CHAPTER – 33
THERMAL AND CHEMICAL EFFECTS OF ELECTRIC CURRENT

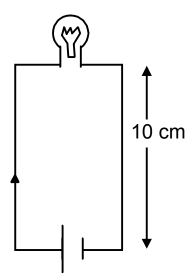
1. $i = 2$ A, $r = 25\ \Omega$,
   $t = 1$ min $= 60$ sec
   Heat developed $= i^2 RT = 2 \times 2 \times 25 \times 60 = 6000$ J

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 × 15
   $\Rightarrow \frac{6 \times 6}{100} \times t = 60 \Rightarrow t = 166.67$ 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) $R = \frac{V^2}{P} = \frac{250 \times 250}{500} = 125\ \Omega$
   (b) $A = 0.5\ mm^2 = 0.5 \times 10^{-6}\ m^2 = 5 \times 10^{-7}\ m^2$
   $R = \frac{fl}{A} = l = \frac{RA}{f} = \frac{125 \times 5 \times 10^{-7}}{1 \times 10^{-6}} = 625 \times 10^{-1} = 62.5$ m
   (c) $62.5 = 2\pi r \times n$, $62.5 = 3 \times 3.14 \times 4 \times 10^{-3} \times n$
   $\Rightarrow n = \frac{62.5}{2 \times 3.14 \times 4 \times 10^{3}} \Rightarrow n = \frac{62.5 \times 10^{-3}}{8 \times 3.14} \approx 2500$ turns

5. $V = 250$ V $P = 100$ w



   $R = \frac{v^2}{P} = \frac{(250)^2}{100} = 625\ \Omega$
   Resistance of wire $R = \frac{fl}{A} = 1.7 \times 10^{-8} \times \frac{10}{5 \times 10^{-6}} = 0.034\ \Omega$
   $\therefore$ The effect in resistance $= 625.034\ \Omega$
   $\therefore$ The current in the conductor $= \frac{V}{R} = \left(\frac{220}{625.034}\right)$ 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
   $R = \frac{V^2}{P} = \frac{220 \times 220}{60} = \frac{220 \times 11}{3}\ \Omega$
   (a) $E = 180$ v $P = \frac{V^2}{R} = \frac{180 \times 180 \times 3}{220 \times 11} = 40.16 \approx 40$ w

(b) E = 240 v $\quad P = \frac{V^2}{R} = \frac{240 \times 240 \times 3}{220 \times 11} = 71.4 \approx 71$ w

7. Output voltage = 220 ± 1% $\quad$ 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 $\quad$ P = 100 w

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

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

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

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

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

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 $\quad$ V = 220 v

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

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

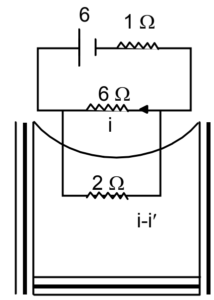
Case II : Power = $\frac{(220)^2}{484} = 82.64$ w

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. $R_{eff} = \frac{12}{8} + 1 = \frac{5}{2}$ $\quad$ $i = \frac{6}{(5/2)} = \frac{12}{5}$ 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. $\theta = 0.001°C$ $\quad$ $a = -46 \times 10^{-6}$ v/deg, $\quad$ $b = -0.48 \times 10^{-6}$ v/deg^2

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

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

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

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

$E = a_{AB}\theta = (0.26 \times 40)\ \mu V = 1.04 \times 10^{-5}$ 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 = 1.6×10^{-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 $\quad$ [As Ag is monoatomic]

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

M = Zit = 0.001118 × 0.5 × 3600 = 2.01

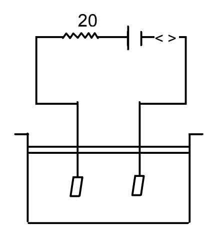
18. t = 3 min = 180 sec   w = 2 g
E.C.E = 1.12×10^{-6} kg/c
$\Rightarrow 3 \times 10^{-3} = 1.12 \times 10^{-6} \times i \times 180$
$\Rightarrow i = \dfrac{3 \times 10^{-3}}{1.12 \times 10^{-6} \times 180} = \dfrac{1}{6.72} \times 10^2 \approx 15$ Amp.

19. $\dfrac{H_2}{22.4L} \to 2g$ $1L \to \dfrac{2}{22.4}$
m = Zit $\dfrac{2}{22.4} = \dfrac{1}{96500} \times 5 \times T \Rightarrow T = \dfrac{2}{22.4} \times \dfrac{96500}{5} = 1732.21$ sec ≈ 28.7 min ≈ 29 min.

20. w_1 = Zit $\Rightarrow 1 = \dfrac{mm}{3 \times 96500} \times 2 \times 1.5 \times 3600 \Rightarrow mm = \dfrac{3 \times 96500}{2 \times 1.5 \times 3600} = 26.8$ g/mole
$\dfrac{E_1}{E_2} = \dfrac{w_1}{w_2} \Rightarrow \dfrac{107.9}{\left(\dfrac{mm}{3}\right)} = \dfrac{w_1}{1} \Rightarrow w_1 = \dfrac{107.9 \times 3}{26.8} = 12.1$ 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
$Z_{Ag} = \dfrac{E}{F} = \dfrac{107.9}{96500}$ m = ZIT
$\Rightarrow 42 = \dfrac{107.9}{96500} \times 15 \times T \Rightarrow T = \dfrac{42 \times 96500}{107.9 \times 15} = 2504.17$ sec = 41.73 min ≈ 42 min

22. w = Zit



$2.68 = \dfrac{107.9}{96500} \times i \times 10 \times 60$
$\Rightarrow I = \dfrac{2.68 \times 965}{107.9 \times 6} = 3.99 \approx 4$ Amp
Heat developed in the 20 Ω resister = $(4)^2 \times 20 \times 10 \times 60$ = 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 = $\dfrac{107.9}{96500} \times 1 \times 30 \times 60 = 2.01$ g ≈ 2 g

24. A= 10 $cm^2 \times 10^{-4} cm^2$
t = 10m = 10×10^{-6}
Volume = A(2t) = $10 \times 10^{-4} \times 2 \times 10 \times 10^{-6} = 2 \times 10^2 \times 10^{-10} = 2 \times 10^{-8}$ m^3
Mass = $2 \times 10^{-8} \times 9000 = 18 \times 10^{-5}$ kg
W = Z × C $\Rightarrow 18 \times 10^{-5} = 3 \times 10^{-7} \times C$
$\Rightarrow q = \dfrac{18 \times 10^{-5}}{3 \times 10^{-7}} = 6 \times 10^2$
$V = \dfrac{W}{q} = \Rightarrow W = Vq = 12 \times 6 \times 10^2 = 76 \times 10^2 = 7.6$ KJ

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