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Thermal Physics

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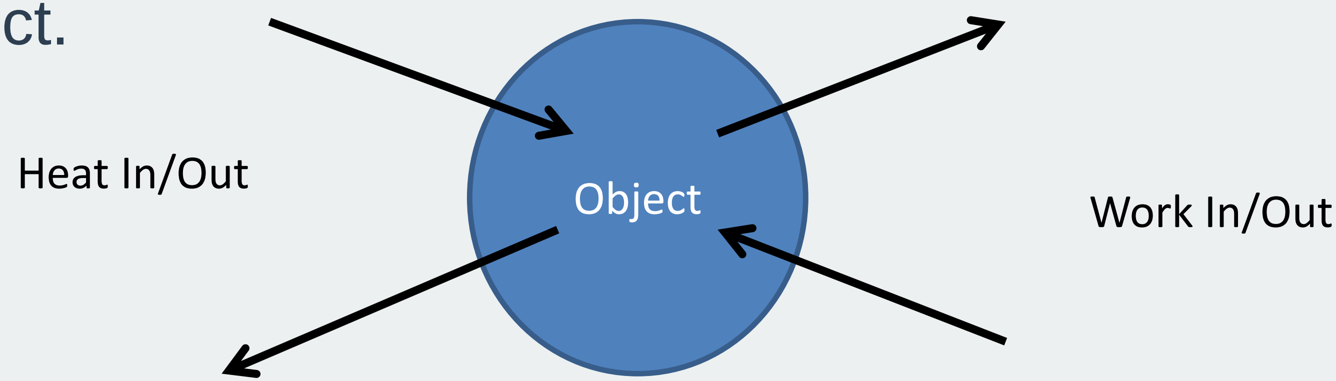
Heat

- Other form of energy that can be added/removed from an object.

- Previously, we know that if we are ***adding*** ***<u>work</u>*** to an object, we are increasing its energy(mechanical). For ex, the object is moving faster or gaining its kinetic energy.
- Now, we are able to add other form energy, heat, to an object.



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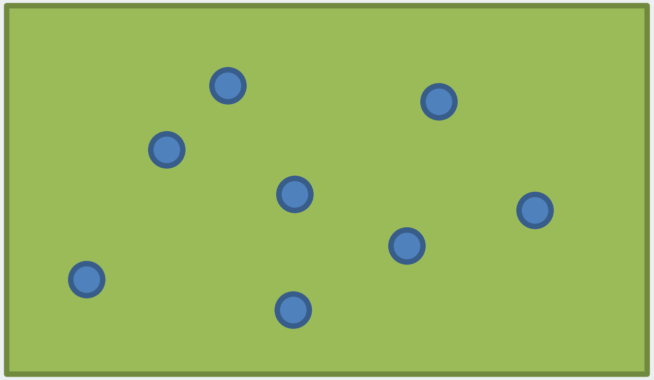
Internal Energy

- In Mechanical Energy, we are focusing on a single object.
- Imagine we have a container which consist of lot of small object and each of them has their own Mechanical Energy(KE+PE)

- If the container is containing an gas and the small objects are atoms of the gas, the summation of all “Mechanical Energy”(KE+PE) of the atom is the **Internal Energy** of the gas



Internal Energy

- In Ideal Gas cases, there is no **Potential Energy** acting on the atom, hence **Internal Energy** is the summation of **Kinetic Energy** of each atom

- ***Interesting fact!***
- For Ideal Gas, Internal Energy can be found by:

$$U = \frac{3}{2}NkT = \frac{3}{2}nRT$$

Monoatomic

$$U = \frac{5}{2}NkT = \frac{5}{2}nRT$$

Diatomic

Internal Energy

- As I mention earlier, Internal Energy is the summation of all atom Kinetic Energy
- That’s what we called Kinetic Theory of Gases. Considering that every atoms are moving in the same average speed. We can find Internal Energy by:

$$U = N.\left(\frac{1}{2}mv_{ave}^2\right)$$

Total number of atom

Average atom speed

Each atom masses

*We can combine previous page equation to obtain with this one and find properties that we need.

