EXERCISE-I (OBJECTIVE QUESTIONS)

1. A steel scale is to be prepared such that the millimeter intervals are to be accurate within 6×10^{-5} mm. The maximum temperature variation from the temperature of calibration during the reading of the millimeter marks is ($\alpha = 12 \times 10^{-6}\ k^{-1}$)

(A) 4.0 ºC (B) 4.5 ºC (C) 5.0 ºC (D) 5.5 ºC

2. A steel rod 25 cm long has a cross-sectional area of 0.8 cm^2. Force that would be required to stretch this rod by the same amount as the expansion produced by heating it through 10ºC is :

(Coefficient of linear expansion of steel is 10^{-5}/ºC and Young's modulus of steel is 2×10^{10} N/m^2.)

(A) 160 N (B) 360 N (C) 106 N (D) 260 N

3. Two rods of different materials having coefficients of thermal expansion α_1, α_2 and Young's moduli Y_1, Y_2 respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of the rods. If $\alpha_1 : \alpha_2 = 2 : 3$, the thermal stresses developed in the two rods are equal provided $Y_1 : Y_2$ is equal to

(A) 2 : 3 (B) 1 : 1 (C) 3 : 2 (D) 4 : 9

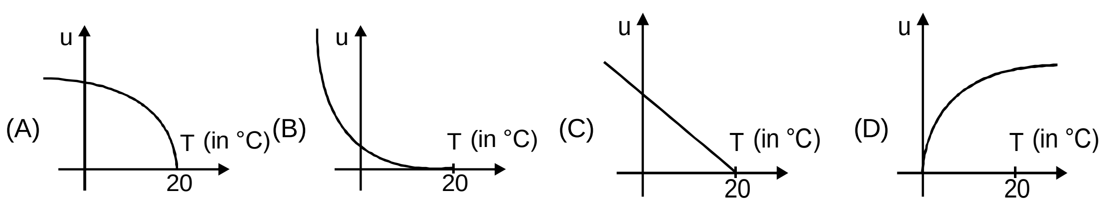
4. If I is the moment of inertia of a solid body having α-coefficient of linear expansion then the change in I corresponding to a small change in temperature ΔT is

(A) $\alpha I \Delta T$ (B) $\frac{1}{2} \alpha I \Delta T$ (C) $2 \alpha I \Delta T$ (D) $3 \alpha I \Delta T$

5. A metallic wire of length L is fixed between two rigid supports. If the wire is cooled through a temperature difference ΔT (Y = young's modulus, ρ = density, α = coefficient of linear expansion) then the frequency of transverse vibration is proportional to :

(A) $\frac{\alpha}{\sqrt{\rho Y}}$ (B) $\sqrt{\frac{Y\alpha}{\rho}}$ (C) $\frac{\sigma}{\sqrt{Y\alpha}}$ (C) $\sqrt{\frac{\sigma\alpha}{Y}}$

6. A metal wire is clamped between two vertical walls. At 20°C the unstrained length of the wire is exactly equal to the separation between walls. If the temperature of the wire is decreased the graph between elastic energy density (u) and temperature (T) of the wire is



7. A steel tape gives correct measurement at 20°C. A piece of wood is being measured with the steel tape at 0°C. The reading is 25 cm on the tape, the real length of the given piece of wood must be :

(A) 25 cm (B) < 25 cm (C) >25 cm (D) can not say

8. A rod of length 20 cm is made of metal. It expands by 0.075 cm when its temperature is raised from 0°C to 100°C. Another rod of a different metal B having the same length expands by 0.045 cm for the same change in temperature, a third rod of the same length is composed of two parts one of metal A and the other of metal B. Thus rod expand by 0.06 cm for the same change in temperature. The portion made of metal A has the length.

(A) 20 cm (B) 10 cm (C) 15 cm (D) 18 cm

9. A sphere of diameter 7 cm and mass 266.5 gm floats in a bath of a liquid. As the temperature is raised, the sphere just begins to sink at a temperature 35°C. If the density of a liquid at 0°C is 1.527 gm/cc, then neglecting the expansion of the sphere, the coefficient of cubical expansion of the liquid is f :

(A) 8.486×10^{-4} per °C (B) 8.486×10^{-5} per °C (C) 8.486×10^{-6} per °C (D) 8.486×10^{-3} per °C

10. The volume of the bulb of a mercury thermometer at 0°C is V_0 and cross section of the capillary is A_0. The coefficient of linear expansion of glass is a_g per °C and the cubical expansion of mercury γ_m per °C. If the mercury just fills the bulb at 0°C, what is the length of mercury column in capillary at T°C.

