EXERCISE – IV TOUGH SUBJECTIVE PROBLEMS

1. Steam = 330 – 200 – 100 = 30 g

Let ice = xg & water = (200 – x) g

loss (steam) = gain (ice + water + calorimeter)

$30 \times 2.25 \times 10^5 = x \times 3.36 \times 10^5$
$+ 200 \times 4.2 \times 10^3 \times 50$
$+ 100 \times 0.42 \times 10^3 \times 50$

$\Rightarrow$ x = 70g & water = 200 – x = 130 g

Ratios = $\frac{7}{13}$

2.

$-10^oC \to -2^oC$

$Q = ms\Delta T$

$64 = 10 \times S_L \times 8 \Rightarrow S_L = 0.8$

1^oC to $3^oC \Rightarrow Q = 900 - 880 = 20$ cal

$Q = ms\Delta T \Rightarrow 20 = 10 \times S_s \times 2 \Rightarrow S_s = 1$

Now, -2^oC to $+1^oC$

$880 = 10 \times 0.8 \times (t_m + 2) + 10\,L + 10 \times 1 \times (1 - t_m)$

$\Rightarrow L = 85.4 + 0.2\,t_m$ (in cal/gm)

for cal/kg

$L = 85400 + 200\,t_m$

3.

(a) $Q = ms\Delta T$

In one second

(a) $= 180 \times 0.1 \times 0.5 = 9$ cal/s
$= 37.8$ water

(b) $P = \tau w \Rightarrow \tau = \frac{p}{w} = \frac{37.8}{6T_1}$

4.

$Q = ms\Delta T$

in one second

$250 = \frac{0.2 \times 10}{1000} \times 5 \times 25$

S = 5000

5. If y length of ice melts then

y – 0.5 length of water forms

$\Rightarrow Ay \times 0.9 = A(y - 0.5) \times 1$

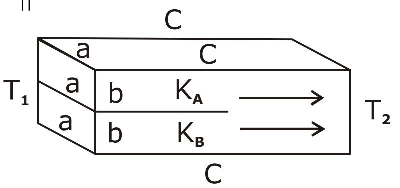
$\Rightarrow$ y = 5 cm ice melts.

loss (water) = goin (ice)

$A \times 10 \times 1 \times 1 \times T$
$= A \times 10 \times 0.9 \times 0.5 \times 20$
$+ A \times 5 \times 0.9 \times 80$

$\Rightarrow T = 45^oC$

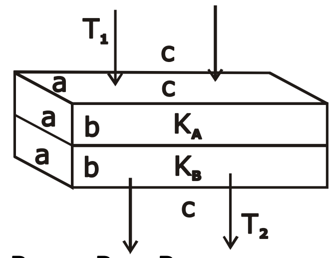
6. $K_{||}$



$\frac{1}{R} = \frac{kA}{l}$

$\Rightarrow \frac{K_{||}(2ab)}{C} = \frac{K_A(ab)}{C} + \frac{K_B(cb)}{C}$

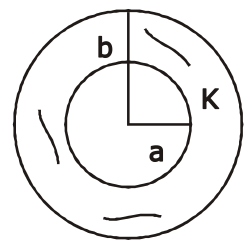
$\Rightarrow K_{||} = \frac{Ka + Kb}{2}$



$Req = R_1 + R_2$

$\frac{2b}{keq(ac)} = \frac{b}{K_A(ac)} + \frac{b}{K_B(ac)} \Rightarrow \boxed{Keq = \frac{2K_AK_B}{K_A + K_B}}$

7.



for cylinder (a to b)

$Req = \frac{\ln(b/a)}{2\pi kl}$

for conductor (R = 0 to R = a)

$dQ = msdT = s \times \pi a^2 l \times dT$

$\frac{dQ}{dt} = \pi a^2 sl \times \frac{dT}{dt} = \frac{T_0 - T}{Re\,q}$

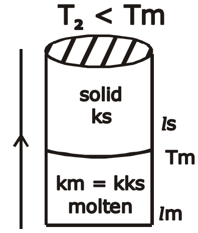
$\Rightarrow \pi a^2 sl \times \frac{dT}{dt} = \frac{T_0 - T}{\ln(b/a)} \times 2\pi\,k\,l$

$\Rightarrow \frac{a^2 s}{2k}\int_{T_1}^{T_2}\frac{dT}{T_0 - T} = \frac{1}{\ln(b/a)}\int_0^T dt$

$\Rightarrow t = \frac{a^2 s}{2k}\ln\left(\frac{b}{a}\right)\ln\left(\frac{T_0 - T_1}{T_0 - T_2}\right)$

8.

