

KEY IDEAS

Section 1 Relationships Between Heat and Work

- A thermodynamic system is an object or set of objects considered to be a distinct physical entity to or from which energy is added or removed. The surroundings make up the system's environment.
- Energy can be transferred to or from a system as heat and/or work, changing the system's internal energy in the process.
- For gases at constant pressure, work is defined as the product of gas pressure and the change in the volume of the gas.

Section 2 The First Law of Thermodynamics

- Energy is conserved for any system and its environment and is described by the first law of thermodynamics.
- A cyclic process returns a system to conditions identical to those it had before the process began, so its internal energy is unchanged.

Section 3 The Second Law of Thermodynamics

- The second law of thermodynamics states that no machine can transfer all of its absorbed energy as work.
- The efficiency of a heat engine depends on the amount of energy transferred as heat to and from the engine.
- Entropy is a measure of the disorder of a system. As a system becomes more disordered, less of its energy is available to do work.
- The entropy of a system can increase or decrease, but the total entropy of the universe is always increasing.

KEY TERMS

system (p. 336)

environment (p. 337)

isovolumetric process (p. 339)

isothermal process (p. 340)

adiabatic process (p. 341)

cyclic process (p. 346)

entropy (p. 355)

PROBLEM SOLVING

See **Appendix D: Equations** for a summary of the equations introduced in this chapter. If you need more problem-solving practice, see **Appendix I: Additional Problems**.

Variable Symbols

Quantities	Units
ΔU change in internal energy	J joules
Q heat	J joules
W work	J joules
eff efficiency	(unitless)

Diagram Symbols

Energy transferred as heat



Energy transferred as work



Thermodynamic cycle

