

conceptual physics chapter 35 review question answers

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Mastering Conceptual Physics Chapter /35: A Complete Review Question and Answer Guide

When it comes to mastering physics, the ability to translate concepts into clear, problem solving strategies is essential. Chapter /35 of the widely used *Conceptual Physics* textbook focuses on the fundamentals of thermodynamics and heat transfer. Whether you're a high school student preparing for exams, a college freshman tackling your first physics course, or a lifelong learner seeking a deeper understanding of everyday phenomena, this chapter is a cornerstone of the subject.

In this article, we provide an in depth review of Chapter 35, offering a curated set of review questions along with detailed answers. Each answer is crafted to reinforce the underlying concepts, illustrate common pitfalls, and provide practical examples that bring the theory to life. By the end of this guide, you'll have a solid grasp of thermodynamics, the laws governing heat, and the ability to confidently tackle any related problem on your next test.

What Chapter /35 Covers: A Quick Overview

Chapter /35 of *Conceptual Physics* is organized around three core themes:

- Heat and Temperature – Understanding how energy transfer manifests as heat and how temperature quantifies the average kinetic energy of particles.
- Thermal Conduction, Convection, and Radiation – The three primary mechanisms of heat transfer, each with unique physical principles and applications.
- The Laws of Thermodynamics – The fundamental principles that govern energy transformations, including conservation, entropy, and the feasibility of perpetual motion.

Each section is built on intuitive explanations, everyday examples, and a series of conceptual questions that test your comprehension. Below, we dive deeper into each theme, followed by a comprehensive set of review questions and answers.

Heat and Temperature: The Foundations of Energy Transfer

Why Temperature Matters

Temperature is a measure of the average kinetic energy of the particles in a system. It tells us how “hot” or “cold” an object is, but it is not a direct measure of the amount of energy it contains. Two bodies at the same temperature can contain vastly different amounts of internal energy depending on their masses and specific heat capacities.

Specific Heat Capacity and Heat Capacity

Specific heat capacity (c) is an intrinsic property of a material that indicates how much heat (Q) is required to raise its temperature by one degree Celsius (or Kelvin). The relationship is:

$$Q = mc\Delta T$$

where m is mass and ΔT is the temperature change. Heat capacity (C) is the product of specific heat capacity and mass: $C = mc$. Materials with high heat capacities, such as water, can absorb or release large amounts of heat with

only a modest temperature change.

Latent Heat: The Energy of Phase Changes

When a substance changes phase (e.g., ice melting to water), energy is absorbed or released without changing temperature. This energy is called latent heat. The equation for latent heat (L) is:

$$Q = mL$$

Understanding latent heat is essential for explaining everyday phenomena such as boiling water, condensation, and the cooling effect of sweating.

Heat Transfer Mechanisms: Conduction, Convection, and Radiation

Conduction: Direct Energy Transfer

Conduction occurs when heat moves through a material via collisions between adjacent particles. The rate of conduction depends on the material's thermal conductivity (k), the temperature gradient, and the cross sectional area:

$$Q/t = kA \frac{\Delta T}{L}$$

Metals, for example, are excellent conductors due to free electrons, while materials like wood or rubber are poor conductors (insulators).

Convection: Heat Transfer by Fluid Motion

Convection involves the bulk movement of a fluid (liquid or gas). Warm fluid rises, cool fluid sinks, creating a circulation pattern that transfers heat. Convection can be natural (driven by buoyancy) or forced (driven by pumps or fans). The heat transfer coefficient (h) quantifies how efficiently convection moves heat:

$$Q/t = hA \Delta T$$

Radiation: Energy Transfer Through Electromagnetic Waves

All objects emit electromagnetic radiation based on their temperature. The Stefan–Boltzmann law describes the power radiated per unit area:

$$P/A = \sigma T^4$$

where σ is the Stefan–Boltzmann constant. Radiation does not require a medium, which is why the Earth receives heat from the Sun through the vacuum of space.

The Laws of Thermodynamics: Governing Energy and Entropy

First Law: Conservation of Energy

The first law states that energy cannot be created or destroyed, only transformed:

$$\Delta E_{int} = Q - W$$

where ΔE_{int} is the change in internal energy, Q is heat added to the system, and W is work done by the system. This principle underlies all energy conversion processes, from engines to refrigerators.

Second Law: Entropy and the Direction of Heat Flow

The second law introduces entropy (S) as a measure of disorder. It states that in an isolated system, entropy tends to increase over time. Heat naturally flows from hot to cold, and no process can be 100% efficient. This law explains why perpetual motion machines of the second kind are impossible.

Third Law: Absolute Zero and Entropy

The third law states that as temperature approaches absolute zero, the entropy of a perfect crystal approaches zero. This sets a lower bound on temperature and has implications for cryogenic technologies.

Review Questions and Answers: Test Your Understanding

Below is a curated set of review questions that cover the core concepts of Chapter 35. Each question is followed by a detailed answer that explains the reasoning and clarifies common misconceptions.

