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 \( \Delta U \).

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

\[
\Delta U = q + w
\]

where \( q \) is heat and \( w \) is work

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

\[
\Delta U_{\text{isolated system}} = 0
\]

Energy is Conserved
\[ \Delta U_{\text{system}} = -\Delta U_{\text{surroundings}} \]

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, \( w < 0 \)
- Since \( \Delta U_{\text{isolated system}} = 0 \), \( \Delta U_{\text{system}} = -\Delta U_{\text{surroundings}} \) and **energy is conserved**.

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**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
- Internal energy is a state function

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**Outside Links**


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