Module 5: Energy and Chemistry
Solving Problems in Thermodynamics

Fundamentals of Chemistry Open Course

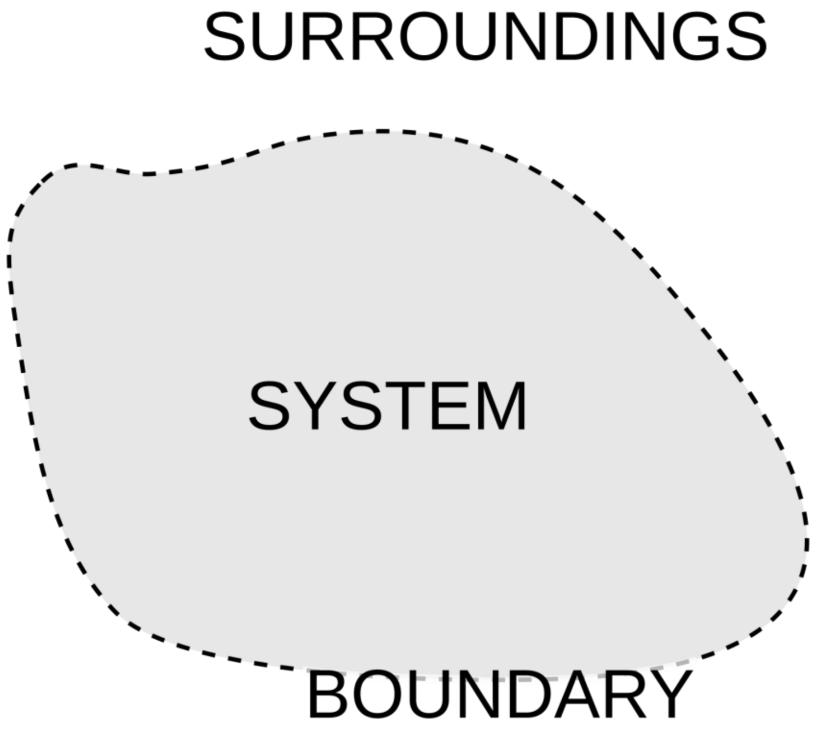
Learning Objectives | Module 5

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.

Thermodynamic Systems

- A **thermodynamic system** is a body of matter or radiation defined by a boundary (real or artificial!) that separates the system from its **surroundings**.

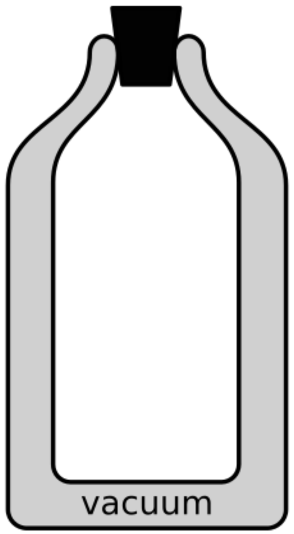
- The system and surroundings taken together include everything (of interest…), which we call the **universe**.



Thermodynamic Systems

- Thermodynamic systems are classified according to whether they can accommodate transfers of matter and/or energy.
  - **Open systems** can engage in transfers of both energy and matter.
  - **Closed systems** can engage in transfers of energy, but matter cannot enter or leave.
  - **Isolated systems** cannot engage in transfers of energy or matter.

Example. Classify each system below as open, closed, or isolated.

