Solutions

S1. Ans.(d)

$E = P \times t = 100 \times 10^3 \times 3600$

$36 \times 10^7\ J$

S2. Ans.(a)

$\frac{dT}{dt} = K(T_{av} - T_0)$

$\frac{10}{t} = K(85 - 20)$

$\frac{20}{t\prime} = K(70 - 20)$

$\frac{t\prime}{2t} = \frac{65}{50}$

$t' = \frac{13}{5}t$

S3. Ans.(d)

$\Delta Q = ms\Delta T$

s is same for same material

Since, $\Delta Q \propto m$ and $m = \frac{4}{3}\pi r^3 p$

$\Delta Q \propto r^3$

$\frac{\Delta Q_1}{\Delta Q_2} = \left(\frac{r_1}{r_2}\right)^3 = \left(\frac{1.5}{1}\right)^3 = \frac{27}{8}$

S4. Ans.(a)

Entire system is thermally insulated. So, no heat exchange will take place. Hence process will be adiabatic.

S5. Ans.(d)

$\alpha_{Cu}L_{Cu} = \alpha_{Al}L_{Al}$

$1.7 \times 10^{-5} \times 88\ cm = 2.2 \times 10^{-5} \times L_{Al}$

$L_{Al} = \frac{1.7\times 88}{2.2} = 68\ cm$

S6. Ans.(d)

$\frac{dH}{dt} = \frac{KA}{l}\Delta T$ (K = coefficient of thermal conductivity)

$\therefore K = \frac{l dH}{A\ dt\ \Delta T}$

Unit of $K = Wm^{-1}K^{-1}$

S7. Ans.(a)

As $\lambda T =$ const. (wien's law)

$T_1 = \frac{C}{\lambda_0}, T_2 = \frac{4C}{3\lambda_0}$ (C is constant)

Power radiated (P) $\propto T^4$

$P_1 = \frac{C^4}{\lambda_0^4}$

$P_2 = \frac{256C^4}{81\lambda_0^4} = nP_1$

Comparing $n = \frac{256}{81}$

S8. Ans.(d)

Thermal resistance $(R) = \frac{l}{kA}$

Rods are in parallel combination

$R_{eq} = \frac{R_1R_2}{R_1+R_2}$

$\frac{l}{K_{eq}(2A)} = \frac{\frac{l}{K_1A}\cdot\frac{l}{K_2A}}{\frac{l}{K_1A}+\frac{l}{K_2A}} = \frac{\frac{1}{K_1K_2}\frac{l}{A}}{\frac{1}{K_1}+\frac{1}{K_2}}$

$= \frac{\frac{1}{K_1K_2}\cdot\frac{l}{A}}{\frac{K_1+K_2}{K_1K_2}} = \frac{1}{(K_1+K_2)}\frac{l}{A}$

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

S9. Ans.(c)

Power radiated $= \sigma A\varepsilon_0 T^4$

$P \propto r^2T^4$

$\frac{P_1}{P_2} = \frac{r_1^2}{r_2^2}\left[\frac{T_1}{T_2}\right]^4$

$\frac{450}{P_2} = \frac{(12\times 10^{-2})^2}{\left(\frac{12}{2}\times 10^{-2}\right)} \times \left[\frac{500}{1000}\right]^4$

$P_2 = 1800\ W$

S10. Ans.(b)

Wien's displacement law

$\lambda.T = b \Rightarrow \lambda_1T_1 = \lambda_2T_2$

$12 \times 10^{-6} \times 200 = 4800 \times 10^{-10} \times T_2$

$T_2 = 5000\ K$

S11. Ans.(a)

Parallel combination of blocks

$C_{eq} = C_1 + C_2 + C_1 + C_2 + C_1 + C_2 = 3C_1 + 3C_2$

$\frac{K\varepsilon_0 6A}{d} = \frac{3K_1A\varepsilon_0}{d} + \frac{3A\varepsilon_0K_2}{d}$

$6K = 3K_1 + 3K_2$

$K = \frac{1}{2}[K_1 + K_2]$

S12. Ans.(d)

Let θ be the final common temperature. Further, let s_c and s_h be the average heat capacities of the cold and hot (initially) bodies respectively (where $s_c < s_h$ given).

From, principle of calorimetry, Heat lost = Heat gained

$s_h(100-\theta) = s_c\theta$

$\therefore \theta = \frac{s_h}{(s_h+s_c)} \times 100°C = \frac{100°C}{\left(1+\frac{s_c}{s_h}\right)}$

$\because \frac{s_c}{s_h} < 1$ $\quad \therefore 1 + \frac{s_c}{s_h} < 2$

$\therefore \theta > \frac{100°C}{2}$ or $\theta > 50°C$ or

Body at 100°C has more heat capacity then body at 0°C so final temperature must be greater than 50°C.

S13. Ans.(d)

$\Delta l_1 = \Delta l_2$

$l_1\alpha_1\Delta T = l_2\alpha_2\Delta T \Rightarrow l_1\alpha_1 = l_2\alpha_2$

S14. Ans.(d)

Maximum amount of emitted radiation corresponding to $\lambda_m = \frac{b}{T}$

$\lambda_m = \frac{2.88\times10^6 nmk}{5760k} = 500\ nm$

$\therefore$ U is maximum at 500 nm.

Hence, $U_2 > U_1$

S15. Ans.(c)

$\frac{\Delta Q}{\Delta t} = \frac{KA\Delta T}{l}$

If $\Delta T = 110 - 100 = 10°C$

$4 = \frac{KA[110-100]}{l}$

If $\Delta T = 210 - 200 = 10°C$

$\frac{\Delta Q}{\Delta t} = \frac{kA[210-200]}{l} \Rightarrow \frac{\Delta Q}{\Delta t} = 4\ J/s$

S16. Ans.(c)

$V = V_0(1+\gamma\Delta T)$ (volumetric expansion)

$\frac{M}{d} = \frac{M}{d_0}(1+\gamma\Delta T)$

$d = d_0(1+\gamma\Delta T) \quad \Rightarrow d = d_0 + d_0\gamma\Delta T$

$d_0\gamma\Delta T = d - d_0 \quad \Rightarrow \frac{d-d_0}{d_0} = \gamma\Delta T$

Fractional change

$= \frac{\Delta d}{d_0} = 5\times10^{-4}\times40 = 0.020$

S17. Ans.(a)

According to Newton's law of cooling

$\frac{\theta_1-\theta_2}{t} = k\left[\frac{\theta_1+\theta_2}{2} - \theta_0\right]$

$\Rightarrow \frac{70-60}{5} = k\left[\frac{70+60}{2} - \theta_0\right]$

$2 = k[65-\theta_0]$ ...(i)

and $\frac{60-54}{5} = k\left[\frac{60+54}{2} - \theta_0\right]$

$\Rightarrow \frac{6}{5} = k[57-\theta_0]$ ...(ii)

By dividing Eqs. (i) by (ii) we have

$\frac{10}{6} = \frac{65-\theta_0}{57-\theta_0} \Rightarrow \theta_0 = 45°C$

S18. Ans.(d)

Heat lost = Heat gained

$mL_v + ms_w\Delta\theta_1 = m_W s_W\Delta\theta_2$

$\Rightarrow m\times540 + m\times1\times(100-80)$

$= 20\times1\times(80-10)$

$\Rightarrow m = 2.5$ g

Total mass of water $= (20+2.5)g = 22.5g$

S19. Ans.(c)

We can explain this observation by using wien's displacement law, $\lambda_m T = b$ Where b is Wien's displacement constant.