

SOLUTIONS

Module - 3 / JEE-2022

IN-CHAPTER EXERCISES	Physics	Properties of Matter
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EXERCISE-A

1. AB : Melting at constant temperature (melting point)

CD : Vaporisation at boiling point.

$$CD = 2 AB \Rightarrow L_{\text{vap.}} = 2 L_{\text{Fusion}}$$

Slope $\frac{dT}{dQ}$ is inversely proportional to specific heat.

Slope $(OA) > \text{Slope}(BC) \Rightarrow$ Thermal capacity in liq. state (BC) is greater than that in solid state (OA) .

2. Let m = mass of ice.

$$\text{Heat taken by ice} = \text{Heat taken by water} \Rightarrow m \cdot L_{\text{ice}} = (50 - m) L_{\text{vap.}} \Rightarrow m = \frac{300}{7} \text{ gm}$$

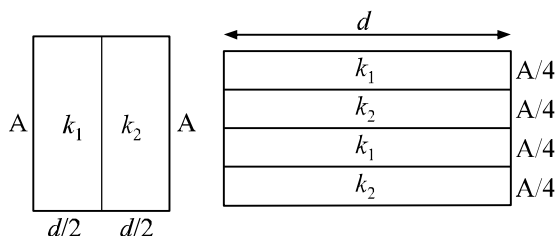
3. Capacity = $\frac{(1000 \times 10^3 \text{ g}) \times (80 \times 4.2 \text{ J/g})}{24 \times 3600} = \frac{35}{9} \text{ kW}$

4. $\theta = \frac{\Delta L}{L\alpha} = \frac{5 \times 10^{-4}}{1(13.22 \times 10^{-6})} = 37.8^\circ\text{C}$

5. Diff. = $\frac{1}{2} (\alpha_1 - \alpha_2) \times \theta \times 86400 = 6.9 \text{ sec.}$

6. $H = \frac{A \cdot \Delta\theta}{\frac{d}{2k_1} + \frac{d}{2k_2}} ; H' = \frac{A(2k_1 + 2k_2)}{4d} \Delta\theta$

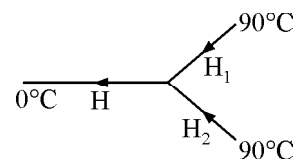
$$\Rightarrow k = \frac{2k_1 k_2}{k_1 + k_2} ; k' = \frac{k_1 + k_2}{2} \Rightarrow k' > k$$



- 7.(C) Mass of water = $2 L \times 1 \text{ kg/L} = 2 \text{ kg}$

$$\text{Heat required} = ms \Delta\theta = 2 \times (4 \cdot 2 \times 10^3) \times 50 \text{ J} = 420 \text{ kJ}$$

$$\text{Time taken} = \frac{\text{Heat req.}}{\text{Net rate of heat input}} = \frac{420 \text{ kJ}}{(1 - 0.16) \text{ kW}} = 500 \text{ s} = 8 \text{ min } 20 \text{ s}$$



- 8.(B) $H = H_1 + H_2$

$$\frac{kA(\theta - 0)}{\ell} = \frac{kA(90 - \theta)}{\ell} + \frac{kA(90 - \theta)}{\ell}$$

$$\Rightarrow \theta = 60^\circ\text{C}$$

- 9.(D) Convection involves bulk transfer of different parts of the fluid. In a bulb, the glass and the filament are very close and convection doesn't play a major role.

The main phenomenon responsible for heating the glass is radiation. Due to the high temperature of filament, the heat radiated per second is very high and the glass receives most of the heat by radiation.

10.(C) $x\phi = x(1 + a_1q)$, $y\phi = y(1 + a_2q)$, $z\phi = z(1 + a_3q)$

Find volume $= x'y'z' = xyz(1 + \alpha_1\theta)(1 + \alpha_2\theta)(1 + \alpha_3\theta)$

$$= xyz[1 + (\alpha_1 + \alpha_2 + \alpha_3)\theta]$$

(Neglecting $\alpha_1\alpha_2$ and α_2^2) $\Rightarrow V' = V[1 + (\alpha_1 + 2\alpha_2)\theta]$; $\gamma = \alpha_1 + 2\alpha_2$

EXERCISE-B

1. Heat per sec $= \sigma(4\pi r^2)(T^4 - T_0^4) = 5.67 \times 10^{-8} \times 4\pi(0.02)^2 [(400)^4 - (373)^4] W = 1.78 W$

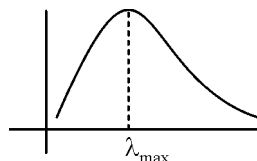
[Rate of energy supplied should equal the rate of heat loss to maintain const. T]

2.(B) By Wien's law, $\lambda_{\max} T = \text{const.}$

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

$\lambda_{\max}$ is greatest for T_2 and least for T_1 .

$$\Rightarrow T_1 > T_3 > T_2$$



3.(A) As the temperature rises, $\lambda_{\max}$ shifts (downwards) towards visible region and later includes all wavelengths of visible region glowing bright white color.

