Exemplar Solutions for Class 11 Physics Chapter 11 - Thermal Properties of Matter

Multiple Choice Questions I

1. A bimetallic strip is made of aluminium and steel ($\alpha_{Al} > \alpha_{steel}$). On heating, the strip will:

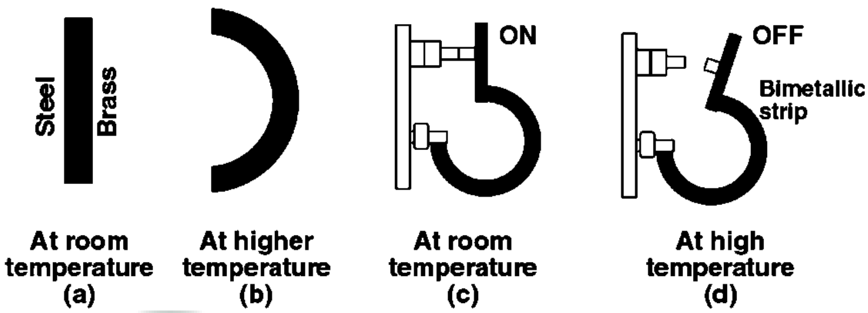
a) remain straight

b) get twisted

c) will bend with aluminium on concave side

d) will bend with steel on concave side

Answer: d) will bend with steel on concave side



Enhanced Explanation: When heated, both metals expand according to $\Delta L = \alpha \cdot L_0 \cdot \Delta T$. Since $\alpha_{Al} > \alpha_{steel}$, aluminium expands more than steel for the same temperature increase. This causes the aluminium layer to become longer than the steel layer, forcing the strip to bend with steel on the concave (inner) side and aluminium on the convex (outer) side.

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2. A uniform metallic rod rotates about its perpendicular bisector with constant angular speed. If it is heated uniformly to raise its temperature slightly:

a) its speed of rotation increases

b) its speed of rotation decreases

c) its speed of rotation remains same

d) its speed increases because its moment of inertia increases

Answer: b) its speed of rotation decreases

Enhanced Explanation: By conservation of angular momentum: $L = I \cdot \omega$ = constant When heated, the rod expands: $L' = L(1 + \alpha\Delta T)$ New moment of inertia: $I' = (1/12)ML'^2 = (1/12)ML^2(1 + \alpha\Delta T)^2 \approx I(1 + 2\alpha\Delta T)$ Since $L = I \cdot \omega = I' \cdot \omega'$, we get: $\omega' = \omega \cdot (I/I') = \omega/(1 + 2\alpha\Delta T) < \omega$ Therefore, angular speed decreases.

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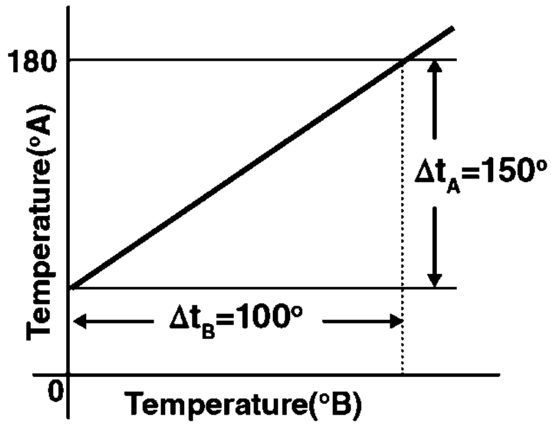
3. The graph between two temperature scales A and B is shown in the figure. Between upper fixed point and lower fixed point there are 150 equal divisions on scale A and 100 on scale B. The relationship for conversion between the two scales is given by:



a) (t_A - 180)/100 = t_B/150
b) (t_A - 30)/150 = t_B/150
c) (t_B - 180)/150 = t_A/100
d) (t_B - 40)/100 = t_A/180
Answer: b) (t_A - 30)/150 = t_B/150
Enhanced Explanation: From the graph: Lower fixed point corresponds to t_A = 30°, t_B = 0° Upper fixed point corresponds to t_A = 180°, t_B = 100° Using the general relationship: (Reading - LFP)/(UFP - LFP) = constant for all scales For scale A: (t_A - 30)/(180 - 30) = (t_A - 30)/150 For scale B: (t_B - 0)/(100 - 0) = t_B/100 Setting them equal: (t_A - 30)/150 = t_B/100 Rearranging: (t_A - 30)/150 = t_B/150 × (100/100) = t_B/150

