

CHAPTER – 33
THERMAL AND CHEMICAL EFFECTS OF ELECTRIC CURRENT

1. $i = 2 \text{ A}$, $r = 25 \Omega$,
 $t = 1 \text{ min} = 60 \text{ sec}$
 Heat developed $= i^2 RT = 2 \times 2 \times 25 \times 60 = 6000 \text{ J}$

2. $R = 100 \Omega$, $E = 6 \text{ v}$
 Heat capacity of the coil $= 4 \text{ J/k}$ $\Delta T = 15^\circ\text{c}$

Heat liberate $\Rightarrow \frac{E^2}{Rt} = 4 \text{ J/K} \times 15$

$\Rightarrow \frac{6 \times 6}{100} \times t = 60 \Rightarrow t = 166.67 \text{ sec} = 2.8 \text{ min}$

3. (a) The power consumed by a coil of resistance R when connected across a supply v is $P = \frac{v^2}{R}$

The resistance of the heater coil is, therefore $R = \frac{v^2}{P} = \frac{(250)^2}{500} = 125 \Omega$

(b) If $P = 1000 \text{ w}$ then $R = \frac{v^2}{P} = \frac{(250)^2}{1000} = 62.5 \Omega$

4. $f = 1 \times 10^{-6} \Omega\text{m}$ $P = 500 \text{ W}$ $E = 250 \text{ v}$

(a) $R = \frac{V^2}{P} = \frac{250 \times 250}{500} = 125 \Omega$

(b) $A = 0.5 \text{ mm}^2 = 0.5 \times 10^{-6} \text{ m}^2 = 5 \times 10^{-7} \text{ m}^2$

$R = \frac{f l}{A} = l = \frac{R A}{f} = \frac{125 \times 5 \times 10^{-7}}{1 \times 10^{-6}} = 625 \times 10^{-1} = 62.5 \text{ m}$

(c) $62.5 = 2\pi r \times n$, $62.5 = 3 \times 3.14 \times 4 \times 10^{-3} \times n$

$\Rightarrow n = \frac{62.5}{2 \times 3.14 \times 4 \times 10^{-3}} \Rightarrow n = \frac{62.5 \times 10^{-3}}{8 \times 3.14} \approx 2500 \text{ turns}$

5. $V = 250 \text{ V}$ $P = 100 \text{ w}$

$R = \frac{v^2}{P} = \frac{(250)^2}{100} = 625 \Omega$

Resistance of wire $R = \frac{f l}{A} = 1.7 \times 10^{-8} \times \frac{10}{5 \times 10^{-6}} = 0.034 \Omega$

\therefore The effect in resistance $= 625.034 \Omega$

\therefore The current in the conductor $= \frac{V}{R} = \left(\frac{220}{625.034} \right) \text{ A}$

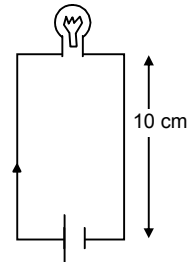
\therefore The power supplied by one side of connecting wire $= \left(\frac{220}{625.034} \right)^2 \times 0.034$

\therefore The total power supplied $= \left(\frac{220}{625.034} \right)^2 \times 0.034 \times 2 = 0.0084 \text{ w} = 8.4 \text{ mw}$

6. $E = 220 \text{ v}$ $P = 60 \text{ w}$

$R = \frac{V^2}{P} = \frac{220 \times 220}{60} = \frac{220 \times 11}{3} \Omega$

(a) $E = 180 \text{ v}$ $P = \frac{V^2}{R} = \frac{180 \times 180 \times 3}{220 \times 11} = 40.16 \approx 40 \text{ w}$



