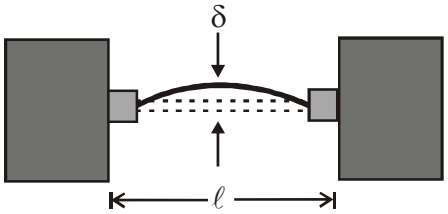
[SINGLE CORRECT CHOICE TYPE]

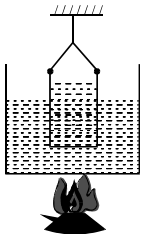
Q.1 A long, thin metal bar of length ℓ is clamped rigidly at its ends at temperature t_0. When the temperature t is increased, the expanding bar will bow out, as shown below. If the bowing in not too large, a fair first approximation to the shape of the bar is two equal straight segments in the form of a wide V. What is the arch δ of the bow as a function of t? (This is the distance between the corner of the V and the straight line that represents the form of the bar at t_0.) **[3]**



(A*) $\delta = (\ell/2)\sqrt{2\alpha(t-t_0)}$ (B) $\delta = (\ell)\sqrt{\alpha(t-t_0)}$

(C) $\delta = (\ell/2)\sqrt{\alpha(t-t_0)}$ (D) $\delta = (\ell)\sqrt{2\alpha(t-t_0)}$

Q.2 Water is boiling in a large vessel as shown in figure. If another vessel containing water is dipped in the bigger vessel as shown. Choose correct options for water in smaller vessel **[3]**



(A*) will not boil (B) will boil below 100°C

(C) will boil above 100°C (D) will boil at 100°C

Q.3 'Gulab Jamuns' (assumed to be spherical) are to be heated in an oven. They are available in two sizes, one twice bigger (in radius) than the other. Pizzas (assumed to be discs) are also to be heated in oven. They are also in two sizes, one twice big (in radius) than the other. All four are put together to be heated to oven temperature. Choose the correct option from the following: **[3]**

(A) Both size gulab jamuns will get heated in the same time.

(B*) Smaller gulab jamuns are heated before bigger ones.

(C) Smaller pizzas are heated before bigger ones.

(D) Bigger pizzas are heated before smaller ones.

Q.4 Three rods of identical cross-section area and made from the same material form the sides of an isosceles triangle ABC, right angled at B. The points A and C are maintained at temperatures T and $\sqrt{2}\,T$ respectively. In the steady state, the temperature of the point B is T_B. Assuming that only heat conduction takes place, the ratio T_B/T is equal to: **[3]**

(A) $\dfrac{2}{\sqrt{2}-1}$ (B*) $\dfrac{1+\sqrt{2}}{2}$ (C) $\sqrt{2}-1$ (D) $\sqrt{2}+1$

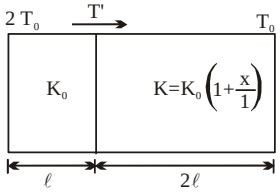
Q.5 In a container of negligible heat capacity 100 gm of a liquid at 20°C is heated. Specific heat of the liquid varies with temperature given as s = (100T + 500) J/kg/°C, where T is in °C. Find the amount of heat required to raise the temperature of the liquid to 40°C. **[3]**

(A) 5000 J (B) 6000 J (C*) 7000 J (D) 8000 J

Q.6 The temperature of a body falls from 52°C to 36°C in 10 minutes when placed in a surrounding of constant temperature 20°C. What will be the temperature of the body after another 10 min. (Use Newton's law of cooling) **[3]**

(A*) 28°C (B) 20°C (C) 32°C (D) 24°C

Q.7 What is the temperature T' at the interface if heat conductivity of first slab of length 'ℓ' is K_0 and is uniform every where but the conductivity of second slab of length '2ℓ' varies with the distance 'x' measured from the interface according to the law $K = K_0\left(1+\frac{x}{\ell}\right)$. The temperature at the boundries of the composite slab are $2T_0$ and T_0 **[3]**



(A) $T' = \left(\frac{2\ell n2+1}{\ell n2+1}\right)T_0$ (B*) $T' = \left(\frac{2\ell n3+1}{\ell n3+1}\right)T_0$

(C) $T' = \left(\frac{\ell n3+1}{2\ell n3+1}\right)T_0$ (D) $T' = \left(\frac{4\ell n3+1}{\ell n3+1}\right)T_0$

