Chapter 11

11.1 (d)

11.2 (b)

11.3 (b)

11.4 (a)

11.5 (a)

11.6 (a)

11.7 (d)

Original volume $V_0 = \frac{4}{3}\pi R^3$

Coeff of linear expansion = α

$\therefore$ Coeff of volume expansion $\simeq 3\alpha$

$$\therefore \frac{1}{V}\frac{dV}{dT} = 3\alpha$$

$$\Rightarrow dV = 3V\alpha dT \simeq 4\pi R^3 \alpha \Delta T$$

11.8 (c)

11.9 (b), (d)

11.10 (b)

11.11 (a), (d)

11.12 (b), (c), (d)

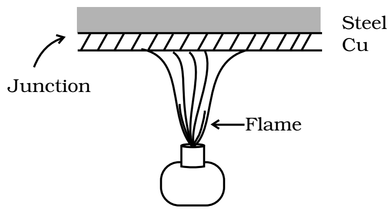
11.13 Diathermic

11.14 2 and 3 are wrong, 4th is correct.

11.15 Due to difference in conductivity, metals having high conductivity compared to wood. On touch with a finger, heat from the surrounding flows faster to the finger from metals and so one feels the heat. Similarly, when one touches a cold metal the heat from the finger flows away to the surroundings faster.

11.16 $-40^\circ\text{C} = -40^\circ\text{F}$

11.17 Since Cu has a high conductivity compard to steel, the junction of Cu and steel gets heated quickly but steel does not conduct as quickly, thereby allowing food inside to get heated uniformly.



11.18 $I = \frac{1}{12} Ml^2$

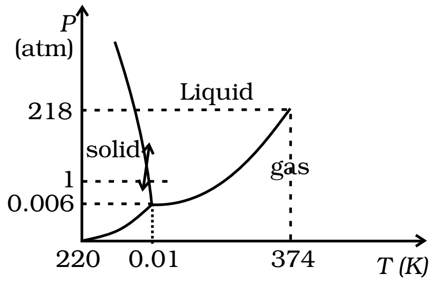
$$I' = \frac{1}{12} M(l + \Delta l)^2 = \frac{1}{12} Ml^2 + \frac{1}{12} 2Ml\Delta l + \frac{1}{12} M(\Delta l)^2 \alpha$$

$$\approx I + \frac{1}{12} Ml^2 2\alpha \Delta T$$

$$= I + 2I\alpha\Delta T$$

$$\therefore \Delta I = 2\alpha I \Delta T$$

11.19 Refer to the P.T diagram of water and double headed arrow. Increasing pressure at 0°C and 1 atm takes ice into liquid state and decreasing pressure in liquid state at 0°C and 1 atm takes water to ice state.



When crushed ice is squeezed, some of it melts. filling up gap between ice flakes. Upon releasing pressure, this water freezes binding all ice flakes making the ball more stable.

11.20 Resultant mixture reaches 0°C. 12.5 g of ice and rest is water.

11.21 The first option would have kept water warmer because according to Newton's law of cooling, the rate of loss of heat is directly proportional to the difference of temperature of the body and the surrounding and in the first case the temperature difference is less, so rate of loss of heat will be less.

11.22 $l_{iron} - l_{brass}, = 10\text{cm}$ at all tempertature

$$\therefore l^\circ_{iron}(1 + \alpha_{iron}\Delta t) - l^\circ_{brass}(1 + \alpha_{brass}\Delta t) = 10\text{cm}$$

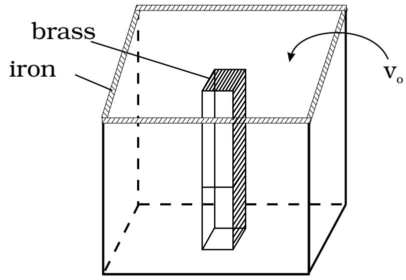
$$l^\circ_{iron}\, \alpha_{iron} = l^\circ_{brass}\, \alpha_{brass}$$

$$\therefore \frac{l^\circ_{iron}}{l^\circ_{brass}} = \frac{1.8}{1.2} = \frac{3}{2}$$

$$\therefore \frac{1}{2} l^\circ_{brass} = 10\text{cm} \Rightarrow l^\circ_{brass} = 20 \text{ cm}$$

and $l^\circ_{iron} = 30$ cm

11.23 Iron vessel with a brass rod inside



$$\frac{V_{iron}}{V_{brass}} = \frac{6}{3.55}$$

$$V_{iron} - V_{brass} = 100\text{cc} = V_o$$

$$V_{brass}^{rod} = 144.9\,\text{cc} \quad V_{iron}^{inside} = 244.9\,\text{cc}$$

11.24 Stress = K × strain

$$= K\frac{\Delta V}{V}$$

$$= K(3\alpha)\Delta t$$

$$= 140 \times 10^9 \times 3 \times 1.7 \times 10^{-5} \times 20$$

$$= 1.428 \times 10^8\,\text{N/m}^2$$

This is about 10^3 times atmospheric pressure.

11.25 $$x = \sqrt{\left(\frac{L}{2} + \frac{\Delta L}{2}\right)^2 - \left(\frac{L}{2}\right)^2}$$

$$\approx \frac{1}{2}\sqrt{2L\ \Delta L}$$

$$\Delta L = \alpha L\ \ \Delta t$$

$$\therefore x \approx \frac{L}{2}\sqrt{2\alpha\ \Delta t}$$

$$\approx 0.11\text{m} \rightarrow 11\text{cm}$$

11.26 **Method I**

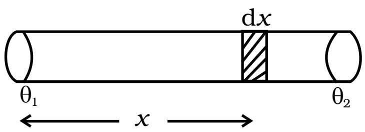
Temperature θ at a distance x from one and (that at θ_1) is given by

$\theta = \theta_1 + \frac{x}{L_o}(\theta_2 - \theta_1)$: linear temperature gradient.

New length of small element of length dx_0

$$dx = dx_o(1 + \alpha\theta)$$

$$= dx_o + dx_o\alpha\left[\theta_1 + \frac{x}{L_o}(\theta_2 - \theta_1)\right]$$



Now $\int dx_o = L_o$ and $\int dx = L$: new length

Integrating

$$\therefore L = L_o + L_o \alpha \theta_1 + \frac{(\theta_2 - \theta_1)}{L_o} \alpha \int x \ \ dx_o$$

$$= L_o\left(1 + \frac{1}{2}\alpha(\theta_2 + \theta_1)\right) \text{as} \int_0^{L_0} x dx = \frac{1}{2} L_0^2$$

Method II

If temperature of the rod varies linearly, we can assume average temperature to be $\frac{1}{2}(\theta_1 + \theta_2)$ and hence new length

$$L = L_o\left(1 + \frac{1}{2}\alpha(\theta_2 + \theta_1)\right)$$

11.27 (i) 1.8×10^{17} J/S (ii) 7×10^9 kg

(iii) 47.7 N/m^2.