- (b) $E = 240 \text{ v}$ $P = \frac{V^2}{R} = \frac{240 \times 240 \times 3}{220 \times 11} = 71.4 \approx 71 \text{ w}$
7. Output voltage = $220 \pm 1\%$ $1\% \text{ of } 220 \text{ V} = 2.2 \text{ v}$
- The resistance of bulb $R = \frac{V^2}{P} = \frac{(220)^2}{100} = 484 \Omega$
- (a) For minimum power consumed $V_1 = 220 - 1\% = 220 - 2.2 = 217.8$
- $\therefore i = \frac{V_1}{R} = \frac{217.8}{484} = 0.45 \text{ A}$
- Power consumed = $i \times V_1 = 0.45 \times 217.8 = 98.01 \text{ W}$
- (b) for maximum power consumed $V_2 = 220 + 1\% = 220 + 2.2 = 222.2$
- $\therefore i = \frac{V_2}{R} = \frac{222.2}{484} = 0.459$
- Power consumed = $i \times V_2 = 0.459 \times 222.2 = 102 \text{ W}$
8. $V = 220 \text{ v}$ $P = 100 \text{ w}$
- $R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484 \Omega$
- $P = 150 \text{ w}$ $V = \sqrt{PR} = \sqrt{150 \times 22 \times 22} = 22\sqrt{150} = 269.4 \approx 270 \text{ v}$
9. $P = 1000$ $V = 220 \text{ v}$ $R = \frac{V^2}{P} = \frac{48400}{1000} = 48.4 \Omega$
- Mass of water = $\frac{1}{100} \times 1000 = 10 \text{ kg}$
- Heat required to raise the temp. of given amount of water = $ms\Delta t = 10 \times 4200 \times 25 = 1050000$
- Now heat liberated is only 60%. So $\frac{V^2}{R} \times T \times 60\% = 1050000$
- $\Rightarrow \frac{(220)^2}{48.4} \times \frac{60}{100} \times T = 1050000 \Rightarrow T = \frac{105000}{6} \times \frac{1}{60} \text{ nub} = 29.16 \text{ min.}$
10. Volume of water boiled = $4 \times 200 \text{ cc} = 800 \text{ cc}$
- $T_1 = 25^\circ\text{C}$ $T_2 = 100^\circ\text{C}$ $\Rightarrow T_2 - T_1 = 75^\circ\text{C}$
- Mass of water boiled = $800 \times 1 = 800 \text{ gm} = 0.8 \text{ kg}$
- $Q(\text{heat req.}) = MS\Delta\theta = 0.8 \times 4200 \times 75 = 252000 \text{ J.}$
- $1000 \text{ watt-hour} = 1000 \times 3600 \text{ watt-sec} = 1000 \times 3600 \text{ J}$
- No. of units = $\frac{252000}{1000 \times 3600} = 0.07 = 7 \text{ paise}$
- (b) $Q = mS\Delta T = 0.8 \times 4200 \times 95 \text{ J}$
- No. of units = $\frac{0.8 \times 4200 \times 95}{1000 \times 3600} = 0.0886 \approx 0.09$
- Money consumed = $0.09 \text{ Rs} = 9 \text{ paise.}$
11. $P = 100 \text{ w}$ $V = 220 \text{ v}$
- Case I : Excess power = $100 - 40 = 60 \text{ w}$
- Power converted to light = $\frac{60 \times 60}{100} = 36 \text{ w}$
- Case II : Power = $\frac{(220)^2}{484} = 82.64 \text{ w}$
- Excess power = $82.64 - 40 = 42.64 \text{ w}$
- Power converted to light = $42.64 \times \frac{60}{100} = 25.584 \text{ w}$

$$\Delta P = 36 - 25.584 = 10.416$$

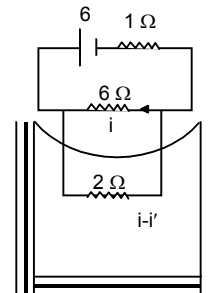
$$\text{Required \%} = \frac{10.416}{36} \times 100 = 28.93 \approx 29\%$$

$$12. R_{\text{eff}} = \frac{12}{8} + 1 = \frac{5}{2} \quad i = \frac{6}{(5/2)} = \frac{12}{5} \text{ Amp.}$$

$$i' \cdot 6 = (i - i') \cdot 2 \Rightarrow i' \cdot 6 = \frac{12}{5} \times 2 - 2i'$$

$$8i' = \frac{24}{5} \Rightarrow i' = \frac{24}{5 \times 8} = \frac{3}{5} \text{ Amp}$$

$$i - i' = \frac{12}{5} - \frac{3}{5} = \frac{9}{5} \text{ Amp}$$



$$(a) \text{ Heat} = i^2 RT = \frac{9}{5} \times \frac{9}{5} \times 2 \times 15 \times 60 = 5832$$

