Numerical Problems

Problem 12.1 A battery has an emf of 12.8 V and supplies current of 3.2 A. What is resistance of circuit? How many coulombs leave battery in 5 minute?

$V = 12.8\ V$ $\quad i = 3.2\ A$ $\quad R = ?$ $\quad Q = ?$ if $t = 5\text{min} = 300\ \text{sec}$

Solution

From Ohm's law we can write $R = \frac{V}{i} = \frac{12.8}{3.2} = 4\ \Omega$

Now charge $\quad Q = i \times t = 3.2 \times 300 = 960\ C$

Problem 12.2 A carbon electrode has a resistance of 0.125 Ω at 20 °C. The temperature co-efficient of carbon is -0.0005 at 20 °C. What will be the resistance of the electrode at 85 °C.

$R_{20} = 0.125\ \Omega$ $\quad T_1 = 20\ °C$ $\quad \alpha = -0.0005$ $\quad R_t = ?$ when $T_2 = 85\ °C$

Solution

Resistance at any temperature T is given by

$$R_t = R_o\,(1 + \alpha T)$$

where

$$T = T_2 - T_1 = 85 - 20 = 65\ °C$$

$$R_t = 0.125\,(1 - 0.0005 \times 65) = 0.12\ \Omega$$

Problem 12.3 Calculate the resistance of wire 10 m long that has a diameter of 2 mm and resistivity of 2.63 x 10⁻² Ω m.

$R = ?$ $\quad L = 10\ m$ $\quad d = 2\ mm = 2 \times 10^{-3}\ m$ $\quad \rho = 2.63 \times 10^{-2}\ \Omega m$

Solution

we know that $\quad R = \frac{\rho L}{A}$

where $A = \pi r^2 = \pi d^2 / 4 = 3.14 \times 10^{-6}\ m^2$

$$R = \frac{(2.63 \times 10^{-2})(10)}{3.14 \times 10^{-6}} = 83758\ \Omega$$ **(Text book needs correction)**

Problem 12.4 A typical 12 V automobile battery has a resistance of 0.012 Ω. What is terminal voltage of this battery when starter draws a current of 100 A? Calculate R, Pε, P_R and P_r .

$\varepsilon = 12\ V$ $\quad r = 0.012\ \Omega$ $\quad$ (a) $V_t = ?$ when $i = 100\ A$ $\quad$ (b) Load $R = ?$

(c) Power of source $P_\varepsilon = ?$ $\quad$ (d) Power $P_R = ?$ $\quad$ (e) Power $P_r = ?$

Solution

(a) We know that emf $\varepsilon = V_t + ir$

$$V_t = \varepsilon - ir = 12 - (100)(0.012) = 10.8\ V$$

(b) Load resistor $\quad R = \frac{V_t}{i} = \frac{10.8}{100} = 0.108\ \Omega$

(c) $P_\varepsilon = i^2 (R + r) = (100)^2 \times (0.108 + 0.012) = 1200\ W$

(d) $P_R = i^2 R = (100)^2 \times 0.108 = 1080\ W$

(e) $P_r = i^2 r = (100)^2 \times 0.012 = 120\ W$

Problem 12.5. A 10 W resister has a value of 120 Ω. What is the rated current through the resister?

P = 10 W R = 120 Ω i = ?

The maximum current that a device can draw without being over-heated is called rated current.

Solution

From definition of power $P = i^2 R$

$$i = \sqrt{\frac{P}{R}} = \sqrt{\frac{10}{120}} = 0.2886\ A$$

Problem 12.6 Resistor of 50 Ω has a P. D of 100 V D.C. across 1 hr. Calculate (a) Power and (b) Energy.

R = 50 Ω V = 100 V t = 1 hr = 3600 sec (a) P = ? (b) E = ?

