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

Very Short Answers

13. Is the bulb of a thermometer made of diathermic or adiabatic wall?

Answer: The bulb of a thermometer is made of diathermic walls as they allow the conduction of heat.

Enhanced Explanation: Diathermic walls allow heat transfer, enabling thermal equilibrium between the thermometer and the medium being measured. Adiabatic walls would prevent heat transfer, making temperature measurement impossible.

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14. A student records the initial length l, change in temperature ΔT and change in length Δl of a rod as follows:

Sl.no	l (m)	ΔT (°C)	Δl (m)
1	2	10	4×10^{-4}
2	1	10	4×10^{-4}
3	2	20	2×10^{-4}
4	3	10	6×10^{-4}

If the first observation is correct, what can you say about observations 2, 3, and 4?

Answer: From the first observation: $\alpha = \Delta l/(l \times \Delta T) = (4 \times 10^{-4})/(2 \times 10) = 2 \times 10^{-5}$ °C^{-1}

For observation 2: $\Delta l = \alpha l\Delta T = 2 \times 10^{-5} \times 1 \times 10 = 2 \times 10^{-4}$ m $\neq 4 \times 10^{-4}$ m **[Incorrect]**

For observation 3: $\Delta l = \alpha l\Delta T = 2 \times 10^{-5} \times 2 \times 20 = 8 \times 10^{-4}$ m $\neq 2 \times 10^{-4}$ m **[Incorrect]**

For observation 4: $\Delta l = \alpha l\Delta T = 2 \times 10^{-5} \times 3 \times 10 = 6 \times 10^{-4}$ m $= 6 \times 10^{-4}$ m **[Correct]**

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15. Why does a metal bar appear hotter than a wooden bar at the same temperature? Equivalently it also appears cooler than wooden bar if they are both colder than room temperature.

Answer: Metal has higher thermal conductivity than wood. When touched:

- Hot objects: Metal conducts heat to your hand faster → feels hotter
- Cold objects: Metal conducts heat away from your hand faster → feels colder The rate of heat transfer, not the actual temperature, determines the sensation.

Enhanced Explanation: Thermal conductivity of metals (~100 W/m·K) >> wood (~0.1 W/m·K) Rate of heat transfer: $q = kA\Delta T/d$, where k is thermal conductivity Higher k means faster heat transfer and stronger temperature sensation.

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16. Calculate the temperature which has same numerical value on Celsius and Fahrenheit scale.

Answer: Conversion formula: $F = (9/5)C + 32$ Setting $F = C = T$: $T = (9/5)T + 32$ Solving: $T - (9/5)T = 32$ $(-4/5)T = 32$ $T = -40$

Therefore, -40°C = -40°F

Enhanced Explanation: The relationship between temperature scales is linear: (C - 0)/(100 - 0) = (F - 32)/(212 - 32) This gives F = (9/5)C + 32. The intersection occurs where the two scales have equal numerical values.

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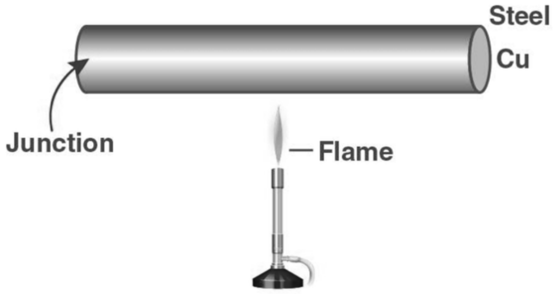
17. These days people use steel utensils with copper bottom. This is supposed to be good for uniform heating of food. Explain this effect using the fact that copper is the better conductor.

Answer: Copper has much higher thermal conductivity ($k_{Cu} \approx 400$ W/m·K) compared to steel ($k_{steel} \approx 50$ W/m·K).



The copper bottom:

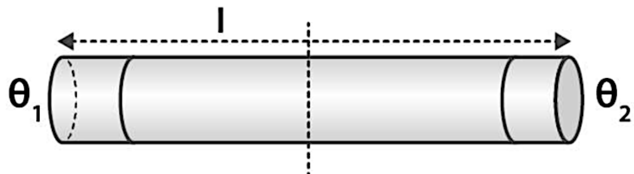
1. Conducts heat rapidly from the flame across the entire base
2. Ensures uniform temperature distribution
3. Eliminates hot spots that could burn food
4. Provides better heat transfer to the steel walls containing the food

This combination uses copper's superior conduction for heat distribution and steel's durability for the container structure.

