat $= I^2R$

$$= (15)^2 \times 8\,\Omega = 1800\,\Omega$$

Example **A wire of resistance 20 ohm is bent in the form of a closed circle. What is the effective resistance between the two points at the ends of any diameter of the circle ?**

Ans. Let R be the required effective resistance.



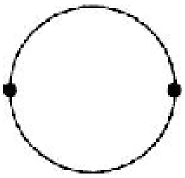
Then

$$\frac{1}{R} = \frac{1}{10} + \frac{1}{10} = \frac{2}{10} = \frac{1}{5}$$

$$R = 5\,\Omega$$

Example **A wire of resistance 10 ohm is bent in the form of a closed circle. What is the effective resistance between the two points at the ends of any diameter of the circle ?**

Ans. Let R be the effective resistance.



Then $\frac{1}{R} = \frac{1}{5} + \frac{1}{5} = \frac{2}{5}$

$\therefore \quad R = \frac{5}{2}\Omega = 2.5\,\Omega$

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