Module 5: Energy and Chemistry
The First Law of Thermodynamics

Fundamentals of Chemistry Open Course

Learning Objectives | Module 5

1. Recognize and define energy and the various forms of energy.

2. Recognize and convert between the most common units of energy in chemistry.

3. Conceptualize problems in thermodynamics by properly defining the system and surroundings.

4. Distinguish between open, closed, and isolated thermodynamic systems.

5. Define and apply the first law of thermodynamics.

6. Provide technical definitions for heat and work and distinguish between them.

The First Law of Thermodynamics

- After properly defining the system and surroundings, the next step in solving thermodynamics problems is applying the appropriate law(s) of thermodynamics.

- All physically possible processes abide by these laws.

- **The first law of thermodynamics** concerns the nature of energy and places a fundamental constraint on energy transfer.
  - Energy is conserved. In all physically allowable processes, energy is neither created nor destroyed—however, energy can change form.
  - Changes in internal energy (ΔU) are due to heat (q) and/or work (w). Heat and work encompass all possible ways energy can be transferred to or from a thermodynamic system.

$$\Delta U = q + w$$

- A good conceptual definition of the first law is available on Wikipedia.

Sign Conventions for Heat and Work

$$\Delta U = q + w$$

- The signs of heat and work reflect whether the energetic content of the system is increasing (+) or decreasing (–).

- Positive *w* indicates that the surroundings are doing work on the system; the internal energy of the system increases as a result.
- Negative *w* indicates that the system is doing work on the surroundings; the internal energy of the system decreases as a result.

$$w = -P\Delta V$$

- Positive *q* indicates that thermal energy is entering the system; the internal energy of the system increases as a result.
- Negative *q* indicates that thermal energy is leaving the system; the internal energy of the system decreases as a result.

$$q = C\Delta T$$

Lingering Questions

- There are three other laws of thermodynamics. What are they and how do we apply them to solve problems?

- The first law says that energy is conserved but places no constraints on the form of energy.
  Can heat be converted fully into work or *vice versa*?

- The laws of thermodynamics are used to define the important thermodynamic quantities enthalpy (*H*), entropy (*S*), and free energy (*G*). What are these quantities and how can we apply them?