

Miscellaneous Questions Bank

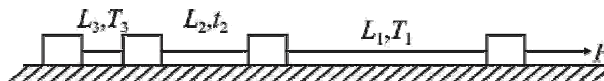
Solutions

- 1.(A)** Water decreases in volume from (0 – 4) C and further expands.
Density is maximum at 4 C.
- 2.(C)** Heat required to raise temp of ice to 0°C = $500 \times 0.5 \times 5 = 1250$ cal
Heat released if 100 gm of water is brought to 0°C = $100 \times 20 \times 1 = 2000$ cal
Final mixture will be at 0°C
Amount of ice melted = $\frac{2000 - 1250}{80} = \frac{750}{80} = 93.75 \text{ gm}$
Amount of ice = $500 - 93.75 = 406.25 \text{ gm}$

- 3.(D)** Young's modulus is the physical property of the material and does not depend on the dimensions.

4.(A) $B = \frac{1}{\text{compressibility}} = 0.25 \times 10^5 \text{ atm}$
 $= \frac{P}{\Delta V / V} = \frac{100 \times 100}{\Delta V}, \quad \Delta V = \frac{10^4 \times 4}{10^5} \text{ cc} = 0.4 \text{ cc}$

- 5.(B)** As $T_1 > T_2 > T_3$
 $\Rightarrow L_1 > L_2 > L_3$

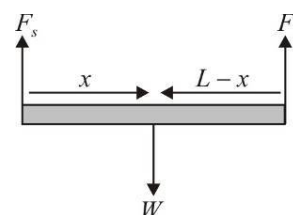


- 6.(A)** As it is under rotational equilibrium,

$$F_s x = F_b (L - x) \quad \dots(i)$$

As stresses are equal, $\Rightarrow \frac{F_s}{A_s} = \frac{F_b}{A_b}$ or, $\frac{F_s}{F_b} = \frac{A_s}{A_b} = \frac{1}{2} \quad \dots(ii)$

From (i) and (ii) $\frac{L - x}{x} = \frac{1}{2} \Rightarrow x = \frac{2L}{3} = \frac{2(2)}{3} = \frac{4}{3} \text{ m} = 1.33 \text{ m}$



- 7.(A)** For equal strains,

$$\frac{\Delta L_s}{L_s} = \frac{\Delta L_b}{L_b} \quad \text{or,} \quad \frac{F_s}{A_s Y_s} = \frac{F_b}{A_b Y_b} \quad \Rightarrow \frac{F_s}{F_b} = \frac{A_s Y_s}{A_b Y_b} = \frac{1}{1} \quad \dots(iii)$$

From 1 & 3; $x = L / 2 = 2 / 2 = 1 \text{ m}$

- 8. A-R; B-S; C-Q; D-P**

For each section, rate of heat flow $\left(\frac{dQ}{dt} \right)$ remains same

$$\Rightarrow \frac{dQ}{dt} = \frac{KA(100 - T_C)}{L} = \frac{A(0.8)K(T_C - T_D)}{1.2L} = \frac{1.2KA(T_D - T_E)}{1.5L} = \frac{1.5KAT_E}{0.6L}$$

$$\Rightarrow 100 - T_C = \frac{0.8}{1.2}(T_C - T_D) = \frac{1.2}{1.5}(T_D - T_E) = \frac{1.5}{0.6}T_E$$

or, $6(100 - T_C) = 4(T_C - T_D) = 4.8(T_D - T_E) = 15T_E$

Solving,

$$\Rightarrow T_A - T_C = 24.1, \quad T_C - T_D = 36.2$$

$$T_D - T_E = 30.1, \quad T_E - T_B = T_E = 9.6$$

9.(BC) $T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{l_0 + \alpha l_0 \Delta\theta}{g}} \approx T_0 \left(1 + \frac{1}{2} \alpha \Delta\theta\right)$ (Using binomial approximation)

At 30°C, fraction loss of time in 1s = $\frac{T_{30^\circ} - T_{20^\circ}}{T_{20^\circ}} = 5\alpha = 5 \times 19 \times 10^{-6} \text{ s} = 95 \times 10^{-6} \text{ s}$

Time loss in 24 hrs = $86400 \times 95 \times 10^{-6} \text{ s} = 8.2 \text{ s}$

On cold day at 10°C, fraction gain = $\frac{T_{10^\circ} - T_{20^\circ}}{T_{20^\circ}} = -5\alpha$

10.(AD)

- (A) Is correct because $Y_{\text{steel}} > Y_{\text{Rubber}}$. Elasticity is defined as tendency to regain its shape which is more in steel.
- (B) Is incorrect. If a string is stretched, both total length of coil & volume does not change. Only the shape undergoes a change. Hence, it is shear modulus that determines the stretching of coil.
- (C) Is also incorrect. The bending of prongs of fork is determined by young's modulus of material. Hence, restoring force on the prongs depends on young's modulus which determines the frequency of the fork.
- (D) Is correct. When the material is not under any stress, its atoms are under equilibrium positions. When a tensile stress is applied, the separation between the atoms becomes greater than the equilibrium separation.