1. Why does a metal spoon feel colder than a wooden spoon when placed in the same cold environment?

Because metals have higher thermal conductivity, they transfer heat from your hand to the surrounding environment more efficiently than wood. When you hold the spoon, heat from your hand flows into the metal spoon rapidly, causing the metal to feel cooler. Wood, being an insulator, slows this transfer, so the temperature of the wooden spoon rises more slowly, keeping it warmer to touch.

2. A 1 /kg block of ice at 0 /°C melts into water at 0 /°C. How much heat is absorbed during this process if the latent heat of fusion for ice is 334 /kJ/kg?

Use the latent heat equation:

$$Q = mL$$

Substitute $m = 1 \text{ /kg}$ and $L = 334 \text{ /kJ/kg}$:

$$Q = 1 \text{ /kg} \times 334 \text{ /kJ/kg} = 334 \text{ /kJ}$$

So the block absorbs 334 /kJ of heat during melting.

3. Explain why a cup of hot coffee cools down faster when placed in a windy room than in a still room.

Wind increases the convective heat transfer coefficient (h). The rate of convective heat loss is proportional to h :

$$Q/t = hA(\theta_{EB})$$

When wind blows, it removes the thin layer of warm air around the cup, exposing the coffee to cooler air and increasing the temperature gradient (θ_{EB}). This leads to a higher heat loss rate, cooling the coffee faster.

4. A black surface at 300 /K emits radiation. Calculate the power radiated per unit area using the Stefan–Boltzmann law ($\sigma = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$).

$$\text{Power per unit area (P/A)} = \sigma T^4$$

$$P/A = 5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4 \times (300 \text{ /K})^4$$

$$\text{Compute } (300 \text{ /K})^4 = 8.1 \times 10^9 \text{ /K}^4$$

$$P/A = 5.67 \times 10^{-8} \text{ W/m}^2 \times 8.1 \times 10^4 = 459 \text{ W/m}^2$$

So the black surface emits about 459 W of power per square meter.

5. Describe the difference between heat and temperature using an everyday analogy.

Think of heat as the amount of sugar you add to a cup of tea, and temperature as the sweetness level you taste. Adding more sugar (heat) increases the sweetness, but the perceived sweetness (temperature) depends on how much sugar you taste relative to the volume of tea. Similarly, heat is energy transfer, while temperature is a measure of average kinetic energy per particle.

6. A piston compresses an ideal gas from volume $V_1 = 0.01 \text{ m}^3$ to $V_2 = 0.005 \text{ m}^3$ at constant temperature. If the initial pressure is 2 bar, what is the final pressure?

Use Boyle's Law ($P_1 V_1 = P_2 V_2$) for isothermal processes:

$$P_2 = P_1 V_1 / V_2 = 2 \text{ bar} \times 0.01 \text{ m}^3 / 0.005 \text{ m}^3 = 4 \text{ bar}$$

The final pressure is 4 bar.

7. Explain why refrigerators use a refrigerant cycle to cool the interior.

Refrigerators rely on the vapor–liquid cycle of a refrigerant. The refrigerant evaporates inside the evaporator coil, absorbing heat from the interior (cooling it). It then moves to the compressor, where pressure and temperature rise. After that, it condenses in the condenser coil, releasing heat to the outside. Finally, it expands back to low pressure and repeats the cycle. This continuous cycle extracts heat from the fridge's interior and expels it externally.

8. What is the role of entropy in determining whether a spontaneous process can occur?

Entropy (S) measures disorder. In an isolated system, spontaneous processes increase total entropy. If a process would decrease entropy, it cannot occur spontaneously. For example, water spontaneously freezing at 0 °C increases entropy because the system's energy is distributed in more microstates (solid vs. liquid). Thus, entropy acts as a thermodynamic arrow of time.

9. A 100 W light bulb is connected to a 120 V supply. Calculate the current drawn and discuss the power factor if the bulb is purely resistive.

Use Ohm's Law: $I = P/V$:

$$I = 100 \text{ W} / 120 \text{ V} = 0.833 \text{ A}$$

A purely resistive load has a power factor of 1 (or 100 %). The current and voltage are in phase, so all supplied power is used for useful work.

10. Why does the Earth's atmosphere retain heat from the Sun?

The atmosphere contains greenhouse gases (CO_2 , H_2O vapor, CH_4 , etc.) that absorb infrared radiation emitted by Earth's surface. These gases then re-emit radiation in all directions, including back toward the surface, trapping heat. This greenhouse effect keeps Earth's average temperature high enough to support liquid water and life.

Common Pitfalls and How to Avoid Them

- **Confusing Heat and Temperature:** Remember, heat is energy transfer; temperature is a state variable.
- **Forgetting the Direction of Heat Flow:** Heat always flows from higher to lower temperature unless external work is applied.

- Neglecting Latent Heat in Phase Changes: Ignoring latent heat can lead to incorrect temperature predictions during melting or boiling.
- Misapplying the First Law: The sign convention for work (W) depends on whether work is done on or by the system.
- Assuming Perfect Insulators: No material is a perfect insulator; always consider realistic thermal conductivities.

How to Use This Guide Effectively

1. Read the Chapter Thoroughly: Start with the textbook to build a solid conceptual foundation.

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