$T_2 < Tm$



$T_1 > Tm$

$\left(\frac{dQ}{dt}\right)_{molten} = \left(\frac{dQ}{dt}\right)_{solid}$

$\frac{K_m A(T_1 - T_m)}{l_m} = \frac{K_s\,A(T_m - T_2)}{l_s}$

$\frac{K(T_1 - T_m)}{T_m - T_2} = \frac{l_m}{l_s}$

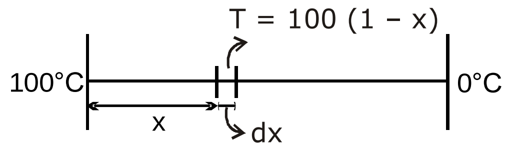
fraction of moltan metar

$$= \frac{l_m}{l_m + l_s} = \frac{1}{1 + \frac{l_s}{l_m}}$$

$$\frac{1}{1 + \frac{T_m - T_2}{k(T_1 - T_m)}} = \frac{k(T_1 - T_m)}{K(T_1 - T_m) + (T_m - T_2)}$$

9. **(a)** $\frac{dT}{dx} = \frac{0-100}{1} = -100^o\ C/m$

(b)

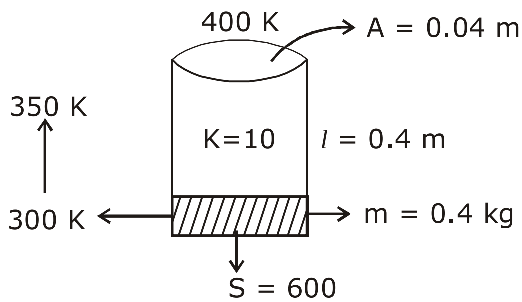


dQ = dm (T – 0) × s

= 2 dx × 10 × 100(1 – x)

$$Q = 2000 \int_0^1 (1-x)\ dx = 1000\ J$$

10.



$$\frac{dQ}{dt} = ms\frac{dT}{dt}$$

$$\frac{10(0.04)(400 - T)}{0.4} = 0.4 \times 600 \times \frac{dT}{dt}$$

t = 240 ln 2 = 166.3 s

11. $-\frac{dT}{dt} = \frac{dQ/dt}{ms} \frac{eA\sigma(T^4 - T_0^4)}{ms}$

$-\frac{dT}{dt} = \frac{K(T^4 - T_0^4)}{R}$ (R = Radius)

$\Rightarrow\ 2.8 = \frac{K}{R}$ $(400^4 - 300^4)$

& $-\frac{dT}{dt} = \frac{k}{2R}$ $(600^4 - 300^4)$

dividing $-\frac{dT}{dt} = -9.72^o\ C/s$

12. $\lambda T = b \Rightarrow T = \frac{b}{\lambda} = \frac{3\times10^{-3}}{7.5\times10^{-6}} \Rightarrow T = 400\ K$

$$\frac{KA(T_A - T_B)}{l} = A\ \sigma\ T_B^4$$

$$\frac{17\times(T_A - 400)}{0.5} = 5.67\times10^{-8}\times400^4$$

$\Rightarrow$ $T_A = 423^o$ Kalvin

13. The shell of a space station is a blackened

Rate of loss initially

$P = A\ \sigma\ T^4 = A\ \sigma\ (500)^4$

later half of radiation emmited are emmited back by shell but not loss must be same.

So, it radiated double $P' = 2p$

$A\ \sigma\ T^4 = 2\ A\ \sigma\ (500)^4$ $\boxed{T = 200 \times 2^{\frac{1}{4}}}$

14.

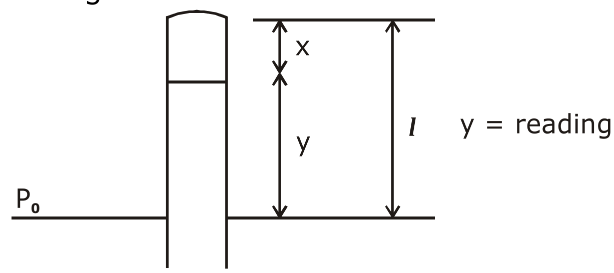
$-\frac{dT}{dt} = k(T - T_0) \Rightarrow \ln\left(\frac{T_1 - T_0}{T_2 - T_0}\right) = kt$

$\ln\left(\frac{80-20}{50-20}\right) = k \times 5 \Rightarrow k = \frac{1}{5}\ln 2$

and $\ln\left(\frac{60-20}{30-20}\right) = kt$

$\Rightarrow \ln 4 = \frac{1}{5}\ln 2 \times t$ t = 10 min

15.



Pressure of traped air is $P_0 - y$

and for T = cons

PV = cons

or Pl = cons

and $Pl = (P_0 - y)(l - y)$ = 1 cm

(a) Pl (73 – 69) (l – 69) = (75 – 70) (l – 70)

$\Rightarrow$ l = 74 cm

Pl = (75 – 70) (74 – 70) = 20

(b) $Pl = (P_0 - y)(l - y) = 20$

$\Rightarrow (P_0 - 69.5)(74 - 69.5) = 20$

$\Rightarrow P_0 = 73.94$ cm

(c) $Pl = (P_0 - y)(l - y) = 20$

$\Rightarrow$ (74 – y) (74 – y) = 20

$\Rightarrow 74 - y = \sqrt{20}$

y = 69.52 cm

16.

(i) $p_1 = P_{H_2} = 1.25 \times 10^6$ Pa ;

$p_2 = p_{H_2} + p_{O_2} + p_{N_2} = 2.8125 \times 10^6$ Pa;

$p_3 = p_{H_2} + p_{N_2} = 1.5625 \times 10^6$ Pa

17. $100^oC - \frac{R}{3} - A - \frac{R}{6} - \frac{R}{3} - 0^oC$

$\boxed{T_A = 60^o C}$