Hence, inter atomic forces will be attractive so that it regains its shape.

11.(4) $\frac{\theta_1 - \theta_2}{t} = \alpha \left(\frac{\theta_1 + \theta_2}{2} - \theta_0 \right)$

In the first case, $\frac{75 - 65}{2} = \alpha \left[\frac{75 + 65}{2} - 30 \right] \dots(i)$

In second case, $\frac{55 - 45}{t} = \alpha \left[\frac{55 + 45}{2} - 30 \right] \dots(ii)$ Solving $\Rightarrow t = 4 \text{ min}$

12.(D) $I = MK^2$

$$\frac{\Delta I}{I} = \frac{2MK \Delta K}{MK^2} = \frac{2\Delta K}{K}$$

$$\frac{\Delta I}{I} = 2\alpha \Delta t$$

13.(C) $dQ = ms dT$

$$Q = \int_5^{15} ms dT = \int_5^{15} 2(0.2 + 0.14t + 0.023t^2) dt = 82 \text{ cal}$$

14.(D) $\lambda_m T = K$

So, $\frac{T_1}{T_2} = \frac{\lambda_2}{\lambda_1} = \frac{1}{2}$

$$\frac{E_1}{E_2} = \left(\frac{1}{2} \right)^4 = \frac{1}{16}$$

- 15.(D)** By mechanical equivalent of heat

$$\frac{100(mgh)}{4.2} = Q \text{ cal} = ms\Delta\theta \times (1000)$$

$$\Delta\theta = \frac{100gh}{4.2 \times s \times 1000} = 11.9^\circ\text{C}$$

- 16.(C)** Work done = Energy stored = $\frac{1}{2}kx^2 = \frac{1}{2}\left(\frac{YA}{L}\right)(l)^2 = \frac{YA}{2L}$

- 17.(C)** $l = l_0(1 + \alpha t)$

$$\frac{2\pi \times 6}{2} = l_0(1 + \alpha t) \quad \text{Also,} \quad \frac{2\pi \times 5.98}{2} = l_0(1 + 20\alpha) \Rightarrow \frac{6}{5.98} = \frac{1 + \alpha t}{1 + 20\alpha} \Rightarrow t = 216.8^\circ\text{C} \approx 217^\circ\text{C}$$

- 18.(C)** Tensile stress = $y \alpha \Delta\theta = 11 \times 10^{10} \times 17 \times 10^{-6} \times (217 - 20) = 3.68 \times 10^8 \text{ N/m}^2$

- 19.(C)** $\alpha L \Delta T + L \frac{F/A}{Y} = 0$

$$\Delta T = -\left(\frac{F/A}{\alpha Y}\right) = \frac{-230 \times 10^6}{(17 \times 10^{-6})(110 \times 10^9)} = -123\text{K} = -94^\circ\text{C}$$

$$\Rightarrow \text{Final temperature at which copper breaks } T_f = T_i + \Delta T = 217 - 123 = 94^\circ\text{C}$$

- 20. A-Q; B-S; C-P,R; D-S**

Unit of heat capacity is J/°C.

Unit of latent heat is J/kg.

- 21.(2)** Loss or gain per day = $dT = \frac{1}{2}\alpha dt \times 86400$

Since, $T = 86400 \text{ s}$ for each day

$$\text{At } 15^\circ\text{C}, 5 = \frac{1}{2}\alpha(t - 15)(86400); \text{ At } 30^\circ\text{C}, 10 = \frac{1}{2}\alpha(30 - t) \times 86400 \Rightarrow \frac{30 - t}{t - 15} = 2 \Rightarrow t = 20^\circ\text{C s}$$

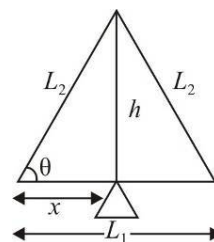
- 22.(D)** Here, h remains constant while the set-up is being heated.

$$\text{but } L_2^2 = h^2 + x^2$$

$$2L_2\Delta L_2 = 2x\Delta x \text{ for small increment}$$

$$\text{or, } L_2\Delta L_2 = \frac{L_1}{2} \frac{\Delta L_1}{2} \Rightarrow 4L_2\Delta L_2 = L_1\Delta L_1$$

$$\text{or, } 4L_2^2\alpha_2\Delta T = L_1^2\alpha_1\Delta T \quad \text{or, } \frac{L_1}{L_2} = 2\sqrt{\frac{\alpha_2}{\alpha_1}}$$



- 23.(B)** Thermal expansion is photographic expansion. So everything will get enlarged.