4. (A) See the article "Growth of ice on the lake surface".

$A \longrightarrow R, S$

(B) In convection, molecular movement takes place which is not possible in solids.

$B \longrightarrow Q$

(C) The lower layers of liquid get lighter due to heating and hence rise upwards.

These convection currents lead to uniform heating.

$C \longrightarrow P, Q$

(D) Winds flow from high temperature over water at night towards lower temperature over land. This is again an example of convection.

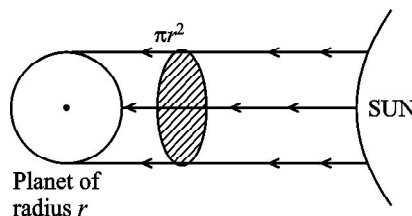
$D \longrightarrow P, Q$

5.(C) P = energy per sec radiated by SUN.

Heat received per sec by planet $= \frac{P}{4\pi d^2} (\pi r^2)$

Heat cost per sec $= \sigma A T^4$

$$\Rightarrow T^4 \propto \frac{1}{d^2} \Rightarrow T \propto d^{-1/2}$$



6.(D) Heat radiated per sec at 50°C = power supplied by heater = 10 W

By Newton's Law of cooling $\Rightarrow \text{Rate of cooling} = \frac{10}{c} \propto (50 - 20) \dots (i)$

After heater is switched off,

Rate of cooling $= \frac{35.1 - 34.9}{60} \Rightarrow \frac{0.2}{60} \propto (35 - 20) \dots (ii)$

Divide (ii) by (i), ; $\frac{0.2}{60} \times \frac{c}{10} = \frac{15}{30} \Rightarrow c = 1500 \text{ J/}^\circ\text{C}$

EXERCISE-C

1. (A) $F_{\max} = \text{Stress} \times A = (7.8 \times 10^8) \times (0.001)^2 \pi = 2449.2 \text{ N}$

(B) $\Delta \ell = \frac{F \ell}{AY} = \frac{70 \text{ g} \times 40}{\pi (0.001)^2 \times 2.6 \times 10^{11}} = 4.04 \text{ cm}$

(C) $\text{Stress} = \frac{F}{A} = \frac{70 \text{ g}}{\pi (0.001)^2} < \text{Elastic limit}$

2. $\Delta(\Delta \ell) = \frac{\Delta F \cdot \ell}{AY} \Rightarrow Y = \frac{(5 - 3) \text{ g} \times 1}{0.4 \times 10^{-4} \times (1.20 - 0.61) \times 10^{-3}} = 12.26 \times 10^8 \text{ N/m}^2$

$$W = U_f - U_i = \frac{1}{2} F_2 \Delta \ell_2 - \frac{1}{2} F_1 \Delta \ell_1 = \frac{1}{2} \times (5 \times 9.8) (1.02 \times 10^{-3}) - \frac{1}{2} (3 \times 9.8) (0.61 \times 10^{-3})$$

$$= 1.635 \times 10^{-2} \text{ J}$$

3. $T_A = T_C \Rightarrow 2T_A + T_B = 100 \text{ g}$

$$\Delta \ell = \frac{T_A \cdot \ell}{AY_A} = \frac{T_B \cdot \ell}{AY_B} \Rightarrow \frac{T_A}{T_B} = \frac{Y_A}{Y_B} = \frac{2}{1.5} = \frac{4}{3}$$

$\Rightarrow T_A = T_C = 356.36 \text{ N}; T_B = 267.27 \text{ N}$

$$\Delta \ell = \frac{T_A \ell}{AY_A} = \frac{356.36 \times 1}{10^{-6} \times 2 \times 10^{11}} = 1.78 \times 10^{-3} \text{ m}$$

4. $\Delta \ell = \ell' - \ell = (5.21 - 0.2) - 5 = 0.01 \text{ m}; R = 5.21 - 0.1 = 5.11 \text{ m}$

$$T_{\text{bottom}} - mg = \frac{mv^2}{R} \Rightarrow T_{\text{bottom}} = mg + \frac{mv^2}{R} \quad \text{and} \quad T_{\text{bottom}} = \frac{AY \Delta \ell}{\ell}$$

$$T_{\text{bottom}} = \frac{\pi (0.05 \times 10^{-2})^2 \times 2 \times 10^{11} \times (1 \times 10^{-2})}{5} = mg + \frac{mv^2}{R} \Rightarrow v = 3.71 \text{ ms}^{-1}$$

5. $P = z\omega \Rightarrow z = \frac{10^3}{2\pi(240/60)} = \frac{\pi \eta r^4 \theta}{2\ell}; \text{Solve to get } \eta = 1.6 \times 10^{10} \text{ N/m}^2$

6.(C) See Illustrations in section - 5

7.(D) $\text{Total Energy} = \frac{1}{2} F \Delta \ell = \frac{1}{2} F \left(\frac{F \ell}{aY} \right)$