(A) $\frac{V_0T(\gamma_m+3a_g)}{A_0(1+2a_gT)}$ (B) $\frac{V_0T(\gamma_m-3a_g)}{A_0(1+2a_gT)}$ (C) $\frac{V_0T(\gamma_m+2a_g)}{A_0(1+3a_gT)}$ (D) $\frac{V_0T(\gamma_m-2a_g)}{A_0(1+3a_gT)}$

11. A metallic rod 1 cm long with a square cross-section is heated through 1°C. If Young's modulus of elasticity of the metal is E and the mean coefficient of linear expansion is α per degree Celsius, then the compressional force required to prevent the rod from expanding along its length is : (Neglect the change of cross-sectional area)

(A) $EA\alpha t$ (B) $EA\alpha t/(1+\alpha t)$ (C) $EA\alpha t/(1-\alpha t)$ (D) $E/\alpha t$

12. The loss in weight of a solid when immersed in a liquid at 0°C is W_0 and at t°C is W. If cubical coefficient of expansion of the solid and the liquid by γ_s and γ_1 respectively, then W is equal to :

(A) $W_0[1+(\gamma_s-\gamma_1)t]$ (B) $W_0[1-(\gamma_s-\gamma_1)t]$ (C) $W_0[(\gamma_s-\gamma_1)t]$ (D) $W_0t/(\gamma_s-\gamma_1)$

13. A thin walled cylindrical metal vessel of linear coefficient of expansion 10^{-3} °C^{-1} contains benzenr of volume expansion coefficient 10^{-3} °C^{-1}. If the vessel and its contents are now heated by 10°C, the pressure due to the liquid at the bottom.

(A) increases by 2% (B) decreases by 1% (C) decreases by 2% (D) remains unchanged

14. A rod of length 2m at 0°C and having expansion coefficient $\alpha = (3x + 2) \times 10^{-6}$ °C^{-1} where x is the distance (in cm) from one end of rod. The length of rod at 20 °C is :

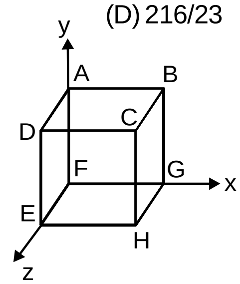
(A) 2.124 m (B) 3.24 m (C) 2.0120 m (D) 3.124 m

15. A copper ring has a diameter of exactly 25 mm at its temperature of 0°C. An aluminium sphere has a diameter of exactly 25.05 mm at its temperature of 100°C. The sphere is placed on top of the ring and two are allowed to come to thermal equilibrium, no heat being lost to the surrounding. The sphere just passes through the ring at the equilibrium temperature. The ratio of the mass of the sphere & ring is :

(given : $\alpha_{Cu} = 17 \times 10^{-6}$/°C, $\alpha_{Al} = 2.3 \times 10^{-5}$/°C, specific heat of Cu = 0.0923 Cal/g°C and specific heat of Al = 0.215 cal/g°C)

(A) 1/5 (B) 23/108 (C) 23/54 (D) 216/23

16. A cuboid ABCDEFGH is anisotropic with $\alpha_x = 1 \times 10^{-5}$/°C, $\alpha_y = 2 \times 10^{-5}$/°C, $\alpha_z = 3 \times 10^{-5}$/°C. Coefficient of superficial expansion of faces can be



(A) $\beta_{ABCD} = 5 \times 10^{-5}$ /°C (B) $\beta_{BCGH} = 4 \times 10^{-5}$ /°C

(C) $\beta_{CDEH} = 3 \times 10^{-5}$/°C (D) $\beta_{EFGH} = 2 \times 10^{-5}$/°C

17. An open vessel is filled completely with oil which has same coefficient of volume expansion as that of the vessel. On heating both oil and vessel,

(A) the vessel can contain more volume and more mass of oil
(B) the vessel can contain same volume and same mass of oil
(C) the vessel can contain same volume but more mass of oil
(D) the vessel can contain more volume but same mass of oil