- 24.(B)** $(50 - T) = (60 - T)e^{-k(10)}, \quad (42 - T) = (50 - T)e^{-k(10)}$

$$\frac{50 - T}{42 - T} = \frac{60 - T}{50 - T}$$

$$(50 - T)^2 = (60 - T)(42 - T) = 2520 - 102T + T^2$$

$$\text{or, } 2500 - 100T + T^2 = 2520 - 102T + T^2 \quad \text{or, } 2T = 20, \quad T = 10^\circ\text{C}$$

- 25.(C)** Black body are perfect absorber and radiator also. So if emissivity of A_1 is e , and absorptivity is a then Heat radiated per second is Q by A_1 so absorbed by B_1 will be equal to Q .

But heat radiated by B_2 will be Q/e and absorbed by $A_2 = \left(\frac{Q}{e}\right)a$ but $a = e$

So, A_2 and B_1 will remain at same temperature therefore ΔP across mercury pellet will remain same as before.

- 26.(D)** For small change in temperature one can treat rate of cooling as a constant.

So, if rates of cooling at 50°C and 40°C is H_1 and H_2 , then

$$\frac{H_1}{H_2} = \frac{50 - 30}{50 - 40} = 2$$

$$\text{Therefore, } \frac{\frac{\Delta\theta}{\Delta t}(\text{at } 50^\circ\text{C})}{\frac{\Delta\theta}{\Delta t}(\text{at } 40^\circ\text{C})} \Rightarrow \frac{\frac{1}{55}}{\frac{0.5}{\Delta t}} = 2 \Rightarrow \Delta t = 5\text{s}$$

- 27.(A)** Due to expansion of material, the diameter of hole will increase.

28.(C) $\gamma_{\text{apparent}} = \gamma_{\text{liquid}} - \gamma_{\text{cont}} = \gamma - 3 \times \frac{\gamma}{3} = 0$

- 29.(D)** For lengths of the rods to be constant $\Delta l_1 = \Delta l_2$

or $l_1 \alpha_1 \Delta T = l_2 \alpha_2 \Delta T \therefore l_1 \alpha_1 = l_2 \alpha_2$

- 30.(AC)** The compressive force in the rod will be same everywhere. Therefore, compressive stress will be maximum at left end. Hence, only (B) is correct.

31.(9) $(\lambda_m)_B = 3(\lambda_m)_A \Rightarrow T_A = 3T_B$

$$E_1 = 4\pi(6)^2 \sigma T_A^4 = 4\pi(6)^2 (3T_B)^4$$

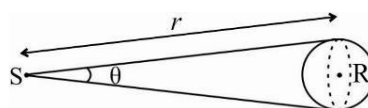
$$E_2 = 4\pi(18)^2 \sigma T_B^4, \quad \frac{E_1}{E_2} = 9$$

- 32.(C)** Total energy received per second

$$\frac{P_{\text{sun}}}{4\pi r^2} (\pi R^2)$$

$$(e\sigma)4\pi R^2 T^4 = \frac{P\pi R^2}{4\pi r^2} a$$

or, $T^4 = K \frac{R^2}{r^2}, \quad T \propto \frac{1}{\sqrt{r}}$



- 33.(A)** Let surface area of both spheres be A_0

Heat radiated by A : $A_{\text{out}} = \sigma A_0 T_A^4$

Heat absorbed by B : $B_{\text{in}} = \sigma A_0 (0.8) T_A^4$

Heat reflected by B and absorbed by A : $\sigma A_0 (0.2) T_A^4$

Heat radiated by B : $B_{\text{out}} = \sigma A_0 (0.8) T_B^4$

So, total heat absorbed by A :

$$A_{in} = \sigma A_0 (0.2) T_A^4 + \sigma A_0 (0.8) T_B^4$$

Now, if A and B are in thermal equilibrium,

$$A_{in} = A_{out} \text{ and } B_{in} = B_{out}$$

This gives $T_A = T_B$

So option (A) is correct

34.(C) $l_1 \alpha_1 = l_2 \alpha_2 \Rightarrow (l+5) \alpha_1 = l \alpha_2$
 $l = 10 \text{ cm}$

35.(C) Rate of cooling at $70^\circ = Q_{70} = 10W$

But $\frac{Q_{70}}{Q_{50}} = \frac{70-30}{50-30} = \frac{40}{20} = 2$

So, $Q_{50} = 5W$ now, $5 \times 60 = c(0.1)$

So, $C = \frac{300}{0.1} = 3000 \text{ J/}^\circ\text{C}$

36.(D) $B = \frac{-V \Delta P}{\Delta V} = \frac{-\Delta P}{-0.001} = \frac{\rho g h}{0.001} = \frac{(1000)(10)(100)}{0.001} = 10^9 \text{ Pa}$

37.(D) If length is doubled, Δl will also become two times and Y will remain same.

