EXERCISE – III

SUBJECTIVE PROBLEMS

1. H = Energy/heat required to change 100°C Water in 200°C Vapour
$=1000\,L_V+1000\times0.5\times(200-100)$
= 590 Kcal.

2. Let mass = m

So, $\frac{1}{4}[mgh] = mL_s$

$h = \frac{4L_s}{g} = \frac{4\times3.4\times10^5}{10}$

$= 13.6 \times 10^4$ m

3. $mgh + \Delta K = ms\Delta T$
$(200\times10^{-3})\times10\times(60\times10^{-2}\sin 37°) + 0$
$= 200 \times 10^{-3} \times 420 \times \Delta T$
$\Delta T = 86 \times 10^{-3}$°C

4. Let all are at 0°C water then heat given
$\Delta Q_{ice} = -[(10 \times 0.5 \times 10) + (10 \times 80)] = -850$ cal
$\Delta Q_{water} = 10 \times 1 \times 20 = 200$ cal
$\Delta Q_{steam} = [2\times540+2\times1\times100] + 1280$ cal.
So, at 0°C water now have (1280 + 200 – 850) cal.
heat extra so it will increase temperature to t
(10 + 10 + 2) (1) (t – 0)
= (1280 + 200 – 850)
t = 28.636°C

5. $A \Rightarrow 200\text{ J} = 4 \times L_A \Rightarrow L_A = 50$
$B \Rightarrow 300\text{ J} = 5 \times L_B \Rightarrow L_B = 60$
$C \Rightarrow 300\text{ J} = 6 \times L_C \Rightarrow L_C = 50$

6. $m_A S_A[\Delta T_A] = -\, mS_B\Delta T_{B,\,C,\,D}$
$\Rightarrow S_A\Delta T_A = -S_B\Delta T_{B,\,C,\,D}$ ....(1)
So,
$1 \Rightarrow S_A = S_B$
$2 \Rightarrow S_A > S_C$
$3 \Rightarrow S_A >> S_D$

7. Total energy released
$= 10 \times 5 \times 4200$
$= 21 \times 10^4$ J
Energy released/min

$= \frac{0.2\times60}{1000} \times 2.27 \times 10^6$

$= 27.24 \times 10^3$
Time required

$= \frac{21\times10^4}{27.24\times10^3} = 7.7$ min

8. $\Delta Q_0 = 100 \times 4 \times 600$
= 24000 Cal.
for 0°C water
$\Delta Q_1 = (100 \times 0.2\times20)$
$+ (200 \times 0.5 \times 20) + (200 \times 80)$
= 18400 cal.
So, let temperature is t then
24000 – 18400
= (200 × 1 + 100 × 0.2) t
t = 25.5°C

9. Density of drink $= \frac{2m}{120}$

$= 0.833\ \frac{gm}{cc}$ (given)
$m \approx 50$ gm.
$ms_{AS}\,\Delta t + ms_W\Delta t = m_{ice}\,L_b + m_{ice}\,S_w\,(t - 0)$
$\Rightarrow 50 \times 0.6 \times (25 - t) + 50 \times 1 \times (25 - t) = 20 \times 80 + 20 \times t$

$t = \frac{50\times25(1+0.6)-20\times80}{50\times(1+0.6)+20}$

= t = 4°C

10. **A**
20°C W
5 gm X = 40°C
eq = 22°C
B
20°C W
5 gm Y = 40°C
eq = 23°C
For A $W(22 - 20) = 5 \times S_X \times (40 - 2\,2)$
W = 9 gm
For B $W(23 - 20) = 5 \times S_Y\,(40-23)$

$S_Y = \frac{27}{85}$

11. If ice completly melts
then $\Delta Q_{ice} = (2 \times 50)\,(0.5)\,(15) + (2 \times 50) \times 80$
= 8750 cal.
for water at °C
$\Delta Q_W = 250 \times 1 \times 25$ cal
= 6250 cal
Let m gram ice then $mL_S = (8750 - 6250)$ cal

$m = \frac{125}{4}$ g.ice.

12. **(i)** Let m

$\left(\frac{4}{5}\times1000\right) = ms \times \Delta T$
$= m\,0.5 \times 80$
m = 20 gm.

