CHAPTER – 33
THERMAL AND CHEMICAL EFFECTS OF ELECTRIC CURRENT

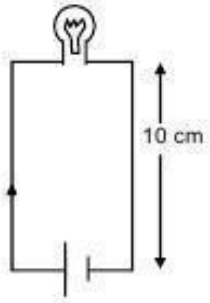
1. $i = 2$ A, $r = 25\ \Omega$,
$t = 1$ min $= 60$ sec
Heat developed $= i^2 RT = 2 \times 2 \times 25 \times 60 = 6000$ J

2. $R = 100\ \Omega$, $E = 6$ v
Heat capacity of the coil = 4 J/k $\Delta T = 15°c$
Heat liberate $\Rightarrow \frac{E^2}{Rt} = 4$ J/K $\times$ 15
$\Rightarrow \frac{6\times6}{100}\times t = 60 \Rightarrow t = 166.67$ sec $= 2.8$ 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 w then $R = \frac{v^2}{P} = \frac{(250)^2}{1000} = 62.5\ \Omega$

4. $f = 1 \times 10^{-6}\ \Omega$m $P = 500$ W $E = 250$ v
(a) $R = \frac{V^2}{P} = \frac{250\times250}{500} = 125\ \Omega$
(b) $A = 0.5\ mm^2 = 0.5 \times 10^{-6}\ m^2 = 5 \times 10^{-7}\ m^2$
$R = \frac{fl}{A} = l = \frac{RA}{f} = \frac{125\times5\times10^{-7}}{1\times10^{-6}} = 625 \times 10^{-1} = 62.5$ m
(c) $62.5 = 2\pi r \times n$, $62.5 = 3 \times 3.14 \times 4 \times 10^{-3} \times n$
$\Rightarrow n = \frac{62.5}{2\times3.14\times4\times10^{3}} \Rightarrow n = \frac{62.5\times10^{-3}}{8\times3.14} \approx 2500$ turns

5. $V = 250$ V $P = 100$ w
$R = \frac{v^2}{P} = \frac{(250)^2}{100} = 625\ \Omega$
Resistance of wire $R = \frac{fl}{A} = 1.7 \times 10^{-8} \times \frac{10}{5\times10^{-6}} = 0.034\ \Omega$
$\therefore$ The effect in resistance $= 625.034\ \Omega$
$\therefore$ The current in the conductor $= \frac{V}{R} = \left(\frac{220}{625.034}\right)$ 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 $= \left(\frac{220}{625.034}\right)^2 \times 0.034 \times 2 = 0.0084$ w $= 8.4$ mw



6. $E = 220$ v $P = 60$ w
$R = \frac{V^2}{P} = \frac{220\times220}{60} = \frac{220\times11}{3}\ \Omega$
(a) $E = 180$ v $P = \frac{V^2}{R} = \frac{180\times180\times3}{220\times11} = 40.16 \approx 40$ w
(b) $E = 240$ v $P = \frac{V^2}{R} = \frac{240\times240\times3}{220\times11} = 71.4 \approx 71$ w

7. Output voltage $= 220 \pm 1\%$ 1% of 220 V = 2.2 v

The resistance of bulb $R = \frac{V^2}{P} = \frac{(220)^2}{100} = 484\ \Omega$

(a) For minimum power consumed $V_1 = 220 - 1\% = 220 - 2.2 = 217.8$

$\therefore i = \frac{V_1}{R} = \frac{217.8}{484} = 0.45$ A

Power consumed $= i \times V_1 = 0.45 \times 217.8 = 98.01$ 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 $= i \times V_2 = 0.459 \times 222.2 = 102$ W

8. V = 220 v P = 100 w

$R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\ \Omega$

P = 150 w $V = \sqrt{PR} = \sqrt{150 \times 22 \times 22} = 22\sqrt{150} = 269.4 \approx 270$ v

9. P = 1000 V = 220 v $R = \frac{V^2}{P} = \frac{48400}{1000} = 48.4\ \Omega$

Mass of water $= \frac{1}{100} \times 1000 = 10$ 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 $\frac{V^2}{R} \times T \times 60\% = 1050000$

$\Rightarrow \frac{(220)^2}{48.4} \times \frac{60}{100} \times T = 1050000 \Rightarrow T = \frac{10500}{6} \times \frac{1}{60}$ nub = 29.16 min.

10. Volume of water boiled = 4 × 200 cc = 800 cc

$T_1 = 25°C$ $T_2 = 100°C$ $\Rightarrow T_2 - T_1 = 75°C$

Mass of water boiled = 800 × 1 = 800 gm = 0.8 kg

Q(heat req.) = $MS\Delta\theta = 0.8 \times 4200 \times 75 = 252000$ J.

1000 watt – hour = 1000 × 3600 watt-sec = 1000× 3600 J

No. of units $= \frac{252000}{1000 \times 3600} = 0.07 = 7$ paise

(b) $Q = mS\Delta T = 0.8 \times 4200 \times 95$ J

No. of units $= \frac{0.8 \times 4200 \times 95}{1000 \times 3600} = 0.0886 \approx 0.09$

Money consumed = 0.09 Rs = 9 paise.