38.(CD) If stress in steel = stress in brass,

Then $\frac{T_S}{A_S} = \frac{T_B}{A_B}$

$$\frac{T_S}{T_B} = \frac{A_S}{A_B} = \frac{10^{-3}}{2 \times 10^{-3}} = \frac{1}{2} \quad \dots (i)$$

System is in equilibrium. So, taking moments about P

$$T_S' x = T_B (2-x) \Rightarrow \frac{T_S}{T_B} = \frac{2-x}{x} \quad \dots (ii)$$

From Eqs. (i) and (ii), we get $x = 1.33 \text{ m}$

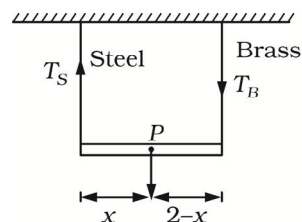
$$\text{Strain} = \frac{\text{Stress}}{Y}$$

If strain in steel = strain in brass,

Then $\frac{T_S / A_S}{Y_S} = \frac{T_B / A_B}{Y_B}$

$$\therefore \frac{T_S}{T_B} = \frac{A_S Y_S}{A_B Y_B} = \frac{(10^{-3})(2 \times 10^{11})}{(2 \times 10^{-3})(10^{11})} = 1 \quad \dots (iii)$$

From Eqs. (ii) and (iii), we get $x = 1m$



39.(BC) $q_1 = \frac{TD}{R_1} \quad \therefore \quad R_1 = \frac{TD}{q_1}$

Similarly, $R_2 = \frac{TD}{q_2}$

In series, $q_s = \frac{TD}{R_1 + R_2} = \frac{TD}{\frac{TD}{q_1} + \frac{TD}{q_2}} = \frac{q_1 q_2}{q_1 + q_2}$

In parallel, $q_p = \frac{TD}{R_{net}} = TD \left(\frac{1}{R_{net}} \right)$
 $= TD \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$
 $= TD \left(\frac{q_1}{TD} + \frac{q_2}{TD} \right) = q_1 + q_2$

40. **A-Q; B-P; C-S; D-R**

(A) $m(s)(\theta' - \theta) = 2m(s)(2\theta - \theta')$

Solving we get, $\theta' = \frac{5}{3}\theta$

(B) $ms(\theta' - \theta) = 3m(s)(3\theta - \theta')$

Solving we get, $\theta' = \frac{5}{2}\theta$

(C) $2m(s)(\theta' - 2\theta) = 3m(s)(3\theta - \theta')$

Solving we get, $\theta' = \frac{13}{5}\theta$

(D) $ms(\theta' - \theta) + 2ms(\theta' - 2\theta) + 3ms(\theta' - 3\theta) = 0$

Solving we get, $\theta' = \frac{7}{3}\theta$

41.(9) Increase in pressure is $\Delta p = \frac{Mg}{A}$

Bulk modulus is $B = \frac{\Delta p}{(\Delta V / V)}$

$\therefore \frac{\Delta V}{V} = \frac{\Delta p}{B} = \frac{Mg}{AB} \quad \dots (i)$

Also, the volume of the sphere is

$V = \frac{4}{3}\pi R^3 \Rightarrow \frac{\Delta V}{V} = \frac{3\Delta R}{R}$

or $\frac{\Delta R}{R} = \frac{1}{3} \cdot \frac{\Delta V}{V}$, using eq. (i), we get

$\frac{\Delta R}{R} = \frac{Mg}{3AB} \quad \therefore n = 9$

42.(A) Black bulb will absorb more heat, hence, expansion of air will be more in limb X, thereby decreasing the level in X & increasing in Y.

$$43.(D) \quad Q = \int ncdT = \int_{300}^{700} 2(27.2 + 4 \times 10^{-3}T)dT = 2.33 \times 10^4 J$$

$$44.(B) \quad L = L_0 \left[1 + \int_{T_0}^T \alpha(T) dT \right]$$

$$45.(A) \quad F = kx, \quad k = \frac{YA}{l}$$

$$\text{So,} \quad \frac{x_1}{x_2} = \frac{k_2}{k_1} = \frac{l_1}{l_2} \cdot \frac{A_2}{A_1} = \frac{4}{4} \times \left(\frac{1}{n^2} \right) \quad \text{or,} \quad \frac{x_2}{x_1} = n^2$$

$$46.(D) \quad (\theta_1 - \theta) = HR_1$$

$$(\theta - \theta_2) = HR_2$$

$$\frac{\theta_1 - \theta}{\theta - \theta_2} = \frac{R_1}{R_2}, \quad R_2\theta_1 - R_2\theta = R_1\theta - R_1\theta_2$$

$$\theta = \frac{R_2\theta_1 + R_1\theta_2}{R_1 + R_2}$$

$$47.(C) \quad u = \frac{1}{2} \text{ stress} \times \text{strain} = \frac{1}{2} \frac{\text{stress} \times \text{stress}}{Y} = \frac{1}{2Y} (\text{stress})^2$$

