HEAT - I

EXERCISE – I | SINGLE CORRECT

1. D

(Calorimeter + Ice to vapour) $_{\text{at } 0 \text{ to } 100°C}$

$= (10 \times 100 + \{ 10 \times 80 + 10 \times 1 \times 100 + 10 \times 540\})$

= 8200 Cal.

2. A

heat / sec = 0.1 * 80 cal/gm = 8 cal/sec

mass = 0.1*100 = 10 gm ice or water [now Q = $ms\Delta T$]

In unit time

$\Delta T = Q/ms = 8/(10*1) = 0.8°C/s$

3. C

Water flow rate = 20 gm/sec

for 1 sec

$i = 2100 = 20 \times 4.2\ (t - 10)$

t = 35°C

4. B

for 1 sec

$P_c \times 80\ \% = (\rho v)\ s\ (t - 10)$

$$2 \times 10^3 \times \frac{80}{100} = (1000)\ .\ 100 \times (10^{-2})^3.4200\ (t - 10)$$

t = 13.8 °C

5. A

$(m_w + w_f)\ (1)\ (70 - 40) = m_{ice}\ L_f + m_{ice}\ (1)\ (40-0)$

$(200 + w_f\ )\ (70 - 40) = 500\ L_f + 50 \times 40$ ..(1)

$(m_w + w_f + m_{ice})\ (40{-}10) = m_{ice}\ L_f + m'_{ice}\ (1)\ (10{-}0)$

$(200 + w + 50)30 = 80\ L_f + 80 \times 10$ ...(2)

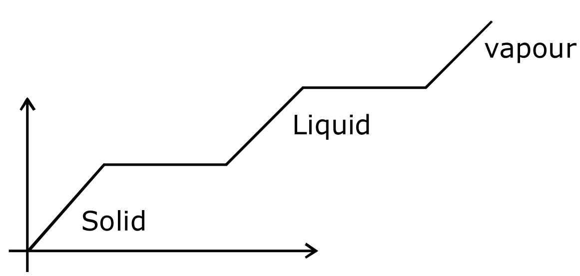
from eq. (1) & (2)

$50 \times 30 = 30\ L_f - 30{\times}40$

$L_f = 90$ cal/gm $= 3.78 \times 10^5$ J/kg

6. D

$$\therefore\ dQ = msdT \Rightarrow \frac{dT}{dQ} = \frac{1}{ms}$$



7. A

Energy conservation

$$\frac{m}{s}(L) = mgh$$

$$\Rightarrow\ h = \frac{L}{5g}$$

8. B

at a temp. T

$dQ = SdT = aT^3dT$

$$Q = a\int_1^2 T^3dT = \frac{a[T^4]_1^2}{4} = \frac{15a}{4}$$

9. C

for vapourization total time

= (30 – 20) min = 10 min

Total Heat Given = 42 ktJ × 10 = 420 KJ

so mL = 420 k

SL = 420

L = 84 KJ/kg

10. D

$S_A\rho_A = (12V)\ \rho_B s_B$

$$\frac{s_A}{s_B} = \frac{12\rho_B}{8\rho_A} = \frac{3}{2} \times \frac{2000}{1500} = 2$$

11. C

$V \downarrow\ \Rightarrow$ Ice Changes to water

Let volume (V_{ice}) change to water

$(0.9\ \rho_w\ V_{ice})L = H$ ...(1)

$$\Delta v = v_{ice} - v_w = \left(v_{ice} - \frac{v_{ice}\ \rho_{ice}}{\rho_w}\right)$$

$= v_{ice}\ (1 - 0.9) = 0.1\ v_{ice} = 1\ cm^3$

$v_{ice} = 10\ cm^3$

So from eq. (1) $[0.9 \times 1 \times 10] \times 80 = H$

H = 720 cal.