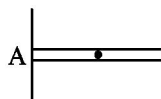
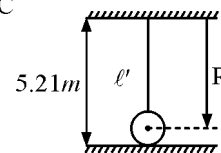
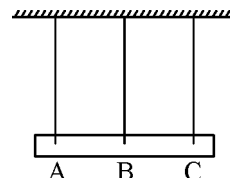
8.(C) Apply $F = YA \alpha \Delta \theta$ as derived in illustration - 37 in section - 5

9.(A) $\text{Energy density} = \frac{1}{2} \cdot \text{stress} \cdot \text{strain} = \frac{1}{2} Y (\text{strain})^2 = \frac{1}{2} \times 2 \times 10^{10} \left(\frac{0.06}{100} \right)^2 = 3600 \text{ J/m}^3$

10.(A) $u = \frac{\text{Energy}}{\text{Volume}} = \frac{1}{2} \text{stress} \times \text{strain} = \frac{(\text{stress})^2}{2Y}$

$$T_A = m\omega^2 \frac{\ell}{2} \quad T_C = \frac{m}{2} \omega^2 \left(\frac{3\ell}{4} \right)$$

$$\frac{u_A}{u_{\text{centre}}} = \left(\frac{T_A}{T_C} \right)^2 = \frac{\frac{1}{4}}{\frac{9}{16}} = \frac{16}{9}$$



MISCELLANEOUS EXERCISE

1.(C) DC is constant $DC^2 = \left[\ell (1 + \alpha_2 \Delta t) \right]^2 - \left[\frac{\ell (1 + \alpha_1 \Delta t)}{2} \right]^2$ is independent of α_1, α_2

$$= \ell^2 (1 + 2\alpha_2 \Delta t) - \frac{\ell^2}{4} (1 + 2\alpha_1 \Delta t)$$

For DC to be independent of Δt ,

$$2\ell^2 \alpha_2 \Delta t - \frac{2\ell^2}{4} \alpha_1 \Delta t = 0 \quad \Rightarrow \quad \alpha_2 = \frac{\alpha_1}{4}$$

2.(A) $v\rho g = Vdg \Rightarrow f = \frac{v}{V} = \frac{d}{\rho}$

$$f_1 \rho_1 = f_2 \rho_2 \quad \Rightarrow \quad \frac{f_1}{1 + \gamma t_1} = \frac{f_2}{1 + \gamma t_2}$$

$$\frac{f_1}{1 + t_1 \gamma} = \frac{f_2}{1 + t_2 \gamma} \quad \text{Solve for } \gamma.$$

3.(B) $V_t = V_0 (1 + 3\alpha_g T)$ [vol of bulb]

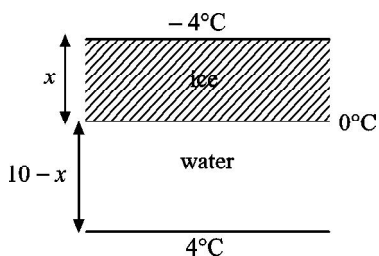
$V'_t = V_0 (1 + \gamma_m T)$ [vol of mercury]

Increase in volume of mercury $= V_0 (1 + \gamma_m T - 1 - 3\alpha_g T) = V_0 (\gamma_m T - 3\alpha_g T) = V_0 (\gamma_m - 3\alpha_g) T$

$$\ell AT = V_0 (\gamma_m - 3\alpha_g) T \quad \ell = \frac{V_0 (\gamma_m - 3\alpha_g)}{A_0 (1 + 2\alpha_g T)}$$

4.(A) At maximum thickness,

$$\frac{K_i A [0 - (-4)]}{x} = \frac{K_w A (4 - 0)}{10 - x}$$



5.(A) $PV = \text{constant} \Rightarrow PdV + VdP = 0 \Rightarrow B = \frac{-dP}{dV/V} = P$

$$x = 7.5 \text{ m.}$$

6.(C) In equilibrium condition,

$$2 \times \sigma A x^4 = \sigma A (2T)^4 + \sigma A T^4$$

$$x^4 = \left(\frac{2^4 + 1}{2} \right) T^4 \Rightarrow x = \left(\frac{17}{2} \right)^{\frac{1}{4}} T$$

Factor by which heat flow reduces

$$= \frac{\sigma A \left[(2T)^4 - \frac{17}{2} T^4 \right]}{\sigma A \left[(2T)^4 - T^4 \right]} = \frac{1}{2}$$

7.(D) Rate of cooling $= \frac{dT}{dt} = -K(T - T_0)$

Initially $\left(\frac{dT}{dt} \right)_A > \left(\frac{dT}{dt} \right)_B$

So $E_A > E_B$

8.(B) $(35 - T_0) = (40 - T_0)e^{\frac{20a}{(100 + W)b}}$

$$(35 - T_0) = (40 - T_0)e^{\frac{25a}{(150 + W)b}}$$

Comparing $\frac{20}{100 + W} = \frac{25}{150 + W}$

$$3000 + 20W = 2500 + 25W$$

$$5W = 500$$

$$W = 100 \text{ gm}$$