$$48.(B) \quad T = \frac{2m_1m_2}{m_1+m_2}g = \frac{2 \times 1 \times 2}{1+2} \times 10 = \frac{40}{3} N$$

$$\text{If } r \text{ is the minimum radius, which will be at the breaking stress point and breaking stress} = \frac{40}{\pi r^2}$$

$$\text{or} \quad \frac{40}{3\pi} \times 10^6 = \frac{40}{3\pi r^2} \quad \Rightarrow \quad r^2 = \frac{1}{10^6} \quad \text{or} \quad r = \frac{1}{10^3} m = 1mm$$

$$49.(A) \quad \text{We have, } -\frac{dT}{dt} = k(T - T_0)$$

Where T_0 is the temperature of the surrounding. If T_1 is the initial temperature and T is the temperature at any time t , then

$$\int_{T_1}^T \frac{dT}{(T - T_0)} = -k \int_0^t dt$$

$$\text{or} \quad \ln(T - T_0) \Big|_{T_1}^T = -kt \quad \text{or} \quad \ln \left[\frac{T - T_0}{T_1 - T_0} \right] = -kt \quad \text{or} \quad T = T_0 + (T_1 - T_0) e^{-kt}$$

50.(B) The body continues to lose heat till its temperature becomes equal to that of the surrounding. The loss of heat $Q = mc(T_1 - T_0)$

If the body loses half of the maximum loss half of the maximum loss that it can, then decrease in temperature $\frac{Q}{2} = mc \left(\frac{T_1 - T_0}{2} \right)$

If body loses this heat in time t , then its temperature at time t' will be $T = T_1 - \left(\frac{T_1 - T_0}{2} \right) = \frac{T_1 + T_0}{2}$

Putting these values in equation (i), we have $\frac{T_1 + T_0}{2} = T_0 + (T_1 - T_0) e^{-kt'}$

or $\frac{T_1 - T_0}{2} = (T_1 - T_0) e^{-kt'}$ or $e^{-kt'} = \frac{1}{2}$ or $t' = \frac{\ln 2}{k}$

51.(B) If $k = \ln 2, t' = \frac{\ln 2}{\ln 2} = 1$ unit

52.(B) $F = Kx = \frac{EA}{l} x = \frac{EA \Delta l}{l} = \frac{EA(\alpha t) l_0}{l_0(1 + \alpha t)} = \frac{EA \alpha t}{1 + \alpha t}$

53.(C) $T = W_1 + \frac{W}{L} \cdot \frac{3L}{4} = W_1 + \frac{3W}{4}$ Stress $= \frac{1}{s} \left(W_1 + \frac{3W}{4} \right)$

54.(D) By Newton's law of cooling
Rate of cooling $= \alpha(\theta - \theta_0)$

55.(A) $F = kx, \frac{F_1}{F_2} = \frac{k_1 x_1}{k_2 x_2}$ or, $\frac{x_2}{x_1} = \frac{k_1 F_2}{k_2 F_1}$

or, $\frac{x_2}{x_1} = \frac{A_1 F_2 l_2}{l_1 A_2 F_1} = \frac{A \cdot 2F \cdot 2l}{4A \cdot l \cdot F} = 1$

$x_2 = x_1 = l$

56.(C) $\Delta V \approx -(0.1\%) = -(0.001V)$ So, $\Delta P = \frac{-B \Delta V}{V} = 2 \times 10^6 \text{ N/m}^2$

57.(D) $-\frac{d\theta}{dt} \propto T^4$

58.(ACD) For body B,

$a = (1 - r - t) = 0.2$

Since, $e = a = 0.2$

$E = (100)(0.2) = 20 \text{ W/m}^2$

Power emitted $= eA = 20 \times 10 = 200 \text{ watt/m}^2$.

59.(4) Area of top surface is $A = 3 \text{ cm} \times 1 \text{ cm} = 3 \text{ cm}^2 = 3 \times 10^{-4} \text{ m}^2$

Shearing stress, $\sigma = \frac{F}{A} = \frac{2.1}{3 \times 10^{-4}} = 0.7 \times 10^4 \text{ Nm}^{-2}$

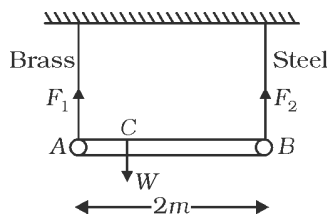
Angle of shear, $\theta = \frac{\text{Shearing stress}}{\text{Shear modulus}} = \frac{0.7 \times 10^4}{1.4 \times 10^5} = 0.05 \text{ rad}$

60.(A) $A_B = 0.2 \times 10^{-4}; A_S = 0.1 \times 10^{-4}$

$F_1 + F_2 = mg$

$\frac{F_1}{A_B} = \frac{F_2}{A_S}$

$F_1 x = F_2 (2 - x)$



$$\frac{F_2 A_B x}{A_S} = F_2 (2 - x)$$

$$x = \frac{2A_S}{A_B + A_S} = 66.6 \text{ cm}$$

61.(B) Bulk modulus is related to volume change and volume change is possible in all three states. Young, modulus is related to length change, which is possible only in solids.

