Thermodynamics

Section Study Guide

Teacher Notes and Answers

RELATIONSHIPS BETWEEN HEAT AND WORK
1. a. 0.020 m³
   b. 7.0 \times 10^3 \text{ J}
   c. 2.0 \times 10^3 \text{ J increase}
2. a. yes, marble to water
   b. no, \Delta U by heat only
   c. decrease; temperature dropped
   d. increase; more water, less ice
   e. no change, the cup is insulated

THE FIRST LAW OF THERMODYNAMICS
1. a. –320 J
   b. The gas lost energy because \Delta U was less than 0.
   c. Student diagrams should show the \( W \) arrow and the \( Q \) arrow pointing OUT of the container.

THE SECOND LAW OF THERMODYNAMICS
1. a. 8.0 \times 10^3 \text{ J}
   b. 20%
   c. 3.2 \times 10^2 \text{ N}
2. a. 7.00 \times 10^3 \text{ J}
   b. 1.30 \times 10^4 \text{ J}
   c. 4.0 \times 10^1 \text{ m}
3. a. 5.0 \times 10^2 \text{ J}
   b. 3.4 \times 10^2 \text{ J}
   c. 1.9 \times 10^2 \text{ J}
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**Concept Review**

**Relationships Between Heat and Work**

1. A gas enclosed in a cylinder occupies 0.030 m$^3$. It is compressed under a constant pressure of $3.5 \times 10^5$ Pa until its final volume is exactly one-third of its initial volume.

   a. What was the change in the gas volume? ______________________________

   b. How much work was done? ________________________________________

   c. The gas lost $5.0 \times 10^3$ J as heat during the compression process. Did the internal energy of the gas increase or decrease? By how much?

2. A steel marble at room temperature is placed in a plastic-foam cup containing ice and water at 0°C. After thermal equilibrium is reached, the temperature of the ice-water mixture and marble is 0°C.

   a. Was energy transferred between the marble and the water as heat? Which object lost energy?

   b. Was any work done on the marble or by the marble? _____________________

   c. Did the internal energy of the marble increase or decrease? What was a measurable effect of this change?

   d. Did the internal energy of the water-ice mixture increase or decrease? How could this be observed?

   e. Did the internal energy of the system consisting of the water-ice mixture and the marble increase or decrease?
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Diagram Skills

The First Law of Thermodynamics

1. A gas trapped in a cylinder does 540 J of work by expansion. At the end of the process, the internal energy has decreased by 860 J.

   a. How much energy was transferred as heat between the gas and its environment?

   b. Did the gas gain or lose energy in this transfer? Explain.

   c. In the space below, sketch a diagram of the gas container, and draw arrows showing the energy transfers as work and as heat.

2. The same amount of work (540 J) is done to compress the gas, this time in an isothermal process.

   a. What is the change in internal energy of the gas?

   b. How much energy is transferred as heat?

   c. Is that energy removed from or added to the gas? Sketch a diagram showing the energy transfers as work and as heat.
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Concept Review

The Second Law of Thermodynamics

1. A steam engine absorbs $4.00 \times 10^4$ J and expels $3.20 \times 10^4$ J as heat.
   a. How much work is done?

   b. What is the efficiency of this engine?

   c. If the engine exerts a constant force through a displacement of 25 m, how great is the force exerted by the engine?

2. The efficiency of a diesel engine is 0.35. The engine absorbs $2.00 \times 10^4$ J as heat.
   a. How much work does the engine do?

   b. How much heat is expelled?

   c. If this engine exerts a force of 175 N on an object, how far will the object be displaced?

3. An experimental gasoline engine performs at 32 percent efficiency and does $1.60 \times 10^2$ J of work in each cycle.
   a. How much energy does the engine absorb as heat in a cycle?

   b. How much energy is lost in each cycle?

   c. How much work would the same engine do if it absorbed the same amount of heat per cycle as described in a, but was operating at a 38 percent efficiency?