18. A metal ball immersed in Alcohol weights W_1 at 0°C and W_2 at 50°C. The coefficient of cubical expansion of the metal $(\gamma)_m$ is less than that of alcohol $(\gamma)_{Al}$. Assuming that density of metal is large compared to that of alcohol, it can be shown that

(A) $W_1 > W_2$ (B) $W_1 = W_2$ (C) $W_1 < W_2$ (D) any of (A), (B) or (C)

19. A solid ball is completely immersed in a liquid. The coefficients of volume expansion of the ball and liquid are 3×10^{-6} and 8×10^{-6} per °C respectively. The percentage change in upthrust when the temperature is increased by 100°C is

(A) 0.5 % (B) 0.11 % (C) 1.1% (D) 0.05 %

20. A thin copper wire of length L increase in length by 1% when heated from temperature T_1 to T_2. What is the percentage change in area when a thin copper plate having dimensions 2L × L is heated from T_1 to T_2 ?

(A) 1% (B) 2% (C) 3% (D) 4%

21. If two rods of length L and 2L having coefficients of linear expansion α and 2α respectively are connected so that total length becomes 3L, the average coefficient of linear expansion of the composition rod equals :

(A) $\frac{3}{2}\alpha$ (B) $\frac{5}{2}\alpha$ (C) $\frac{5}{3}\alpha$ (D) none of these

22. The bulk modulus of copper is 1.4×10^{11} Pa and the coefficient of linear expansion is 1.7×10^{-5} $(C°)^{-1}$. What hydrostatic pressure is necessary to prevent a copper block from expanding when its temperature is increased from 20°C to 30°C ?

(A) 6.0×10^5 Pa (B) 7.1×10^7 Pa (C) 5.2×10^6 Pa (D) 40 atm

23. The coefficients of thermal expansion of steel and a metal X are respectively 12×10^{-6} and 2×10^{-6} per °C, At 40°C, the side of a cube of metal X was measured using a steel vernier callipers. The reading was 100 mm. Assuming that the calibration of the vernier was done at 0°C, then the actual length of the side of the cube at 0°C will be

(A) > 100 mm (B) < 100 mm (C) = 100 mm (D) data insufficient to conclude

24. A glass flask contains some mercury at room temperature. It is found that at different temperature the volume of air inside the flask remains the same. If the volume of mercury in the flask is 300 cm^3, then volume of the flask is (given that coefficient of volume expansion of mercury and coefficient of linear expansion of glass are $1.8 \times 10^{-4}(°C)^{-1}$ and $9 \times 10^{-6}(°C)^{-1}$ respectively)

(A) 4500 cm^3 (B) 450 cm^3 (C) 2000 cm^3 (D) 6000 cm^3

Question No. 25 to 29 (5 question)

Solids and liquids both expand on heating. The density of substance decreases on expanding according to the relation

$$\rho_2 = \frac{\rho_1}{1+\gamma(T_2 - T_1)}$$

where, $\rho_1 \rightarrow$ density at T_1

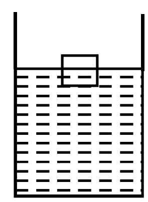
$\rho_2 \rightarrow$ density at T_2

$\gamma \rightarrow$ coeff. of volume expansion of substances

when a solid is submerged in a liquid, liquid exerts an upward force on solid which is equal to the weight of liquid displaced by submerged part of solid.

Solid will float or sink depends on relative densities of solid and liquid.

A cubical block of solid floats in a liquid with half of its volume submerged in liquid as shown in figure (at temperature T)



$\alpha_s \rightarrow$ coeff. of linear expansion of solid

$\gamma_L \rightarrow$ coeff. of volume expansion of liquid

$\rho_s \rightarrow$ density of solid at temp. T

$\rho_L \rightarrow$ density of liquid at temp. T

25. The relation between densities of solid and liquid at temperature T is

(A) $\rho_S = 2\rho_L$ (B) $\rho_S = (1/2)\,\rho_L$ (C) $\rho_S = \rho_L$ (D) $\rho_S = (1/4)\,\rho_L$

26. If temperature of system increases, then fraction of solid submerged in liquid

(A) increases (B) decreases (C) remains the same (D)inadequate information

27. Imagine fraction submerged does not change on increasing temperature the relation between γ_L and α_S is

(A) $\gamma_L = 3\alpha_S$ (B) $\gamma_L = 2\alpha_S$ (C) $\gamma_L = 4\alpha_S$ (D) $\gamma_L = (3/2)\alpha_S$