62.(D) If initial volume of metal is V_m , then $V_m \rho_l = 16 \text{ gm}$

$$V_m' (\rho_l)' = 15.5 \text{ gm} \quad \text{or,} \quad \left(\frac{V_m}{V_m'} \right) \frac{\rho_l}{(\rho_l)'} = \frac{16}{15.5} \quad \text{or,} \quad \frac{1}{(1 + 3\alpha t)} \cdot \frac{1.24}{1.20} = \frac{16}{15.5}$$

$$\alpha = 7.9 \times 10^{-4} / ^\circ\text{C}$$

63.(A) $x = \frac{F}{k}$

$$x \propto \frac{l}{YA}$$

$$\frac{l}{A} \text{ is maximum}$$

64.(B) Maximum stress $= (2.4 \times 10^8) \frac{1}{3}$

$$\text{So, } \frac{(1200)(g+a)}{3 \times 10^{-4}} = 0.8 \times 10^8 \text{ or, } (g+a)400 \times 10^4 = 0.8 \times 10^8$$

$$\text{or, } (g+a) = 20, \quad a = 10$$

65.(B) $F_{net} = F_1 + F_2 = (k_1 + k_2)x = k_{eq}x$ or, $\left(\frac{Y_1 A_1}{l} + \frac{Y_2 A_2}{l} \right) = k_{eq} = \frac{Y_{eq}(2A)}{l}$ or, $Y_{eq} = \frac{Y_1 + Y_2}{2}$

66.(B) Rate of cooling decreases with decrement of temperature difference between surrounding and system.

67.(D) Fact

68.(D) Longitudinal strain $= \frac{\Delta L}{L} = \alpha \Delta T$

$$\text{Elastic PE per unit volume} = \frac{1}{2} \times \text{stress} \times \text{strain}$$

$$(E) = \frac{1}{2} \times Y \times (\text{Strain})^2 = \frac{1}{2} Y \left(\frac{\Delta L}{L} \right)^2 = \frac{1}{2} Y \alpha^2 (\Delta T)^2$$

$$\text{Also, } \gamma = 3\alpha \Rightarrow E = \frac{1}{2} Y \left(\frac{\gamma}{3} \right)^2 (\Delta T)^2 = \frac{1}{18} \gamma^2 Y T^2 \text{ (as } \Delta T = T)$$

69.(BD) $ms(2\theta - \theta') = m(2s)(\theta' - \theta)$

$$\text{Solving this equation we get, } \theta' = \frac{4}{3} \theta$$

Further, heat capacity

$$C = ms \text{ or } C \propto s \text{ (as } m \text{ is same)} \quad \therefore \frac{C_1}{C_2} = \frac{s_1}{s_2} = \frac{1}{2}$$

$$70.(C) \quad \Delta x = \frac{Fl}{AY} \quad \therefore F = \left(\frac{AY}{L} \right) \Delta x$$

i.e. F versus Δx graph is a straight line of slope $\frac{YA}{L}$.

(Slope)_B > (Slope)_A

$$\therefore \left(\frac{YA}{L} \right)_B > \left(\frac{YA}{L} \right)_A \quad \text{or} \quad (A)_B > (A)_A$$

They are of same material. Hence, $Y_B = Y_A$

$$71.(ABCD) \quad E = \sigma AT^4 e$$

$$d_m T = \text{constant}$$

All the statements are correct

$$72.(A) \quad \text{Potential energy density} = \frac{1}{2}(\text{stress})^2 Y$$

$$\frac{u_1}{u_2} = \frac{\left(\frac{F}{A_1} \right)^2}{\left(\frac{F}{A_2} \right)^2} \times \frac{Y_2}{Y_1} \quad ; \quad \frac{u_1}{u_2} = \left(\frac{A_2}{A_1} \right)^2 = \left(\frac{r_2}{r_1} \right)^4, \quad u_2 = u_1 \left(\frac{r_1}{r_2} \right)^2 = 16$$

$$73.(B) \quad x = \frac{Fl}{YA} \text{ so, } \frac{x_1}{x_2} = \frac{l_1}{l_2} \times \frac{A_2}{A_1} \quad \text{or, } x_2 = \frac{x_1 A_1}{A_2} = 0.6 \text{ cm}$$

$$74.(B) \quad \left(\frac{F}{k_1} \right) / \left(\frac{F}{k_2} \right) = 1 \quad \text{or, } \frac{k_2}{k_1} = 1$$

$$\text{or, } \frac{Y_2 A_2 l_1}{Y_1 A_1 l_2} = 1 \quad \text{or, } \frac{A_2}{A_1} = \frac{10}{20}$$

$$\text{or, } \left(\frac{r_2}{r_1} \right)^2 = \frac{1}{2}, \quad \left(\frac{r_2}{r_1} \right)^2 = \frac{1}{2} \quad R_s = \frac{R_B}{\sqrt{2}}$$