12. A

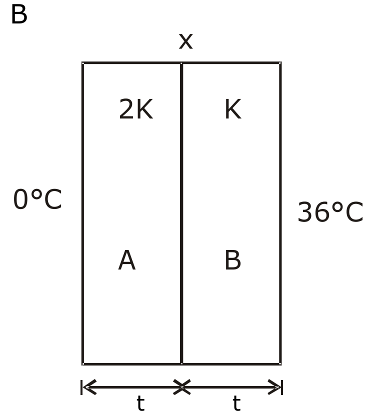
Let m is the mass

$mL_v + ms_w\ (100 - 80) = (1.1 + 0.02)s_w(80 - 15)$

$m(540 + 20) = (1.12)\ 65$

m = 0.130 kg

13. B



$$\frac{d\theta_A}{dt} = \frac{d\theta_B}{dt}$$

$$2KA\left(\frac{x - 0}{t}\right) = KA\left(\frac{36 - x}{t}\right)$$

x = 12°C

14. (a) A (b) D

$i_{net} = i_{A\ell} + i_{cu}$

$$= K_{A\ell} A\left(\frac{100-20}{3\times10^{-2}}\right) + K_{Cu}\,A\,\frac{100-20}{3\times10^{-2}}$$

$$= (209 + 385)\,(3 \times 10^{-2}) = \frac{80}{3\times10^{-2}}$$

$= 1.43 \times 10^{3}$ N

(b) $\frac{K_{cu}}{K_{A\ell}} = \frac{385}{209} = 1.84$

15. B

in (a) $\frac{dQ}{dt} = \frac{10}{2}$ cal/min = $AK\left(\frac{100-0}{29}\right)$ ..(1)

in (b) $\frac{d\theta'}{dt}$ = (2A) K $\left(\frac{100-0}{a}\right)$ ...(2)

so 10 = $\frac{d\theta'}{dt}.t$ = 2 × 10 × t

t = 0.5 min

16. B

$$\frac{1}{R_{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)3$$

$$\Rightarrow \frac{K_{eq}(6A)}{d} = 3\left(\frac{k_1A}{d} + \frac{k_2A}{d}\right)$$

$$K_{eq} = \frac{K_1 + K_2}{2}$$

17. A

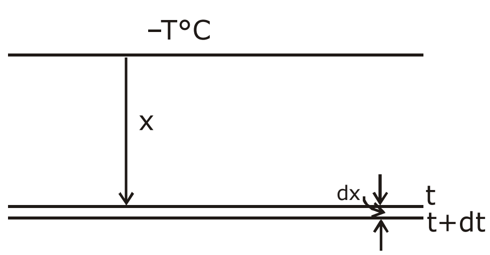
$$i_p = K_{steel}A.\frac{dT}{dx} = \frac{m}{t}.\,L_v$$

$$50.2 \times 0.15 \times \frac{(x-100)}{1.2\times10^{-2}}$$

$$= \frac{0.44}{5\times60}\times2.25\times10^{6}$$

x = 105.25°C

18. C



$$i_t = \frac{KAT}{x} = \frac{dx\,A\,\rho_{ice}}{dt}.L_f$$

$$\Rightarrow KAT\int_0^{3600} dt = A\rho_{ice}L\int_2^4 x\,dx$$

T = 30°C

19. C

$$i = \frac{dm}{dt}.\,L_f = KA\left(\frac{20-0}{2.35}\right)$$

$$\frac{dm}{dt} = 2.4\,\pi\times10^{-6}$$

20. A

$$i = K(\pi R^2)\frac{dT}{dx}, \qquad i \propto \frac{R^2}{\ell}$$

21. C

$R_1 \,||\, R_2$ – Resistances

$A_1 = \pi R^2 \quad A_2 = \pi 4R^2 - \pi R^2 = 3\pi R^2$

Now $R_{eq} = \frac{R_1R_2}{R_1 + R_2} \quad \Rightarrow \frac{\ell}{K_1 4\pi R^2}\times\frac{\ell}{K_2 3\pi R^2}$

$$\frac{1}{\pi R^2}\left[\frac{1}{K_1} + \frac{1}{3K_2}\right] = \frac{\ell}{K_{eq}(\pi 4R^2)}$$

$$\frac{1}{4K_{eq}} = \frac{1}{3k_2 + k_2} \Rightarrow k_{eq} = \frac{1}{4}(k_1 + 3k_2)$$

22. B

i = – kAdT / dx

And slope dT/dx = – i/kA

i is constant (steady state), A is cons, but since k is decreasing from 2k to k, hence slope is –ve but less – ve to more –ve.