28. Imagine the depth of the block submerged in the liquid does not change on increasing temperature then

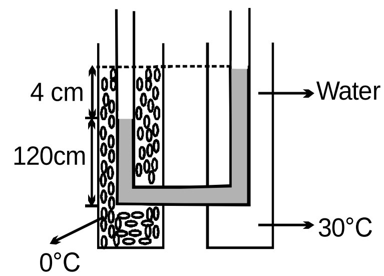
(A) $\gamma_L = 2\alpha$ (B) $\gamma_L = 3\alpha$ (C) $\gamma_L = (3/2)\alpha$ (D) $\gamma_L = (4/3)\alpha$

29. Assume block does not expand on heating. The temperature at which the block just begins to sink in liquid is
(A) $T + 1/\gamma_L$ (B) $T + 1/(2\gamma_L)$ (C) $T + 2/\gamma_L$ (D) $T + \gamma_L/2$

30. The coefficient of apparent expansion of a liquid in a copper vessel is C and in a silver vessel is S. The coefficient of volume expansion of copper is γ_C. What is the coefficient of linear expansion of silver?
(A) $\frac{(C+\gamma_c+S)}{3}$ (B) $\frac{(C-\gamma_c+S)}{3}$ (C) $\frac{(C+\gamma_c-S)}{3}$ (D) $\frac{(C-\gamma_c-S)}{3}$

31. An aluminium container of mass 100 gm contains 200 gm of ice at –20°C. Heat is added to the system at the rate of 100 cal/s. The temperature of the system after 4 minutes will be (specific heat of ice = 0.5 and L = 80 cal/gm, specific heat of A*l* = 0.2 cal/gm/°C)
(A) 40.5°C (B) 25.5°C (C) 30.3°C (D) 35.0°C

32. Two vertical glass tubes filled with a liquid are connected by a capillary tube as shown in the figure. The tube on the left is put in an ice bath at 0°C while the tube on the right is kept at 30° C in a water bath. The differenece in the levels of the liquid in the two tubes is 4 cm while the height of the liquid column at 0° C is 120 cm. The coefficient of volume expansion of liquid is (Ignore expansion of glass tube)



(A) 22×10^{-4}/°C (B) 1.1×10^{-4}/°C
(C) 11×10^{-4}/°C (D) 2.2×10^{-4}/°C

33. A difference of temperature of 25ºC is equivalent to a difference of :
(A) 45º F (B) 72º F (C) 32º F (D) 25º F

34. Two thermometers x and y have fundamental intervals of 80º and 120º. When immersed in ice, they show the reading of 20º and 30º. If y measures the temperature of a body as 120º, the reading of x is :
(A) 59º (B) 65º (C) 75º (D) 80º

MULTIPLE CHOICE QUESTIONS

35. When an enclosed perfect gas is subjected to an adiabatic process :
(A) Its total internal energy does not change
(B) Its temperature does not change
(C) Its pressure varies inversely as a certain power of its volume
(D) The product of its pressure and volume is directly proportional to its absolute temperature.

36. Four rods A, B, C, D of same length and material but of different radii r, $r\sqrt{2}$, $r\sqrt{3}$ and 2r respectively are held between two rigid walls. The temperature of all rods is increased by same amount. If the rods donot bend, then
(A) the stress in the rods are in the ratio 1 : 2 : 3 : 4
(B) the force on the rod exerted by the wall are in the ratio 1 : 2 : 3 : 4
(C) the energy stored in the rods due to elasticity are in the ratio 1 : 2 : 3 : 4
(D) the strains produced in the rods are in the ratio 1 : 2 : 3 : 4

37. A body of mass M is attached to the lower end of a metal wire, whose upper end is fixed. The elongation of the wire is l.
(A) Loss in gravitational potential energy of M is Mgl
(B) The elastic potential energy stored in the wire is Mgl
(C) The elastic potential energy stored in the wire is 1/2 Mgl
(D) Heat produced is 1/2 Mgl

38. When the temperature of a copper coin is raised by 80ºC, its diameter increases by 0.2%.
(A) Percentage rise in the area of a face is 0.4%
(B) Percentage rise in the thickness is 0.4%
(C) Percentage rise in the volume is 0.6%
(D) Coefficient of linear expansion of copper is 0.25×10^{-4}C^{o-1}.