11.1: Internal Energy

The internal energy of a system is identified with the random, disordered motion of molecules; the total (internal) energy in a system includes potential and kinetic energy. This is contrast to external energy which is a function of the sample with respect to the outside environment (e.g. kinetic energy if the sample is moving or potential energy if the sample is at a height from the ground etc). The symbol for Internal Energy Change is ΔU.

Energy on a smaller scale

- Internal energy includes energy on a microscopic scale
- It is the sum of all the microscopic energies such as:
  1. translational kinetic energy
  2. vibrational and rotational kinetic energy
  3. potential energy from intermolecular forces

Example

One gram of water at zero °Celsius compared with one gram of copper at zero °Celsius do NOT have the same internal energy because even though their kinetic energies are equal, water has a much higher potential energy causing its internal energy to be much greater than the copper's internal energy.

Internal Energy Change Equations

The first law of thermodynamics states:

$$dU = dq + dw \tag{11.1.1}$$

where dq is heat and dw is work.

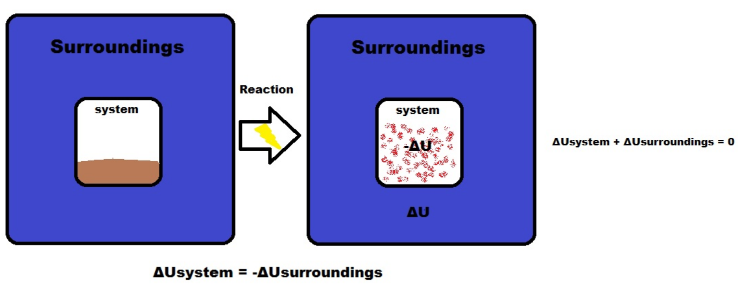
An isolated system cannot exchange heat or work with its surroundings making the change in internal energy equal to zero:

$$dU_{\text{isolated system}} = 0 \tag{11.1.2}$$

Therefore, in an isolated system:

$$dq = -dw \tag{11.1.3}$$

Energy is Conserved



$$dU_{\text{isolated system}} = dU_{\text{system}} + dU_{\text{surroundings}} \tag{11.1.4}$$

$$dU_{\text{system}} = -dU_{\text{surroundings}} \tag{11.1.5}$$

The signs of internal energy

- Energy *entering* the system is **POSITIVE (+)**, meaning heat is *absorbed*, **q>0**. Work is thus done *on* the system, **w>0**
- Energy *leaving* the system is **NEGATIVE (-)**, meaning heat is *given off* by the system, **q<0** and work is done *by* the system, **w<0**

Quick Notes

- A system *contains* ONLY Internal Energy
- A system does NOT *contain* energy in the form of heat or work
- Heat and work only exist during a change in the system; they are path functions
- Internal energy is a state function

Outside Links

- Levine, Ira N. "Thermodynamic internal energy of an ideal gas of rigid rotors." J. Chem. Educ. **1985**: 62, 53.

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