(ii) $mL = \left[\frac{1000}{5}\right] \times 4$

$L = \frac{1000\times4}{5\times20} = 40\ \frac{cal}{C\ gm}$

(iii) $ms_\ell\,(120 - 80) = \frac{1000}{5}\times3$

$S_\ell = \frac{1000\times3}{5\times40\times20} = 0.75\ \frac{cal}{C\ gm}$

13. $\dfrac{dQ}{dt} = KA\dfrac{dT}{dx}$

$= 0.8 \times (10 \times 10^{-2}) \times \left(\dfrac{90-10}{1\times10^{-2}}\right)$

$= 64$ J

14. $i = mL_s = KA\dfrac{dT}{dx}$

$m = \dfrac{42\times(0.04\times10^{-4})100}{3.36\times10^{5}\times1}$

$= 50 \times 10^{-9}$ Kg

$= 5 \times 10^{-5}$ g/s

15. (T-100)/2.5 + (T–0)/2.5 + (T–25)/5=0

So, T = 45°C

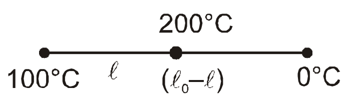
Hence,

I(CD) = V/R

= (45–25)/5 = 4 W

16. $\dfrac{i_c}{i_\ell} = \dfrac{KA\dfrac{dT}{\pi R}}{KA\dfrac{dT}{2R}} = \dfrac{2}{\pi}$

17.



$\dfrac{dm_v}{dt}L_v = \dfrac{KA(200-100)}{\ell}$ ..... (1)

$\dfrac{dm_{ice}}{dt}L_s = KA\left(\dfrac{200-0}{\ell_0-\ell}\right)$ .... (2)

(1) ÷ (2)

$\dfrac{L_V}{L_S} = \dfrac{100}{\ell}\left[\dfrac{\ell_0-\ell}{200}\right]$

$\dfrac{540}{80\times40} = \dfrac{1}{2}\left(\dfrac{1.45-\ell}{\ell}\right)$

$27\ell = 2 \times 1.45 - 2\ell$

$\boxed{\ell = 0.1\text{m}}$

18. Req = $R_1 + R_2 + R_3$

$\dfrac{t_1+t_2+t_3}{\text{Req}\,A}$

$= \dfrac{t_1}{K_1A} + \dfrac{t_2}{K_2A} + \dfrac{t_3}{K_3A}$

19. $KA\dfrac{dT}{dx} = 1 \times 10^3$ **W**

0.2 × 5 5 $\dfrac{(T-25)}{4\times10^{-2}} = 10^3$

T = $4 \times 10^{-2} \times 10^3 + 25$

$\boxed{T = 65°C}$

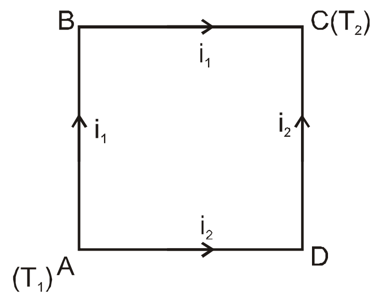
20. $\dfrac{dQ_1}{dt} = KA\dfrac{10}{d}$ $\Rightarrow \theta = 5°C$

$\dfrac{dQ_2}{dt} = 2KA\left(\dfrac{10-\theta}{d}\right)$ $\Rightarrow \theta = 5°C$