23. A

$$i_1 = i_2 \Rightarrow k_1A\frac{T_B - T_A}{d} = \frac{k_2A(T_c - T_B)}{2d}$$

$$\frac{k_1}{k_2} = \frac{T_C - T_B}{2(T_B - T_{A)}} = \frac{1}{2}\left(\frac{4T_A - 2T_A}{2T_A - T_A}\right) = 1$$

24. D

$$i = kA\frac{dT}{dx}$$

$\frac{dT}{dx}\ \alpha\ \frac{1}{K} \qquad \therefore$ i and A same

i = – kA (dT/dx)

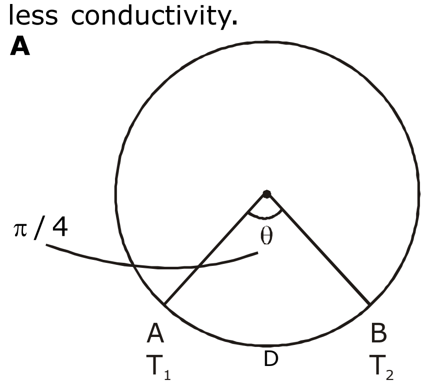
i and A are constant hence slope

dT/dx = –i/(kA) is – ve but

Slope α (1/k)

Hence in air slope will be more – ve due to very less conductivity.

25. A



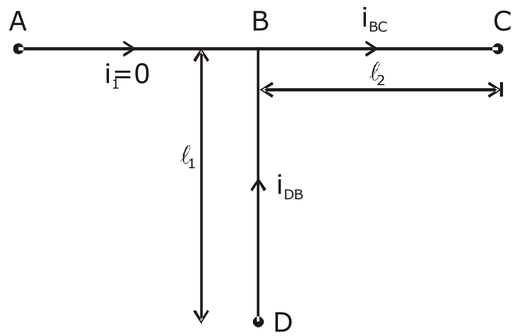
Initially

$$H = \frac{kA(T_2 - T_1)}{(2\pi - \theta)R} + \frac{kA(T_2 - T_1)}{\theta R} \quad ...(1)$$

finally
$$2H = \frac{kA(T_2 - T_1)}{(2\pi - \theta)R} + \frac{k'A(T_2 - T_1)}{\theta R} \quad ...(2)$$

from (1) & (2) $\quad k' = \frac{4k}{3} + k = \frac{7k}{3}$

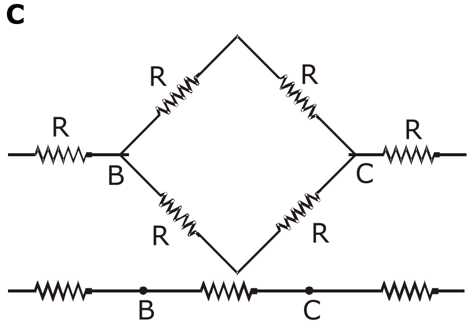
26. B



$$i_{BD} = i_{DB} \Rightarrow \frac{kA(90-20)}{\ell_1} = \frac{kA(20-0)}{\ell_2}$$

$$\frac{\ell_1}{\ell_2} = \frac{7}{2}$$

27. C



$$T_C - 20 = T_B - T_C = \frac{200-20}{3} = 60$$

$T_C = 80$

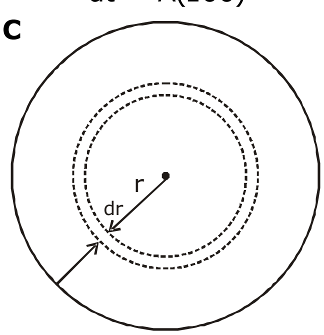
So $T_B = 80 + 60 = 140$ °C

28. B

$$i = \frac{dm_{ice}}{dt} \cdot L_f = \frac{kA(100)}{\ell}$$

$$k = \frac{dm_{ice}}{dt} \cdot \frac{\ell L_f}{A(100)} = 60\ Wm^{-1}\ k^{-1}$$

29. C



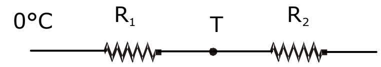
$$\int dR = \int_{r_1}^{r_2} \frac{dr}{k(4\pi r^2)}$$

$$R_{eq} = \frac{1}{4\pi k}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

Now R_1 (when $r_1 = R$, $r_2 = 2R$) $= \frac{1}{8\pi kR}$

and R_2 (when $r_1 = 2R$, $r_2 = 3R$) $= \frac{1}{4\pi kR}\left[\frac{1}{2} - \frac{1}{3}\right]$

$$= \frac{1}{24\pi kR}$$



$$T = \frac{R_1}{R_1 + R_2} \times 100 = 75° \text{ C}$$

Since

$i = (T - 0) / R, = (100 - 0) / (R_1 + R_2)$

30. C

$i = -kA\ dT / dx$

Slope $dT/dx = - i/kA$ is – ve but due to radiation loss because of not lagged, as we move ahead current i will be less. Hence slope wil be more – ve to less – ve.