Solution

(a) Power $P = \frac{V^2}{R} = \frac{(100)^2}{50} = 200\ w$

(b) Energy $E = P \times t = 200 \times 3600 = 0.72 \times 10^6\ J = 0.72\ MJ$

Problem 12.7 Calculate the current through a single loop circuit if ε = 120 V, R = 1000 Ω and internal resistance r = 0.01 Ω.

i =? ε = 120 V R = 1000 Ω r = 0.01 Ω

Solution

Using the relation $\varepsilon = i(R + r)$

or $i = \frac{\varepsilon}{R+r} = \frac{120}{1000 + 0.01} = 0.1199\ A$ or 120 mA

Problem 12.9 Find current flowing through the resistors of the figure given.

Current i = ? in the given circuit

Let $\varepsilon_1 = 10\ V$ $\varepsilon_2 = 6\ V$ $R_1 = 2\ \Omega$ $R_2 = 1\Omega$ i = ?

Solution

Applying KVL along closed loop abcda (counter clockwise)

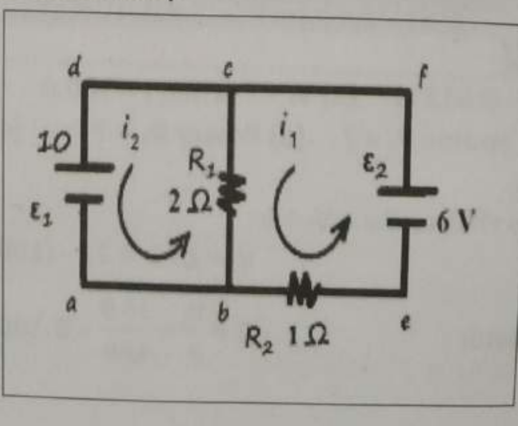
$$-\varepsilon_1 - (i_1 - i_2) R_1 = 0$$

$$-10 - (i_1 - i_2) R_1 = 0 \quad (1)$$

Similarly applying KVL along the closed loop befcb (counter clockwise)

$$-i_2 R_2 + \varepsilon_2 - (i_1 - i_2) R_1 = 0$$

$$-i_2 R_2 + 6 - (i_1 - i_2) R_1 = 0$$



$$+6 - i_2 R_2 - (i_1 - i_2) R_1 = 0 \quad \text{------------- (2)}$$

Adding eq (1) and (2) we get

$$-i_2 R_2 - 4 = 0$$

$$i_2 = -4\ A$$

putting this value in eq (1) we get

$$-2 i_1 + 2(-4) - 10 = 0$$

solving for i_1 we get

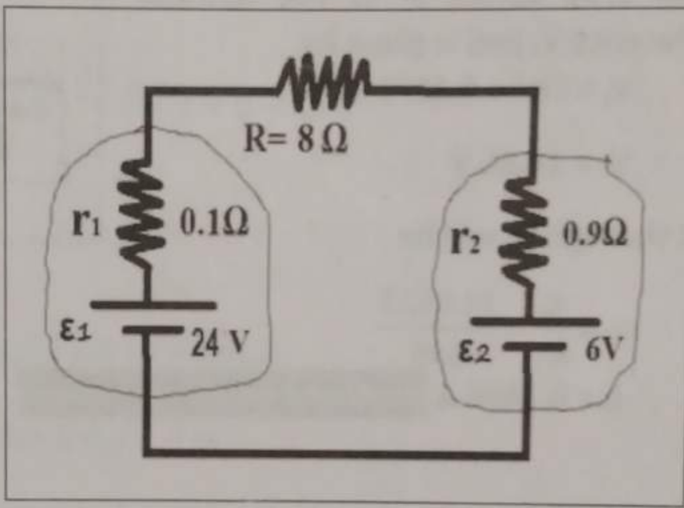
$$i_1 = -9\ A$$

Current flowing through R_2 is i_2 (-4 A) and current flowing through R_1 is $(i_1 - i_2) = -5$ A

Problem 12.10 Find terminal P.D of each cell in the circuit of figure given.