$\dfrac{dQ_3}{dt} = KA\dfrac{(\theta+5)}{d}$ $\Rightarrow \theta = 5°C$

$\dfrac{dQ_4}{dt} = 2K\dfrac{(5)}{d}$ $\Rightarrow \theta = 5°C$

21. Initially



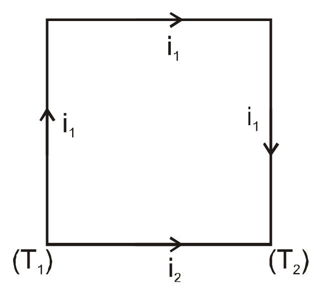
Given

W = $i_1 + i_2$

$\Rightarrow w = \left[KA\left(\dfrac{T_2-T_1}{2\ell}\right)\right] \times 2$

$\boxed{W = \dfrac{KA(T_2-T_1)}{\ell}}$ .... **(1)**

Now,



Now, w' = $i_1' + i_2'$

$= \dfrac{KA(T_2-T_1)}{\ell} + \dfrac{KA(T_2-T_1)}{3\ell}$

Or

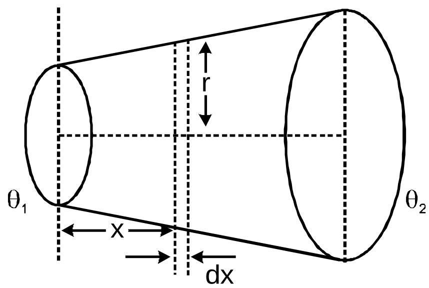
$\boxed{W' = W + \dfrac{W}{3} = \dfrac{4}{3}W}$ **From eq-1**

22. $160\pi = \dfrac{50-10}{\text{Req}}$

$160\pi = \dfrac{50\times10}{\dfrac{1}{4\pi K}\left[\dfrac{1}{r_1}-\dfrac{1}{r_2}\right]}$

$$\frac{160\pi}{4\pi} = \frac{40K}{\left(\frac{1}{5}-\frac{1}{20}\right)\times\frac{1}{10^{-2}}} \Rightarrow K = 15$$

23.



$$\frac{r_2 - r_1}{L} = \frac{r - r_1}{x}$$

$$r = r_1 + \frac{x}{L}(r_2 - r_1)$$

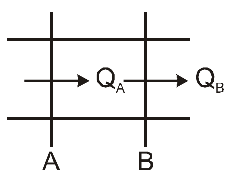
$$\int dR = \int \frac{dx}{K\pi r^2}$$

$$R = \frac{1}{K\pi}\int \frac{dx}{\left[r_1 + \frac{x}{L}(r_2 - r_1)\right]^2}$$

$$R = \frac{L}{K\pi(r_1 r_2)}$$

$$i = \frac{Q_2 - Q_1}{R}$$

24.



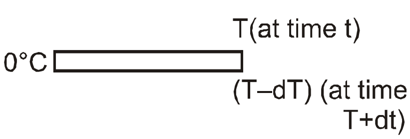
$$\frac{\Delta Q_{AB}}{\Delta t} = \frac{dQ_A}{dt} - \frac{dQ_B}{dt}$$

$$\Rightarrow \frac{\Delta Q}{\Delta t} = i_A - i_B$$

$$\Rightarrow (ms)\frac{dQ_{AB}}{dt} = KA\left(\frac{dT}{dx}\right)_A - KA\left(\frac{dT}{dx}\right)_B$$

$$\Rightarrow 0.40\ \frac{dQ_{AB}}{dt} = 200\times(1\times10^{-4})\left[(5-2.6)\times10^2\right]$$

25.



$$i = \frac{dQ}{dt} = \frac{KA(T-0)}{\ell}$$

$$Q_T = \int dQ = \int_0^{(10\times60)\text{Sec}} \frac{KAT}{\ell}dt \ .... (1)$$

Now, $T = \frac{t}{10}$ .... (2)

So,

$$Q_T = \int dQ = \int_0^{600}\frac{KAt}{\ell 10}dt = \frac{KA\left[t^2\right]_0^{600}}{20\ell} = 1800\text{ J}$$

26. Here

$$\frac{50.1-49.9}{5} = K(50 - 30°)$$

$$\frac{0.2}{5} = K \times 20$$

$$\Rightarrow K = \frac{1}{500}$$

Now,

$$\frac{40.1-39.9}{t} = K(40 - 30)$$

$$\frac{0.2}{t} = \frac{0.2}{5\times20}(10)$$

$\Rightarrow t = 10$sec.

27. $M_{cube} = m_{sphere}$

$$\Rightarrow \rho \times a^3 = \rho \times \frac{4}{3}\pi r^3$$

$$\Rightarrow \frac{a}{r} = \left(\frac{4}{3}\pi\right)^{\frac{1}{3}}$$

Rate of cooling $\frac{-dT}{dt} = eA\sigma(T^4 - T_0^4)$

$$\text{Ratio}: \frac{\text{Cube}}{\text{Sphere}} = \frac{A_{Cu}}{A_{Sp}} = \frac{6a^2}{4\pi r^2}$$

$$= \frac{3}{2\pi}\times\left(\frac{4}{3}\pi\right)^{\frac{2}{3}} = \left(\frac{6}{\pi}\right)^{\frac{1}{3}}$$