31. A

$$T_p = \frac{100+0}{2} = 50°$$

P to Q

$$T_Q = \frac{30+60}{2} = 45°$$

32. A

Slope $dT/dX = - i/kA$ is less – ve for 1st layer

Hence 1st layer should have larger k.

So $k_1 > k_2$

33. A

$$R_A = \frac{\ell_1}{k_1 A} \qquad R_B = \frac{2\ell_1}{\frac{k_1}{2}A}$$

So $\quad \theta = \left[\frac{R_B}{R_A + R_B}\right][100 - 0]$

$\theta = 80°$ C

34. A

$$R_A = \frac{\ell}{3kA} \qquad R_B = \frac{\ell}{kA}$$

$$\frac{R_A}{R_B} = \frac{1}{3}$$

35. B

$$i = \frac{3k_A T_A}{\ell} = \frac{kAT_B}{\ell} \qquad \frac{T_A}{T_B} = \frac{1}{3}$$

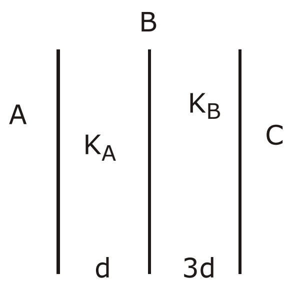
36. B

$$i_A = i_B \Rightarrow 3kA\left(\frac{dT}{dx}\right)_A = kA\left(\frac{dT}{dx}\right)_B$$

$$3kAG_A = kAG_B$$

$$\frac{G_A}{G_B} = \frac{1}{3}$$

37. A



38. C

Initially $i = \frac{dm}{dt}.L_f = k\pi R^2.\frac{100}{\ell}$

$$\frac{dm}{dt} \propto \frac{kR^2}{\ell}$$

$$\frac{\frac{dm_2}{dt}}{\frac{dm_1}{dt}} = \frac{\frac{k}{4}\left(\frac{(2R)^2}{\ell/2}\right)}{\frac{kR^2}{\ell}}$$

$$\frac{\frac{dm_2}{dt}}{0.1} = 2 \Rightarrow \frac{dm_2}{dt} = 0.2$$

39. A

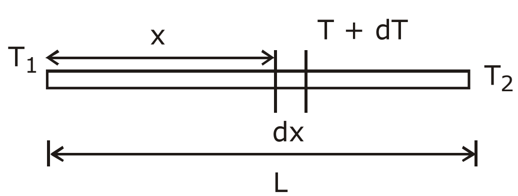
$$R_{eq} = R_1 + R_2 + R_3$$

$$\frac{3\ell}{k_{eq}A} = \frac{\ell}{\frac{k}{2}A} + \frac{\ell}{5kA} + \frac{\ell}{kA}$$

$$\frac{3}{k_{eq}A} = \frac{2}{k} + \frac{1}{5k} + \frac{1}{k} = \frac{16}{5k}$$

$$k_{eq} = \frac{15}{16}k$$

40. A



$$i = \frac{\alpha}{T}A\frac{dT}{dx} = C \text{ (const.)}$$

$$\Rightarrow \alpha A[\ell nT]_{T_1}^{T} = Cx$$

$$\alpha\ell n\left(\frac{T}{T_1}\right) = \left(\frac{C}{A}\right)x$$

at $x = L, T = T_2 \Rightarrow \frac{C}{A} = \frac{\alpha}{L}\ln\frac{T_2}{T_1}$

So $T = T_1\left(\frac{T_2}{T_1}\right)^{x/L}$

41. B

$$\text{Req.} = \frac{1}{4\pi k}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

Let at R then

$$\frac{1}{R_1} - \frac{1}{R} = \frac{1}{R} - \frac{1}{R_2}$$

$$R = \frac{2R_1R_2}{R_1 + R_2}$$

42 A

Req is same so $i_1 = i_2$

43. D

$$i = ms\frac{d\theta}{dt} = msk\,(50° – 20°) = 10 \text{ W} \quad ..(1)$$

and $\frac{35.1 - 34.9}{60} = k\,(35 – 20) \quad ...(2)$

from (1) & (2)