$r_1 = 0.1\ \Omega$ $\quad r_2 = 0.9\ \Omega$ $\quad R = 8\ \Omega$ $\quad \varepsilon_1 = 24$ V

$\varepsilon_2 = 6$ V $\quad V_{t_1} = ?$ $\quad V_{t_2} = ?$



Solution

Since ε_1 and ε_2 oppose each other so net emf is equal to their difference. Resistors are all in series, so net resistance is equal to the sum of individual resistance.

$$i = \frac{\varepsilon_n}{R_n} = \frac{\varepsilon_1 - \varepsilon_2}{r_1 + R + r_2}$$

$$i = \frac{24 - 6}{0.1 + 8 + 0.9} = 2\ A$$

Now terminal P.D of both cells can be calculated as follow;

For 1st cell: eq(1)⇒

$$V_{t_1} = \varepsilon_1 - i\, r_1 = 24 - (2 \times 0.1) = 23.8\ V$$

For 2nd cell: eq(1) ⇒

$$V_{t_2} = \varepsilon_2 + i\, r_2 = 6 + (2 \times 0.9) = 7.8\ V$$

Problem 12.11 Voltmeter in circuit may be considered to be ideal. Values are $\varepsilon = 15$ V, internal resistance $r = 5\ \Omega$, $R_1 = 100\ \Omega$, $R_2 = 300\ \Omega$. Calculate current in R_1.

Solution

$\varepsilon = 15$ V $\quad r = 5\ \Omega$ $\quad R_1 = 100\ \Omega$ $\quad R_2 = 300\ \Omega$

Current i = ? through R_1

First we need to calculate equivalent resistance R_{eq} as the given circuit contains more than one resistors. Ideal voltmeter has infinite resistance, so there will be no current through it.

R_1 and R_2 are in parallel so their net resistance will be

$$R^{/} = \frac{R_1 x R_2}{R_1 + R_2} = \frac{100 x 300}{100 + 300} = 75\ \Omega$$

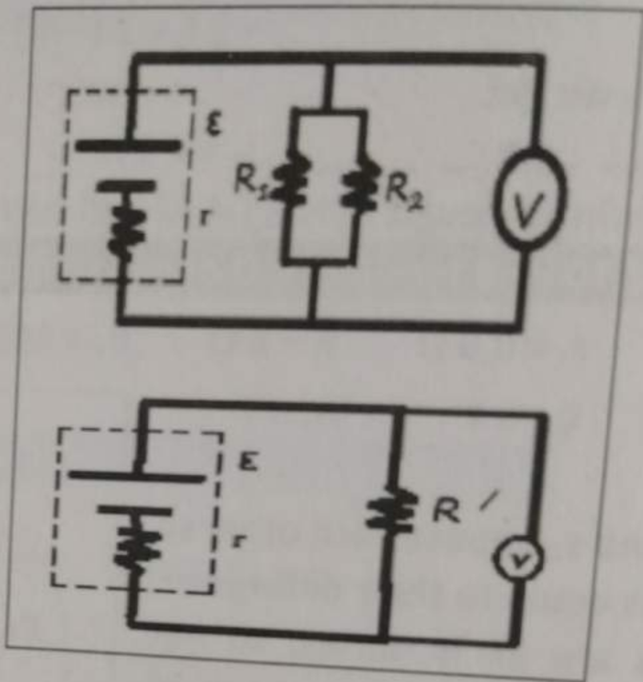
Now this $R^{/}$ is in series with r in the circuit.
So we further simplify the circuit to find total resistance. So

$$R_{eq} = R^{/} + r = 75 + 5 = 80\ \Omega$$

Now from Ohm's law

$$i = \frac{\varepsilon}{R_{eq}} = \frac{15}{80}$$

$$i = 0.1875\ A$$



Now this current "i" will pass through both r and $R^{/}$. Potential drop across $R^{/}$ is the terminal potential difference V_t and is given by

$$V_t = i R^{/} = 0.1875 \times 75$$

$$V_t = 14.06\ V$$

Now current through R_1 will be

$$i_1 = \frac{V_t}{R_1} = \frac{14.0625}{100}$$

$i_1 = 0.1406$ A **(textbook needs correction)**