Q.8 The young's modulus, E, of a material measures how stiff it is ; the larger the value of E the more stiff the material. Consider a solid, rectangular steel beam which is anchored horizontally to the wall at one end and allowed to deflect under its own weight. The beam has length L, vertical thickness h, width w, mass density ρ and Young's modulus E; the acceleration due to gravity is g. What is the distance through which the other end moves? (Hint : you are expected to solve this problem by eliminating implausible answers. Also note that all the options are dimensionally correct.) **[3]**

(A) $2\frac{\rho gh^2}{E}$ (B) $\sqrt{2Lh}$ (C*) $\frac{3}{2}\frac{\rho gL^4}{Eh^2}$ (D) $\sqrt{3}\frac{EL}{\rho gh}$

Q.9 The rates of heat radiation from two patches of skin each of area S, on a patient's chest differ by 2%. If the patch of the lower temperature is at 300 K and the emissivity of body the patches is assumed to be unity, the temperature of the other patch is closest to : **[3]**

(A*) 301.5 K (B) 306 K (C) 308.5 K (D) 312 K

Q.10 The solar constant of earth is 2 cal/min-cm^2. If distance of mercury planet from sun is 0.4 times the distance of earth from the sun, then solar constant of mercury planet will be: **[3]**

(A*) 12.5 cal/min–cm^2 (B) 25 cal/min–cm^2

(C) 0.32 cal/min–cm^2 (D) 2 cal/min–cm^2

Q.11 A solid body of linear expansion coefficient 2×10^{-5} (°C)$^{-1}$ floats in a liquid with 20% of its volume out of the liquid at a temperature 20°C. The volumetric expansion coefficient of liquid is 3 times that of the solid body's volumetric expansion coefficient. If the temperature is increased to 70 °C, the new fraction of the body's volume out of the liquid will be approximately **[3]**

(A) 19.7% (B) 20.1% (C*) 19.5% (D) 20.7%

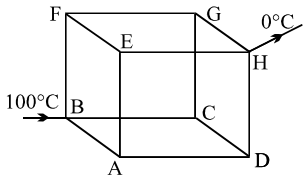
Q.12 1 g of steam at 100°C and an equal mass of ice at 0°C are mixed. The temperature of the mixture in steady state will be: [Latent heat of steam = 540 cal g^{-1} and latent heat of ice = 80 cal/g] **[3]**

(A) 50°C (B*) 100°C (C) 67°C (D) None of these

Q.13 Two thin walled spheres of different materials, one with double the radius and one-fourth wall thickness of the other, are filled with ice. If the time taken for complete melting of ice in the sphere of larger radius is 25 minutes and that for smaller one is 16 minutes, the ratio of thermal conductivities of the materials of larger sphere to the smaller sphere is **[3]**

(A) 4 : 5 (B) 25 : 1 (C) 1 : 25 (D*) 8 : 25

Q.14 Twelve conducting rods form the riders of a uniform cube of side '*l*'. If in steady state, B and H ends of the rod are at 100°C and 0°C. Find the temperature of the junction 'A'. **[3]**



(A) 80°C (B*) 60°C (C) 40°C (D) 70°C

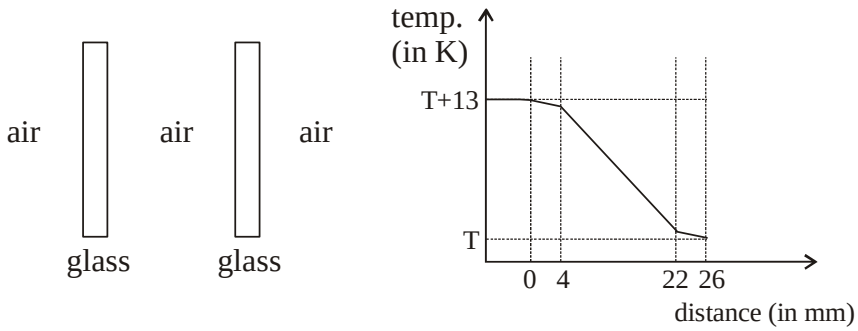
Q.15 When a body is placed in surroundings at a constant temperature of 20°C, and heated by a 10-W heater, its temperature remains constant at 40°C. If the temperature of the body is now raised from 20°C to 80° in 5 minutes at a uniform rate, the total heat it will lose to the surroundings will be **[3]**

(A) 3000 J (B) 3600 J (C*) 4500 J (D) 5400 J

[PARAGRAPH TYPE]

Paragraph for question nos. 16 to 17

The figure shows a cross section of a double glass unit and a graph of the temperatures at different points within the unit. The temperature difference across the unit is 13K. It has a cross sectional area of 1.3 m^2 and the rate of heat flow through it is 65 W. The temperature distance graph does not change with time. Glass has a thermal conductivity of 1W/mk.