$$\frac{0.2}{60} = \frac{10}{ms(30)} \times 15$$

ms = 1500 J/°C

44. B

Let at time t radius r

Then $\frac{dQ}{dt} = CA = 4C\pi r^2 = -\frac{dm}{dt}.L_f$

$m = \rho_{ice}\frac{4}{3}\pi r^3 \Rightarrow dm = C_0 r^2\, dr$

So. $(4C\pi)\, r^2 = -L_f C_0 r^2 \frac{dr}{dt}$

$$\Rightarrow \frac{dr}{dt} = \text{const}$$

45. D

Power

$$P = \frac{dQ}{dt} = A\sigma T^4 = A\sigma\left(\frac{b}{\lambda}\right)^4$$

$$\frac{P_2}{P_1} = \left(\frac{\lambda_1}{\lambda_2}\right)^4 = \left(\frac{\lambda_0}{3/4\,\lambda_0}\right)^4 = \frac{256}{81}$$

46. B

Let $I = \frac{P'}{4\pi d^2}$ or $I = \frac{e\sigma AT^4}{4\pi d^2}$

and I A_f = P (Given)

Now $P_{new} = I_{new} A_f = \frac{e\sigma A(2T)^4}{4\pi(2d)^2}.A_f$

$= \frac{16}{4}\left[\frac{e\sigma AT^4}{4\pi d^2}.A_f\right] = \frac{16}{4}P$

47. A

$\lambda_{max} \propto \frac{1}{T}$

$\frac{\lambda_{1\,max}}{\lambda_{2\,max}} = \frac{T_2}{T_1}$

$\Rightarrow \frac{T_2}{T_1} = \frac{3}{4}$

48. C

$-\frac{dT_p}{dt} = x\left(-\frac{dT_Q}{dt}\right)$

$\Rightarrow \frac{eA_p\sigma(T^4 - T_0^4)}{m_pS} = \frac{xe\sigma A_Q(T^4 - T_0^4)}{m_QS}$

$\Rightarrow x = \frac{A_pm_Q}{A_Qm_p} = \left(\frac{r}{3r}\right)^2 \times \left(\frac{3r}{r}\right)^3$

$\Rightarrow x = 3$

49. B

Initially T increases then phase change and so on

50. D

Area = $\int ydx = \int \frac{dE}{d\lambda} \times d\lambda = \int dE$

Area (A) = E = $\sigma T^4 = \sigma\left(\frac{b}{\lambda}\right)^4$

$\frac{Area_1}{Area_2} = \left(\frac{\lambda_2}{\lambda_1}\right)^4 \Rightarrow \frac{1}{9} = \left(\frac{\lambda_2}{\lambda_1}\right)^4$

$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{3}$

51. B

$\frac{T_S}{T_{NS}} = \frac{\lambda_{NS_{max}}}{\lambda_{S_{max}}} = \frac{350}{510} = 0.69$

52. B

$E_P = E_P\,\sigma\,(A)\,Q_P^4 = E_Q = E_Q\,\sigma A\,Q_Q^4$

$\left(\frac{E_Q}{E_p}\right)^{1/4} Q_Q = Q_p$

53. B

$\frac{60-50}{4} = k\left(\frac{60+50}{2} - Q_0\right)$

$\frac{5}{2} = k\,(55 - \theta_0)$ ...(1)

and $\frac{40-30}{8} = k\left(\frac{40+30}{2} - \theta_0\right)$

$\frac{5}{4} = k(35 - \theta_0)$ ..(2)

from (1) & (2)

$2 = \frac{55-\theta_0}{35-\theta_0}$

$\theta_0 = 70 - 55 = 15°C$

54. A

$E_{273} = eA\,(273 + 273)^4$
= E(Given)

$E_0 = eA\,(273 + 0)^4$

$E_0 = \frac{E}{16}$

55. A

$\frac{75-65}{5} = k\left(\frac{75+65}{2} - 25\right)$

$2 = K(70 - 25) \Rightarrow K = \frac{2}{45}$

Now $\frac{65-x}{5} = k\left(\frac{65+x}{2} - 2.5\right)$

$2\,(65 - x) = 5k\,(65 + x - 50)$

$130 - 2x = 5 \times \frac{2}{45}\,(15 + x)$

x = 57°c

56. C

$\frac{40-36}{5} = k\left(\frac{40+36}{2} - 16\right)$

$\frac{4}{5} = K(38 - 16)$

$\Rightarrow k = \frac{2}{55}$ ..(1)

$\frac{36-32}{t} = \frac{2}{55}\left(\frac{36+32}{2} - 16\right)$

$\frac{2 \times 55}{t} = (34 - 16)$

t = 6.1 mm