11. P = 100 w V = 220 v

Case I : Excess power = 100 – 40 = 60 w

Power converted to light $= \frac{60 \times 60}{100} = 36$ w

Case II : Power $= \frac{(220)^2}{484} = 82.64$ w

Excess power = 82.64 – 40 = 42.64 w

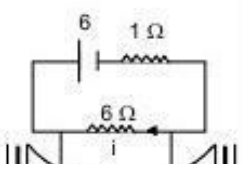
Power converted to light $= 42.64 \times \frac{60}{100} = 25.584$ w

$\Delta P = 36 - 25.584 = 10.416$

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

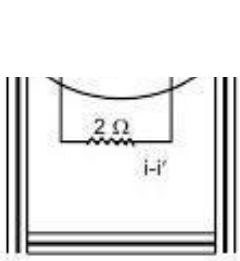
12. $R_{eff} = \frac{12}{8} + 1 = \frac{5}{2}$ $i = \frac{6}{(5/2)} = \frac{12}{5}$ Amp.

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



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

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



(a) 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 $R_{eff} = 1 + 2 = 3\ \Omega$

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

Heat = 2 × 2 × 2 ×15 × 60 = 7200 J

2000 J raises the temp. by 1K

7200 J raises the temp by 3.6k

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

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

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

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

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

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

15. $\theta = 0°C$

$a_{Cu,Fe} = a_{Cu,Pb} - a_{Fe,Pb} = 2.76 - 16.6 = -13.8\ \mu v/°C$

$B_{Cu,Fe} = b_{Cu,Pb} - b_{Fe,Pb} = 0.012 + 0.030 = 0.042\ \mu v/°C^2$

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

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

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

6.023×10^{23} atoms require 96500 C

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

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

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

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

17. At Wt. At = 107.9 g/mole

I = 0.500 A

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

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

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

18. t = 3 min = 180 sec w = 2 g

E.C.E = 1.12×10^{-6} kg/c

$\Rightarrow 3\times 10^{-3} = 1.12\times 10^{-6}\times i\times 180$

$\Rightarrow i = \frac{3\times 10^{-3}}{1.12\times 10^{-6}\times 180} = \frac{1}{6.72}\times 10^2 \approx 15$ Amp.

19. $\frac{H_2}{22.4L} \rightarrow 2g$ $1L \rightarrow \frac{2}{22.4}$

$m = Zit$ $\frac{2}{22.4} = \frac{1}{96500}\times 5\times T \Rightarrow T = \frac{2}{22.4}\times\frac{96500}{5} = 1732.21$ sec ≈ 28.7 min ≈ 29 min.

mm 3×96500

20. $w_1 = Zit \quad \Rightarrow 1 = \frac{\text{.....}}{3\times96500}\times2\times1.5\times3600 \Rightarrow mm = \frac{\text{.....}}{2\times1.5\times3600} = 26.8$ g/mole

$$\frac{E_1}{E_2} = \frac{w_1}{w_2} \Rightarrow \frac{107.9}{\left(\frac{mm}{3}\right)} = \frac{w_1}{1} \Rightarrow w_1 = \frac{107.9\times3}{26.8} = 12.1 \text{ gm}$$

21. I = 15 A Surface area = 200 cm^2, Thickness = 0.1 mm

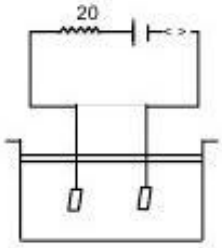
Volume of Ag deposited = 200 × 0.01 = 2 cm^3 for one side

For both sides, Mass of Ag = 4 × 10.5 = 42 g

$$Z_{Ag} = \frac{E}{F} = \frac{107.9}{96500} \qquad m = ZIT$$

$$\Rightarrow 42 = \frac{107.9}{96500}\times15\times T \Rightarrow T = \frac{42\times96500}{107.9\times15} = 2504.17 \text{ sec} = 41.73 \text{ min} \approx 42 \text{ min}$$

22. w = Zit



$$2.68 = \frac{107.9}{96500}\times i\times10\times60$$

$$\Rightarrow I = \frac{2.68\times965}{107.9\times6} = 3.99 \approx 4 \text{ Amp}$$

Heat developed in the 20 Ω resister = $(4)^2$ × 20 × 10 × 60 = 192000 J = 192 KJ

23. For potential drop, t = 30 min = 180 sec

$V_i = V_f + iR \Rightarrow 12 = 10 + 2i \Rightarrow i = 1$ Amp

$$m = Zit = \frac{107.9}{96500}\times1\times30\times60 = 2.01 \text{ g} \approx 2 \text{ g}$$

24. A= 10 cm^2× $10^{-4}cm^2$

t = 10m = 10 × 10^{-6}

Volume = A(2t) = 10 × 10^{-4} × 2 × 10 × 10^{-6} = 2 × 10^2 × 10^{-10} = 2 × 10^{-8} m^3

Mass = 2 × 10^{-8} × 9000 = 18 × 10^{-5} kg

W = Z × C ⇒ 18 × 10^{-5} = 3 × 10^{-7} × C

$$\Rightarrow q = \frac{18\times10^{-5}}{3\times10^{-7}} = 6\times10^2$$

$$V = \frac{W}{q} = \Rightarrow W = Vq = 12\times6\times10^2 = 76\times10^2 = 7.6 \text{ KJ}$$