Short Answers

18. Find out the increase in moment of inertia I of a uniform rod about its perpendicular bisector when its temperature is slightly increased by ΔT.

Answer: Initial moment of inertia: $I = (1/12)ML^2$



When heated, new length: $L' = L(1 + \alpha\Delta T)$ New moment of inertia: $I' = (1/12)ML'^2 = (1/12)ML^2(1 + \alpha\Delta T)^2$

For small $\alpha\Delta T$: $(1 + \alpha\Delta T)^2 \approx 1 + 2\alpha\Delta T$ Therefore: $I' = I(1 + 2\alpha\Delta T)$

Increase in moment of inertia: $\Delta I = I' - I = I(2\alpha\Delta T) = 2I\alpha\Delta T$

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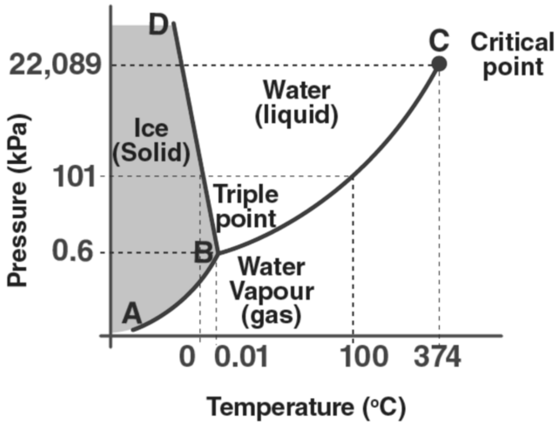
19. During summers in India, one of the common practice to keep cool is to make ice balls of crushed ice, dip it in flavoured sugar syrup and sip it. For this a stick is inserted into crushed ice and is squeezed in the palm to make it into the ball. Equivalently in winter, in

those areas where it snows, people make snow balls and throw around. Explain the formation of ball out of crushed ice or snow in the light P-T diagram of water.

Answer: From the P-T diagram of water, the solid-liquid boundary has a negative slope (unusual property of water).



When pressure is applied by squeezing:

1. Pressure increases along the ice-water boundary
2. Due to negative slope, increased pressure lowers the melting point
3. Ice melts locally at the contact points under pressure
4. When pressure is released, water refreezes
5. This creates bonds between ice particles, forming a cohesive ball

This regelation process allows ice particles to stick together under pressure and refreeze when pressure is removed.

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20. 100 g of water is supercooled to -10°C. At this point, due to some disturbance mechanised or otherwise some of it suddenly freezes to ice. What will be the temperature of the resultant mixture and how much mass would freeze?

Answer: When supercooled water at -10°C partially freezes, the final temperature will be 0°C (ice-water equilibrium).

Heat released by water cooling from -10°C to 0°C = Heat absorbed by ice formation

Let m be the mass that freezes: 100g × 1 cal/g°C × 10°C = m × 80 cal/g (latent heat of fusion)

1000 cal = m × 80 cal/g m = 1000/80 = 12.5 g

Final mixture: 12.5 g ice + 87.5 g water at 0°C

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21. One day in the morning, Ramesh filled up 1/3 bucket of hot water from geyser, to take bath. Remaining 2/3 was to be filled by cold water to bring mixture to a comfortable temperature. Suddenly Ramesh had to attend something which would take some times, say 5-10 minutes before he could take bath. Now he has two options: a) fill the remaining bucket completely by cold water and then attend the work b) first attend to the work and fill the remaining bucket just before taking bath. Which option do you think would have kept water warmer? Explain.

Answer: Option (a) will keep water warmer.

Using Newton's Law of Cooling: $dT/dt = -k(T - T_0)$ Rate of cooling $\propto (T - T_0)$

Option (a): Mix hot and cold water first

- Creates moderate temperature difference with surroundings
- Lower cooling rate during the waiting period

Option (b): Keep hot water separate initially

- Large temperature difference between hot water and surroundings
- Higher cooling rate, more heat lost during waiting period

The key principle: Smaller temperature differences result in slower heat loss rates.