The First Law of Thermodynamics

Thermodynamics is the study of how heat moves. It tells us nothing about the time it takes for a process to happen but the laws of Thermodynamics have proven to govern whether things happen. Things can be anything from macroscopic phenomenon to biochemical processes.

Learning goals for today:

1. Be able to state the first law of Thermodynamics
2. Define the internal energy of a chemical system
3. Define how a state function differs from a non-state function
4. Give at least three examples of state functions
5. Define a Thermodynamic system

Statement of the first law

The internal energy of an isolated system, U_{sys}, is a state function and subject to conservation ($\Delta U_{sys} = 0$ if the initial and final states are the same).

A state function has values that do not depend on the path taken.

An isolated system is one that cannot exchange heat or matter with surroundings.

$$\Delta U_{sys} = U_{sys}^{final} - U_{sys}^{initial}$$

Internal energy

The internal energy of a chemical system is a measure of the chemical (potential) and thermal (kinetic) energy in the system. It is denoted *internal* because it does not include the kinetic and potential energies of the system moving as a whole or the interaction with the system and the surroundings. Within the context of chemistry, things like bond energies and the non-bonded interactions that we have discussed would be included in the internal energy.

State function

State functions are important in Thermodynamics. These functions do not depend on path but only the initial and final position. Examples in Thermodynamics include change in internal energy (ΔU), change in enthalpy (ΔH), change in entropy (ΔS), change in free energy (ΔG or ΔA), and others. State functions have the mathematical property of having an exact differential which will be important later on.

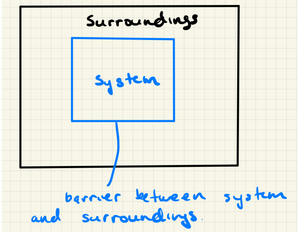
Examples of things that are not state functions: work, heat, and other specific forms of energy.

Example of a state function

Consider going from point A to point B anywhere on the globe. Change in elevation is a state function but distance traveled is not. We say that distance traveled is path dependent.

Thermodynamic system

The concept of a *system* in Thermodynamics is somewhat vague but important. A system can be defined as anything but is typically the substance/volume of interest. This might be, for example, the beaker with the solution of interest during an experiment. Key concepts regarding a system are: definition of the system, surroundings and types of barriers between system and surroundings.



Types of Thermodynamic systems

Isolated: An isolated system cannot transfer heat or mass between system and surroundings.

Closed: A closed system is one that cannot transfer mass between the system and the surroundings.

Open: An open system can transfer both heat and mass between the system and the surroundings.