2000 J of heat raises the temp. by 1K

5832 J of heat raises the temp. by 2.916K.

(b) When 6Ω resistor get burnt $R_{\text{eff}} = 1 + 2 = 3 \Omega$

$$i = \frac{6}{3} = 2 \text{ Amp.}$$

$$\text{Heat} = 2 \times 2 \times 2 \times 15 \times 60 = 7200 \text{ J}$$

2000 J raises the temp. by 1K

7200 J raises the temp by 3.6k

$$13. \theta = 0.001^\circ\text{C} \quad a = -46 \times 10^{-6} \text{ v/deg}, \quad b = -0.48 \times 10^{-6} \text{ v/deg}^2$$

$$\text{Emf} = a_{\text{BiAg}} \theta + (1/2) b_{\text{BiAg}} \theta^2 = -46 \times 10^{-6} \times 0.001 - (1/2) \times 0.48 \times 10^{-6} (0.001)^2$$

$$= -46 \times 10^{-9} - 0.24 \times 10^{-12} = -46.00024 \times 10^{-9} = -4.6 \times 10^{-8} \text{ V}$$

$$14. E = a_{\text{AB}}\theta + b_{\text{AB}}\theta^2 \quad a_{\text{CuAg}} = a_{\text{CuPb}} - b_{\text{AgPb}} = 2.76 - 2.5 = 0.26 \mu\text{V}/^\circ\text{C}$$

$$b_{\text{CuAg}} = b_{\text{CuPb}} - b_{\text{AgPb}} = 0.012 - 0.012 \mu\text{VC} = 0$$

$$E = a_{\text{AB}}\theta = (0.26 \times 40) \mu\text{V} = 1.04 \times 10^{-5} \text{ V}$$

$$15. \theta = 0^\circ\text{C}$$

$$a_{\text{Cu,Fe}} = a_{\text{Cu,Pb}} - a_{\text{Fe,Pb}} = 2.76 - 16.6 = -13.8 \mu\text{V}/^\circ\text{C}$$

$$b_{\text{Cu,Fe}} = b_{\text{Cu,Pb}} - b_{\text{Fe,Pb}} = 0.012 + 0.030 = 0.042 \mu\text{V}/^\circ\text{C}^2$$

$$\text{Neutral temp. on } -\frac{a}{b} = \frac{13.8}{0.042} ^\circ\text{C} = 328.57^\circ\text{C}$$

16. (a) 1eq. mass of the substance requires 96500 coulombs

Since the element is monoatomic, thus eq. mass = mol. Mass

$$6.023 \times 10^{23} \text{ atoms require } 96500 \text{ C}$$

$$1 \text{ atoms require } \frac{96500}{6.023 \times 10^{23}} \text{ C} = 1.6 \times 10^{-19} \text{ C}$$

(b) Since the element is diatomic eq.mass = (1/2) mol.mass

$$\therefore (1/2) \times 6.023 \times 10^{23} \text{ atoms } 2\text{eq. } 96500 \text{ C}$$

$$\Rightarrow 1 \text{ atom require } = \frac{96500 \times 2}{6.023 \times 10^{23}} = 3.2 \times 10^{-19} \text{ C}$$