75.(D) It is clear that at desired temperature, $T^\circ\text{C}$, the densities of the wood and benzene must be just equal for the wood to just sink, i.e., $\rho_W(tT) = \rho_B(T)$

$$\text{Using } \rho = \frac{\rho_0}{1 + \rho \Delta T}$$

$$\frac{880}{1 + 1.2 \times 10^{-3} T} = \frac{900}{1 + 1.5 \times 10^{-3} T}$$

$$\frac{90}{88} = \frac{1 + 1.5 \times 10^{-3} T}{1 + 1.2 \times 10^{-3} T}$$

Solving for T , we have $T = 83.2^\circ\text{C}$

$$\begin{aligned} 76.(C) \quad L &= L_0 + \int_0^2 \alpha \Delta \theta \cdot dx ; \quad = 2 + \int_0^2 (3x + 2) \times 10^{-6} \times 20 dx \\ &= 2 + 3 \times \frac{2^2}{2} \times 10^{-6} \times 20 + 2 \times 10^{-6} \times 20 \times 2 = 2.0002m \end{aligned}$$

$$77.(B) \quad F = kx = k\Delta l = k l_0 \alpha \Delta T = \frac{YA}{l_0} l_0 \alpha \Delta T = YA \alpha \Delta T = 10^{11} \times 10^{-4} \times 10^{-5} \times 10^2 = 10^4 N$$

$$\begin{aligned} 78.(A) \quad (65 - 30) &= (75 - 30)e^{-k2} \Rightarrow 35 = 45e^{-2k} \Rightarrow \ln\left(\frac{7}{9}\right) = -2k \\ (45 - 30) &= (55 - 30)e^{-tk} \Rightarrow 15 = 25e^{-tk} \Rightarrow \ln\left(\frac{3}{5}\right) = -tk, \quad t = \frac{2 \ln(3/5)}{\ln(7/9)} \end{aligned}$$

79.(A) Fact

80.(A) The diameter of rod will be less where tension is more.

$$81.(A) \quad (\theta - \theta_0) = (\theta_i - \theta_0)e^{-Kt}$$

$$82.(D) \quad \frac{\frac{1}{2}k_1x_1^2}{\frac{1}{2}k_2x_2^2} = \frac{W_1}{W_2} \quad \text{or,} \quad \frac{W_1}{W_2} = \frac{K_1}{K_2} = \frac{A_1 l_2}{A_2 l_1} = \left(\frac{r_1}{r_2}\right)^2 \frac{l_2}{l_1} = \left(\frac{r_1}{r_1/2}\right)^2 \frac{l_1}{l_1} = 2^2 \times \frac{1}{2} = 2 \Rightarrow W_2 = 1J$$

$$83.(A) \quad a_1, a_2 \text{ is area of cross section of } A, B \text{ respectively, so } \frac{F_1}{F_2} = \frac{k_1 x_1}{k_2 x_2} \text{ or, } k_1 x_1 = k_2 x_2$$

$$\begin{aligned} \left(\frac{YA_1}{l_1}\right)x_1 &= \left(\frac{YA_2}{l_2}\right)x_2 \quad \text{or,} \quad \frac{x_1}{x_2} = \frac{l_1 A_2}{l_2 A_1} = \frac{A_1 l_1 (A_2)^2}{A_2 l_2 (A_1)^2} = \left(\frac{A_2}{A_1}\right)^2 = \left(\frac{r_2}{r_1}\right)^4 = 16 \\ \frac{x_1}{x_2} &= \frac{16}{1} \end{aligned}$$

$$84.(A) \quad \frac{msdT}{dt} = -k(T - T_0)$$

{ T_0 = Room temperature }

$$\frac{-k}{mg} \int dt = \int \frac{dT}{T - T_0}$$

$$\frac{-k}{ms} t = \ln(T - T_0)$$

$\therefore$ a straight line

85.(A) Assuming cross sectional area remains same.

$$\frac{\Delta v}{V} = \frac{A \Delta l}{A l} = \frac{\Delta l}{l}$$

$$86.(C) \quad \tau = C\theta \text{ where } c = \frac{\pi r^4}{2nl}; \quad \frac{\theta_1}{\theta_2} = \frac{r_2^4}{r_1^4}$$