Temperature

- SI Unit for temperature is Kelvin

$$T_{Kelvin} = T_{Celcius} + 273.15$$

- T_{kelvin}=0 → State of an object where its Internal Energy is the lowest(zero internal energy)

Specific Heat Temperature

- The amount of heat energy needed to increase **1 Kelvin temperature** for *1 kg* of a substance, without causing a change in state.

$$c = \frac{Q}{m\,\Delta T}$$

$$Q = mc\Delta T$$

Specific Latent Heat

- Specific Latent Heat of Evaporation
  - The amount of heat energy needed to change *1 kg* of a substance from **liquid phase** to **gaseous phase** without a change of temperature.
- Specific Latent Heat of Fusion
  - the amount of heat energy needed to change *1kg* of a substance from **solid phase** to **liquid phase** without a change of temperature

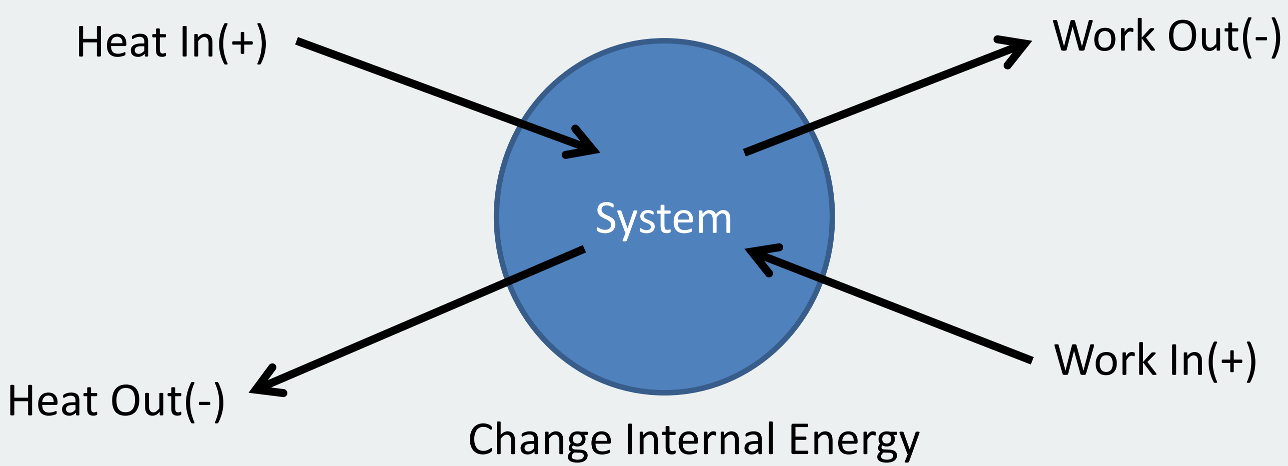
$$L = \frac{Q}{m}$$

$$Q = m.L$$

First Law of Thermodynamics

- The *increase* of internal energy of a system is equal to the sum of the heat supplied to the system and the work done on the system.

$$\Delta U = Q + W$$



- **Work Done to a system**

$$W = -\int p.dv$$

- Negative sign(-) is the convention to give us **positive work done** when negative volume change.
- When the volume is reduce, work done to the system is positive as we are compressing the system.

Thermodynamics Processes

- **Isothermal**
  - No temperature change
  - As internal energy is proportional to the temperature, when there's no temperature change, there's no change in internal energy
  - **$\Delta U=0$**
  - **$Q+W=\Delta U=0$**
  - **$Q=-W$**

- **Isothermal(Cont.)**
  - Recall ideal gas equation:

$$pv = nRT$$

$$p = \frac{nRT}{v}$$

  - Recall work done equation

$$W = -\int p.dv$$

Substitute **p** in the second equation with the first one.

$$W = -\int \frac{nRT}{v}.dv$$

Known that the nRT is constant, you can find the Work Done in Isothermal process by integrating

Thermodynamics Processes

- **Isobaric**
  - Constant temperature process
  - Effecting the work done to the system.

$$W = -\int p.\,dv$$

Constant Pressure

$$W = -p\int dv$$

$$W = -p.\Delta v$$
$$W = -p.(v_2 - v_1)$$

- **Adiabatic**
  - There's no heat addition or removal in the process
  - **$W=\Delta U$**

- **Isochoric/ Isovolumetric**
  - There's no change in volume in the process
  - As $\Delta V=0 \rightarrow W=0$
  - **$Q=\Delta U$**