17. At Wt. At = 107.9 g/mole

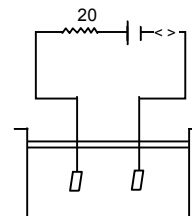
$$I = 0.500 \text{ A}$$

$$E_{\text{Ag}} = 107.9 \text{ g} \quad [\text{As Ag is monoatomic}]$$

$$Z_{\text{Ag}} = \frac{E}{f} = \frac{107.9}{96500} = 0.001118$$

$$M = Zit = 0.001118 \times 0.5 \times 3600 = 2.01$$

18. $t = 3 \text{ min} = 180 \text{ sec}$ $w = 2 \text{ g}$
 $E.C.E = 1.12 \times 10^{-6} \text{ kg/c}$
 $\Rightarrow 3 \times 10^{-3} = 1.12 \times 10^{-6} \times i \times 180$
 $\Rightarrow i = \frac{3 \times 10^{-3}}{1.12 \times 10^{-6} \times 180} = \frac{1}{6.72} \times 10^2 \approx 15 \text{ Amp.}$
19. $\frac{H_2}{22.4L} \rightarrow 2g$ $1L \rightarrow \frac{2}{22.4}$
 $m = Zit$ $\frac{2}{22.4} = \frac{1}{96500} \times 5 \times T \Rightarrow T = \frac{2}{22.4} \times \frac{96500}{5} = 1732.21 \text{ sec} \approx 28.7 \text{ min} \approx 29 \text{ min.}$
20. $w_1 = Zit \Rightarrow 1 = \frac{\text{mm}}{3 \times 96500} \times 2 \times 1.5 \times 3600 \Rightarrow \text{mm} = \frac{3 \times 96500}{2 \times 1.5 \times 3600} = 26.8 \text{ g/mole}$
 $\frac{E_1}{E_2} = \frac{w_1}{w_2} \Rightarrow \frac{107.9}{\left(\frac{\text{mm}}{3}\right)} = \frac{w_1}{1} \Rightarrow w_1 = \frac{107.9 \times 3}{26.8} = 12.1 \text{ gm}$
21. $I = 15 \text{ A}$ Surface area = 200 cm^2 , Thickness = 0.1 mm
 Volume of Ag deposited = $200 \times 0.01 = 2 \text{ cm}^3$ for one side
 For both sides, Mass of Ag = $4 \times 10.5 = 42 \text{ g}$
 $Z_{\text{Ag}} = \frac{E}{F} = \frac{107.9}{96500}$ $m = Zit$
 $\Rightarrow 42 = \frac{107.9}{96500} \times 15 \times T \Rightarrow T = \frac{42 \times 96500}{107.9 \times 15} = 2504.17 \text{ sec} = 41.73 \text{ min} \approx 42 \text{ min}$
22. $w = Zit$
 $2.68 = \frac{107.9}{96500} \times i \times 10 \times 60$
 $\Rightarrow i = \frac{2.68 \times 965}{107.9 \times 6} = 3.99 \approx 4 \text{ Amp}$
 Heat developed in the 20Ω resistor = $(4)^2 \times 20 \times 10 \times 60 = 192000 \text{ J} = 192 \text{ KJ}$
23. For potential drop, $t = 30 \text{ min} = 180 \text{ sec}$
 $V_i = V_f + iR \Rightarrow 12 = 10 + 2i \Rightarrow i = 1 \text{ Amp}$
 $m = Zit = \frac{107.9}{96500} \times 1 \times 30 \times 60 = 2.01 \text{ g} \approx 2 \text{ g}$
24. $A = 10 \text{ cm}^2 \times 10^{-4} \text{ cm}^2$
 $t = 10 \text{ m} = 10 \times 10^{-6}$
 Volume = $A(2t) = 10 \times 10^{-4} \times 2 \times 10 \times 10^{-6} = 2 \times 10^2 \times 10^{-10} = 2 \times 10^{-8} \text{ m}^3$
 Mass = $2 \times 10^{-8} \times 9000 = 18 \times 10^{-5} \text{ kg}$
 $W = Z \times C \Rightarrow 18 \times 10^{-5} = 3 \times 10^{-7} \times C$
 $\Rightarrow q = \frac{18 \times 10^{-5}}{3 \times 10^{-7}} = 6 \times 10^2$
 $V = \frac{W}{q} \Rightarrow W = Vq = 12 \times 6 \times 10^2 = 76 \times 10^2 = 7.6 \text{ KJ}$



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