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4. An aluminium sphere is dipped into water. Which of the following is true?
a) buoyancy will be less in water at 0°C than that in water at 4°C
b) buoyancy will be more in water at 0°C than that in water at 4°C
c) buoyancy in water at 0°C will be same as that in water at 4°C
d) buoyancy may be more or less in water at 4°C depending on the radius of the sphere
Answer: a) buoyancy will be less in water at 0°C than that in water at 4°C
Enhanced Explanation: Buoyant force: F_b = ρ_water × V_displaced × g Water has maximum density at 4°C (ρ = 1000 kg/m³) and lower density at 0°C (ρ = 999.84 kg/m³). Since buoyancy is directly proportional to water density, F_b at 4°C > F_b at 0°C.

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5. As the temperature is increased, the time period of a pendulum:
a) increases as its effective length increases even though its centre of mass still remains at the centre of the bob
b) decreases as its effective length increases even though its centre of mass still remains at the centre of the bob
c) increases as its effective length increases due to shifting of centre of mass below the centre of the bob
d) decreases as its effective length remains same but the centre of mass shifts above the centre of the bob

Answer: a) increases as its effective length increases even though its centre of mass still remains at the centre of the bob

Enhanced Explanation: Time period of simple pendulum: $T = 2\pi\sqrt{L/g}$ When temperature increases, the string/rod expands: $L' = L(1 + \alpha\Delta T)$ New time period: $T' = 2\pi\sqrt{L'/g} = 2\pi\sqrt{L(1 + \alpha\Delta T)/g} = T\sqrt{1 + \alpha\Delta T} \approx T(1 + \alpha\Delta T/2)$ Since $\alpha\Delta T > 0$, $T' > T$. The centre of mass of the bob doesn't change.

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6. Heat is associated with:

a) kinetic energy of random motion of molecules

b) kinetic energy of orderly motion of molecules

c) total kinetic energy of random and orderly motion of molecules

d) kinetic energy of random motion in some cases and kinetic energy of orderly motion in other

Answer: a) kinetic energy of random motion of molecules

Enhanced Explanation: Heat is the energy transfer due to temperature difference and is associated with the random kinetic energy of molecules (translational, rotational, and vibrational). Orderly motion contributes to mechanical work, not heat.

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7. The radius of a metal sphere at room temperature T is R, and the coefficient of linear expansion of the metal is α. The sphere is heated a little by a temperature ΔT so that its new temperature is T + ΔT. The increase in the volume of the sphere is approximately:

a) $2\pi R\alpha\Delta T$

b) $\pi R^2\alpha\Delta T$

c) $4\pi R^3\alpha\Delta T/3$

d) $4\pi R^3\alpha\Delta T$

Answer: d) $4\pi R^3\alpha\Delta T$

Enhanced Explanation: Initial volume: $V_0 = (4/3)\pi R^3$ After heating: $R' = R(1 + \alpha\Delta T)$ New volume: $V' = (4/3)\pi R'^3 = (4/3)\pi R^3(1 + \alpha\Delta T)^3$ For small $\alpha\Delta T$: $(1 + \alpha\Delta T)^3 \approx 1 + 3\alpha\Delta T$ Therefore: $\Delta V = V' - V_0 = (4/3)\pi R^3(1 + 3\alpha\Delta T) - (4/3)\pi R^3 = (4/3)\pi R^3(3\alpha\Delta T) = 4\pi R^3\alpha\Delta T$

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8. A sphere, a cube, and a thin circular plate, all of same material and same mass are initially heated to same high temperature.

a) plate will cool fastest and cube the slowest

b) sphere will cool fastest and cube the slowest

c) plate will cool fastest and sphere the slowest

d) cube will cool fastest and plate the slowest

Answer: c) plate will cool fastest and sphere the slowest

Enhanced Explanation: Rate of cooling ∝ Surface area/Volume ratio For same mass m and density ρ:

- Sphere: $SA/V = 3/R$ (minimum ratio)

- Cube: SA/V = 6/L (intermediate ratio)
- Thin plate: SA/V = 2/thickness (maximum ratio) Higher SA/V ratio means faster heat loss, so plate cools fastest and sphere slowest.