28. $\frac{dQ}{dt}$ (loss)

$$= ms \left(\frac{-dT}{dt}\right) = \left(\frac{4}{3}\pi R^3\right)\rho s\left(\frac{-dT}{dt}\right)$$

$$\frac{dQ_1}{dt}\Big/\frac{dQ_2}{dt} = \frac{\rho_1}{\rho_2}\times\frac{s_1}{s_2}$$

$$= \frac{8}{1}\times\frac{1}{4} = 2$$

29. $\lambda_{max} = \frac{b}{T}$

$\Rightarrow \frac{\lambda_s}{\lambda_{st}} = \frac{T_{star}}{T_{sum}}$

$\Rightarrow T_{Star} = \frac{4753}{9506} \times 6050\ K$

$= 3025\ K$

30. $\sigma(300)^4 = 5$ ....(1)
$\sigma(600)^4 = x$ ....(2)
Now, eq (2)/(1)

$\frac{x}{5} = \left(\frac{600}{300}\right)^4$

$\Rightarrow x = 80$ watt/cm^2

31. $100 = \quad e\ \sigma\ A_s T^4$

$\Rightarrow T^4 = \frac{100}{e\sigma A_s}$

$\because A_s = 2\pi R\ell$
$T = 1696.7\ K$
$\approx 1700\ K$

32. $i = e\sigma A\ (T^4 - T_0^4) = 210$
$= e\sigma A\ ((500)^4 - (300)^4)$
$= 210$ .... (1)
Now,
$i = 700 = \sigma A\ [(500)^4 - (300)^4]$....................(2)
(1)/(2)

$\ell = \frac{210}{700} = 0.3$

33. $\frac{P_s}{4\pi d_{ES}^2}\left(\frac{\pi d_E^2}{4}\right) = \sigma A_E T_E^4$

and $P_s = \sigma A_s T_s^4$

$\Rightarrow \frac{T_E^4}{4} = \frac{R_s^2}{d_{ES}^2} \cdot T_s^4$

$T_E = \frac{1}{\sqrt{2}}\left(\frac{6.9 \times 10^8}{1.49 \times 10^{11}}\right)^{1/2}\ 6000\ K$

$= 288.7\ K$

$\boxed{T_E = 15.7°C}$

34. $T = \frac{b}{\lambda_{max}}$

$T_B = \frac{0.3}{5000 \times 10^{-8}} = 6 \times 10^3\ K$

$T_R = \frac{0.3}{7500 \times 10^{-8}} = 4 \times 10^3\ K$

35. $T = \frac{b}{\lambda_{max}} = \frac{0.3}{5000 \times 10^{-8}} = 6000\ K$

$E = \sigma AT^4$
$= (5.6 \times 10^{-8})\ (1 \times 10^{-4})\ (6000)^4$
$= 7.2576 \times 10^3$ watt

$= 7.2576 \times 10^{10}\ \frac{erg}{cm^2\ sec}$

36. $E\lambda_{max} = 16 \longrightarrow$
$\lambda'_{max} = 6$ at 500 K
$\lambda'_m T =$ Constant
$6 \times 500 = \lambda_m 1000$

$\boxed{\lambda_m = 3\mu m}$

37. $\frac{70-60}{5} = K\left(\frac{70+60}{2} - 30\right)$

$2 = K\ (65 - 30)$ .... (1)
Now,

$\frac{60-50}{t} = K\left(\frac{60+50}{2} - 30\right)$

(1) ÷ (2)

$\frac{2t}{10} = \frac{35}{55-30}$

$t = \frac{35 \times 5}{25} = 7$ min

38. $\frac{50-45}{5} = K\left(\frac{50+45}{2} - \theta_0\right)$

Or $2 = K\ (95 - 2\theta_0)$ .... (1)

$\frac{45-40}{8} = K\left(\frac{45+40}{2} - \theta_0\right)$

cos $\frac{5 \times 2}{8} = K\ (85 - 2\theta_0)$ ...... (2)

(1) ÷ (2)

$\frac{8}{5} = \frac{95 - 2\theta_0}{85 - 2\theta_0}$

$\Rightarrow 205 = 6\theta_0$

$\boxed{\theta_0 = 34.16°C}$