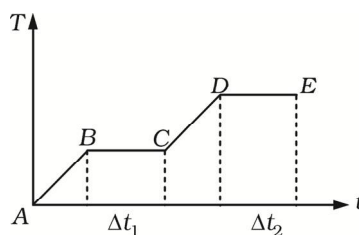
87.(BC) $dQ = mCdT$ or $Hdt = mCdT$

$$\therefore C = \left(\frac{H}{m}\right) \frac{1}{(dT/dt)}$$

As $\frac{dT}{dt}$ of CD is smaller, so $C_{\text{liquid}} > C_{\text{solid}}$

$$Q_1 = H(\Delta t_1) \text{ and } Q_2 = H(\Delta t_2)$$

$$\text{As } \Delta t_2 > \Delta t_1, \therefore Q_2 > Q_1$$



88.(AC) According to Wien's law, $\lambda_m T = \text{constant}$ or $\frac{T}{\nu_m} = \text{constant}$

So, if T is doubled, ν_m is also doubled.

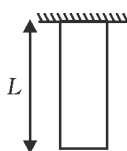
Further, according to Stefan's law $E \propto T^4$

When T is doubled, E increases by a factor of 16.

89.(6) If L is the maximum length of the wire that can be suspended. Then $F = mg$, where $m = \rho LA$ (where, A = cross-sectional area)

$$\therefore \text{Maximum stress} = \frac{mg}{A}$$

$$= g \times \frac{\rho LA}{A} = \rho Lg$$



$$\text{Given, breaking stress} = \sigma_b = 9 \times 10^{10} \text{ Nm}^{-2} \therefore \rho Lg = 9 \times 10^{10}$$

90. A-P, Q; B-P; C-R, S; D-R

$$\Delta \ell = \frac{F \ell}{AY} \text{ and stress} = \frac{F}{A}$$

91.(AC) Given $M_A = 4M_B$ (Since material is same so density is also same)

$$V_A = 4V_B$$

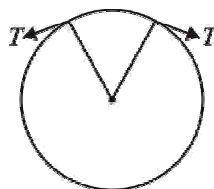
$$4 / 3 \pi r_A^3 = 4(4 / 3 \pi r_B^3)$$

Rate of heat loss

$$P = \sigma e A (T^4 - T_0^4) = \sigma e 4 \pi r^2 (T^4 - T_0^4) \Rightarrow P \propto r^2$$

$$\text{Rate of Cooling } \frac{dT}{dt} \propto \frac{1}{r}$$

$$92.(A) \frac{F_1}{F_2} = \frac{k_1 x_1}{k_2 x_2} = \frac{\frac{Y_1 A_1}{l_1} \cdot \Delta l_1}{\frac{Y_2 A_2}{l_2} \cdot \Delta l_2} = \frac{Y_1 A_1 \alpha_1 \Delta T}{Y_2 A_2 \alpha_2 \Delta T} = \frac{3}{2}$$



$$93.(B) T = kx = \frac{YA}{l} (2\pi R - 2\pi r) = \frac{YA 2\pi}{2\pi r} (R - r) = YA \left(\frac{R - r}{r} \right)$$

94.(A) $\frac{dQ}{dt} = \frac{KA\Delta\theta}{l}$ As K, A and $\Delta\theta$ are same, $\frac{dQ}{dt} \propto \frac{1}{l}$ $\Rightarrow \left(\frac{dQ}{dt}\right)_{ACB} = \frac{l_{AB}}{l_{ACB}} = \frac{2}{\pi}$

95.(A) Lag per second $= \frac{1}{2}\alpha\Delta\theta = \frac{1}{2} \times 10^{-5} \times 10$
Lag per day $= \frac{1}{2} \times 10^{-5} \times 10 \times 86400 \approx 4.32 \text{ sec}$

96.(B) $K(a-l) = 4$,
 $K(b-l) = 5$ where l is the natural length of the spring

So, $\frac{a-l}{b-l} = \frac{4}{5} \Rightarrow 5a - 5l = 4b - 4l \Rightarrow l = 5a - 4b$

$$K = \frac{4}{a - (5a - 4b)} = \frac{4}{4(b - a)} = \frac{1}{b - a}$$

So, $K(x-l) = 9$ or, $x = \frac{9}{K} + l = 9(b-a) + 5a - 4b = 5b - 4a$

97.(BC) Thermal force $= YA\alpha d\theta = Y\pi r^2\alpha d\theta$

$r_1 = r, r_2 = r\sqrt{2}, r_3 = r\sqrt{3}, r_4 = 2r$

Thermal stress $= Y\alpha d\theta$

98.(C) $E = e A \sigma (T^4 - T_0^4)$

$= 0.4 \times 200 \times 10^{-4} \times 5.67 \times 10^{-8} [800^4 - 300^4] = 182 \text{ J}$

99.(B) Point B is the elastic limit.

100.(B) Point B is the elastic limit.

101.(B) Beyond B even if deforming forces are removed still some deformation is left.