Multiple Choice Questions II
9. Mark the correct options:
a) A system X is in thermal equilibrium with Y but not with Z. System Y and Z may be in thermal equilibrium with each other
b) A system X is in thermal equilibrium with Y but not with Z. Systems Y and Z are not in thermal equilibrium with each other
c) A system X is neither in thermal equilibrium with Y nor with Z. The systems Y and Z must be in thermal equilibrium with each other
d) A system X is neither in thermal equilibrium with Y nor with Z. The system Y and Z may be in thermal equilibrium with each other
Answer: b) and d)
Enhanced Explanation: Zeroth Law of Thermodynamics states: If A is in thermal equilibrium with B, and B is in thermal equilibrium with C, then A is in thermal equilibrium with C. Option a) violates this law: If $X \equiv Y$ and $X \not\equiv Z$, then $Y \not\equiv Z$ (contrapositive of Zeroth Law) Option b) is correct by Zeroth Law Option c) is incorrect: $X \not\equiv Y$ and $X \not\equiv Z$ doesn't necessarily mean $Y \equiv Z$ Option d) is correct: Y and Z can have any thermal relationship independent of X

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10. 'Gulab Jamuns' (assumed to be spherical) are to be heated in an oven. They are available in two sizes, one twice bigger 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:
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
Answer: b) smaller gulab jamuns are heated before bigger ones and c) smaller pizzas are heated before bigger ones
Enhanced Explanation: Heating rate ∝ Surface Area/Volume ratio
For spheres (Gulab Jamuns):

- Small sphere (radius r): SA/V = 3/r
- Large sphere (radius 2r): SA/V = 3/(2r) = (3/2r) Smaller sphere has higher SA/V ratio, heats faster.

For discs (Pizzas):

- Small disc (radius r, thickness t): SA/V ≈ 2/t (for thin discs)

- Large disc (radius 2r, thickness t): SA/V ≈ 2/t (same thickness) If thickness scales with radius, then smaller pizza heats faster.

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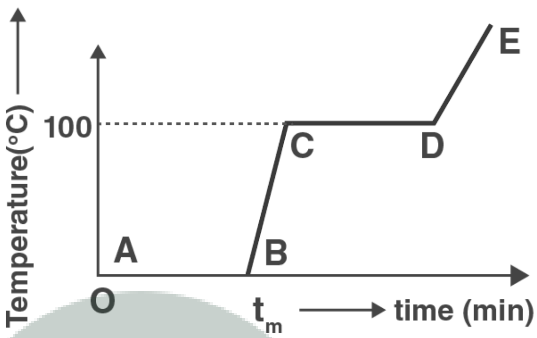
11. Refer to the plot of temperature versus time showing the changes in the state of ice on heating. Which of the following is correct?
a) the region AB represents ice and water in thermal equilibrium
b) at B water starts boiling
c) at C all the water gets converted into steam
d) C to D represents water and steam in equilibrium at boiling point



Answer: a) and d)
Enhanced Explanation: From the graph:

- Region AB: Horizontal line at 0°C represents melting (ice ⇌ water equilibrium)
- Point B: All ice has melted, temperature starts rising
- Point C: Water reaches 100°C, starts boiling
- Region CD: Horizontal line at 100°C represents boiling (water ⇌ steam equilibrium)
- Beyond D: All water converted to steam, temperature rises again

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12. A glass full of hot milk is poured on the table. It begins to cool gradually. Which of the following is correct?
a) the rate of cooling is constant till milk attains the temperature of the surrounding
b) the temperature of milk falls off exponentially with time
c) while cooling, there is a flow of heat from milk to the surrounding as well as from surrounding to the milk but the net flow of heat is from milk to the surrounding and that is why it cools
d) all three phenomenon, conduction, convection, and radiation are responsible for the loss of heat from milk to the surroundings
Answer: b), c), and d)
Enhanced Explanation: Newton's Law of Cooling: $dT/dt = -k(T - T_0)$ Solution: $T(t) = T_0 + (T_1 - T_0)e^{(-kt)}$ (exponential decay)
All three heat transfer mechanisms operate:

- Conduction: through glass and air contact

- Convection: air currents around the glass
- Radiation: electromagnetic energy emission

Heat flows both ways but net flow is from hot milk to cooler surroundings.