Q.16 Select the correct statement **[3]**

(A) The unit is in steady state and in thermal equilibrium

(B*) The unit is in steady state but not in thermal equilibrium

(C) The unit is not in steady state but is in thermal equilibrium

(D) The unit is neither in steady state nor in thermal equilibrium

Q.17 The thermal conductivity of air is **[3]**

(A) $\frac{1}{10}$ W/mk (B) $\frac{1}{12}$ W/mk (C*) $\frac{1}{14}$ W/mk (D) $\frac{1}{18}$ W/mk

[MULTIPLE CORRECT CHOICE TYPE]

Q.18 A hollow copper sphere & a hollow copper cube , of same surface area & negligible thickness, are filled with warm water of same temperature and placed in an enclosure of constant temperature, a few degrees below that of the bodies. Then in the beginning **[4]**

(A) the rate of energy lost by the sphere is greater than that by the cube

(B*) the rate of energy lost by the two are equal

(C) the rate of energy lost by the sphere is less than that by the cube

(D*) the rate of fall of temperature for sphere is less than that for the cube.

Q.19 Two rods of different material having coefficients of linear expansion α_1 and α_2 and Young's modulus Y_1 and Y_2 respectively are fixed between two rigid walls. The rods are heated to same temperature. If $\alpha_1 : \alpha_2$: :: 2 : 3 and the thermal stress in two rods are same, then the ratio Y_1/Y_2 is **[4]**
(A) 2/3 (B) 1 / 1 (C*) 3/2 (D) 4/9

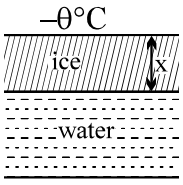
Q.20 Two thermometers, one containing mercury and another spirit read same temperature. The mercury thermometer has a lower emissivity than spirit thermometer. Both have the same area and heat capacity. If both are brought in bright sun. **[4]**
(A) The temperature rises at equal rate in both.
(B*) The temperature rises at higher rate in spirit thermometer.
(C*) Final steady state temperature will be the same in both.
(D) Final steady state temperature will be higher in spirit thermometer.

Q.21 A black body emits radiation at the rate P when its temperature is T. At this temperature the wavelength of peak intensity is λ. If its temperature becomes T' such that wavelength of peak intensity is $\lambda/4$. The rate of radiation is P. **[4]**
(A*) P ' T ' = 1024 PT (B*) T ' = 4 T (C*) P ' = 256 P (D) P ' T ' = 4 PT

Q.22 A uniform cylinder of steel of mass *M*, radius *R* is placed on frictionless bearings and set to rotate about its axis with angular velocity ω_0. After the cylinder has reached the specified state of rotation, it is heated from temperature T_0 to $(T_0 + \Delta T)$ without any mechanical contact . If $\frac{\Delta I}{I}$ is the fractional change in moment of inertia of the cylinder and $\frac{\Delta\omega}{\omega_0}$ be the fractional change in the angular velocity of the cylinder and α be the coefficient of linear expansion, then **[4]**

(A*) $\frac{\Delta I}{I} = \frac{2\Delta R}{R}$ (B) $\frac{\Delta I}{I} = \frac{2\Delta\omega}{\omega_0}$ (C*) $\frac{\Delta\omega}{\omega_0} = -2\alpha\Delta T$ (D) $\frac{\Delta I}{I} = -\frac{2\Delta R}{R}$

Q.23 Consider the shown case of a freezing lake due to negative environmental temperature (–θ°C). Thickness (x) of ice layer is small in comparison to depth of lake. Rate of increase in x will be greater **[4]**



(A) if environmental temperature increases
(B) for larger thickness of ice layer
(C*) if environmental temperature decreases
(D*) for smaller thickness of ice layer

Q.24 A calorimeter of water equivalent 50 g contains 100 g water at 30°C. In each of the situations, select the option(s) that indicate the correct final temperature, after mixing (in calorimeter) **[4]**
(A*) 15 g of ice at –20°C ; final temperature 210/11°C
(B*) 5 g of steam at 100°C ; final temperature 1540/31°C
(C) 80 g of water at 70°C ; final temperature 430/9°C
(D*) 15 g of ice at 0°C ; final temperature 20°C