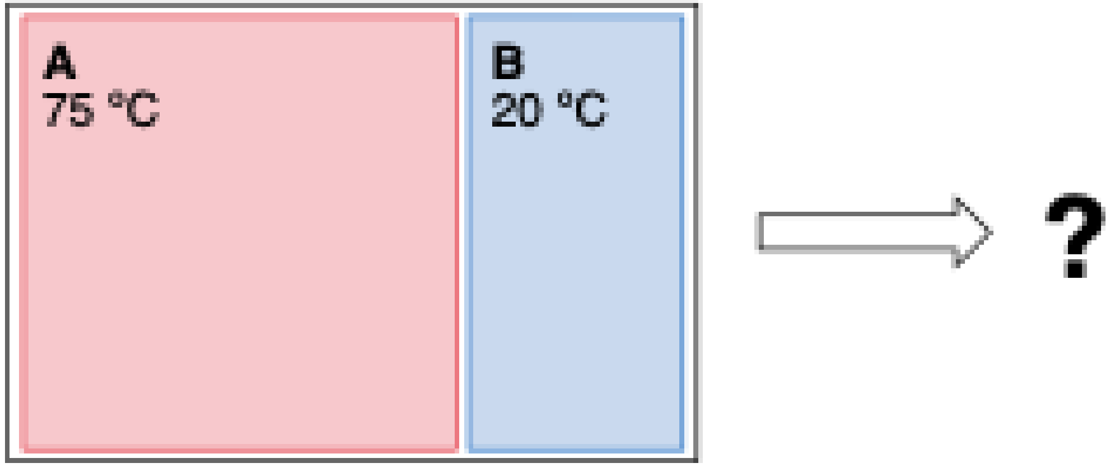


Thermodynamic States and Equilibrium

- Thermodynamic systems are described by **state:** values of a specified set of variables such as pressure P, temperature T, volume V, number of particles N, etc.

- A system is said to be in **equilibrium** when no macroscopic transfers of matter or energy are occurring between the system and its surroundings (equivalently, when no macroscopic changes in state variables are observed).

- Problems in thermodynamics center on describing or predicting how transfers of matter and/or energy will cause a thermodynamic system to evolve from one equilibrium state to another.

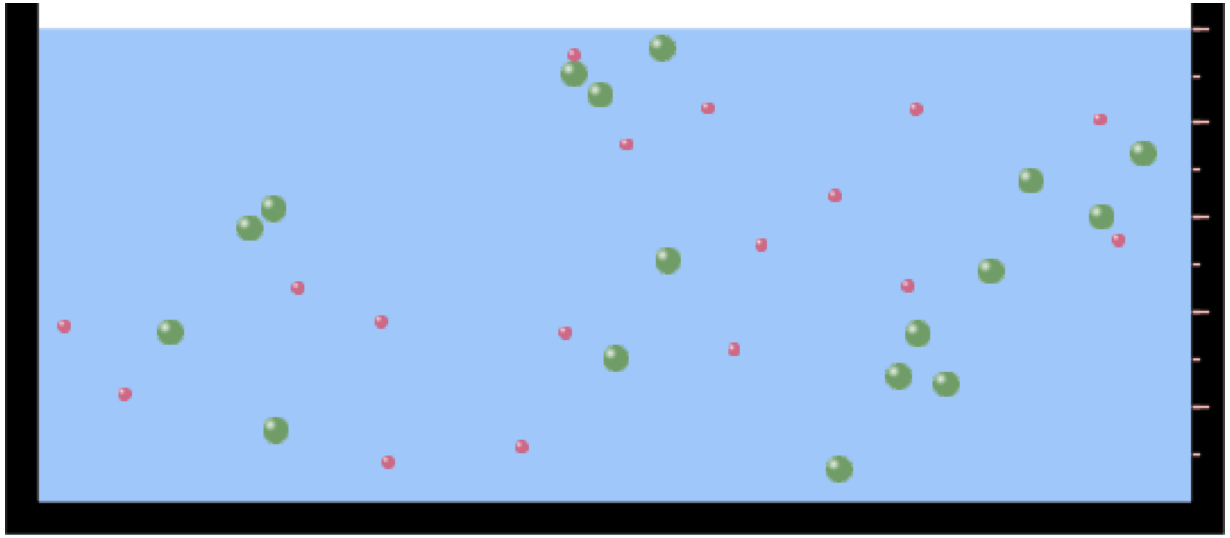


- The first step of solving any thermodynamics problem is properly defining the system, surroundings, and universe.

- We can't measure everything all at once—the universe is usually constrained to the system of interest and its immediate surroundings. We ignore all transfers of matter or energy outside our assumed universe.

- In *chemical* thermodynamics problems, the submicroscopic reactant and product molecules constitute the system. Solvent, container walls, ambient gas, etc. constitute the surroundings.

Example. When reactions take place in aqueous solutions, solvent water is considered part of the surroundings. Only the reactive solute molecules constitute the system of interest.



Lingering Questions

- What kinds of *processes* are involved in thermodynamics problems? What specific examples of transfers of matter and energy come up?

- Once we define the system and surroundings, what’s next? What concepts and equations are used to guide problem solving in chemical thermodynamics?