Welcome to CH-1201
Elements of Chemistry-II

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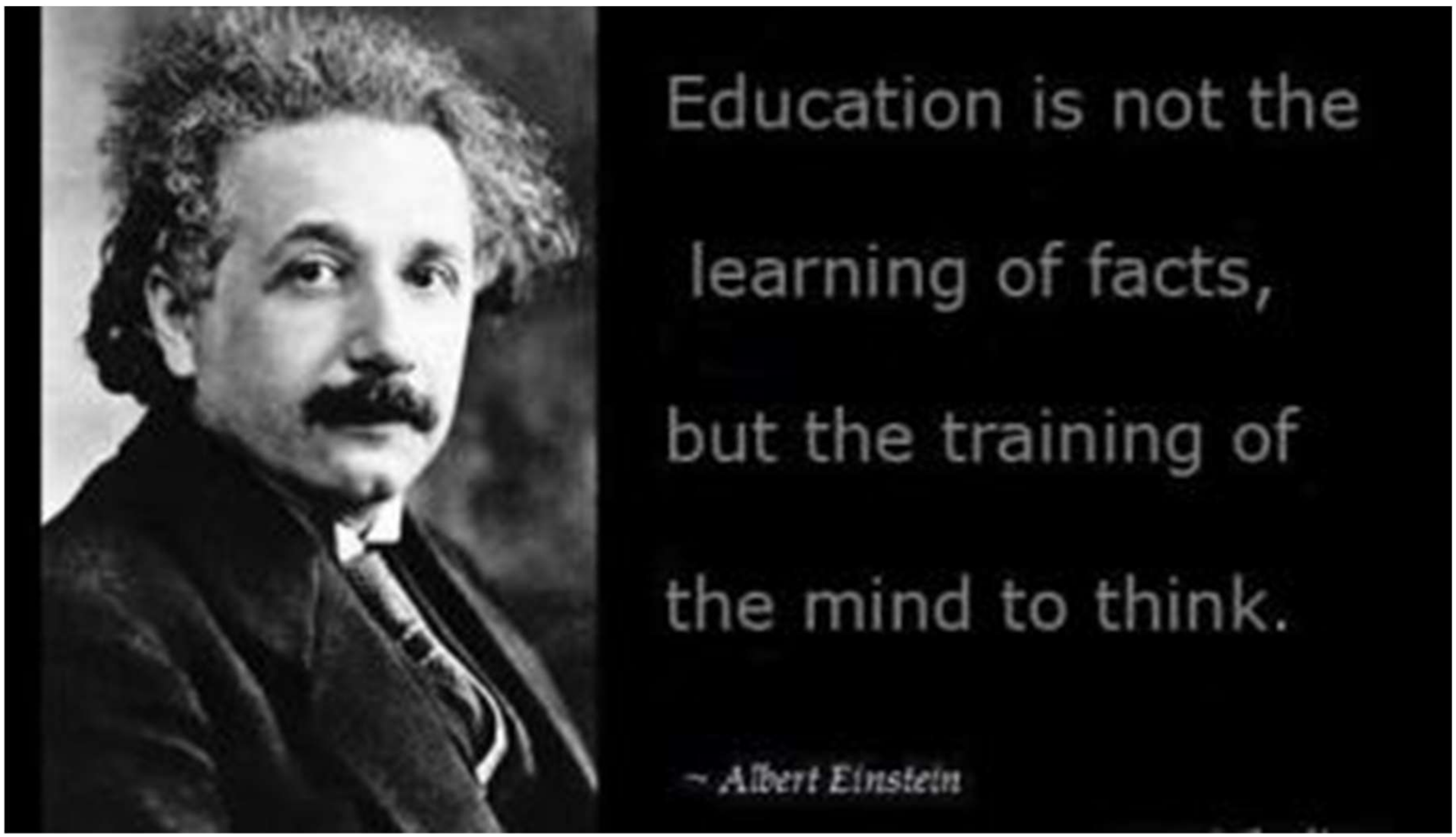


The Tale of a Tea-kettle

This image could have imperfections as it's either historical or reportage.
The Tale of a Tea-kettle'. James Watt as a boy watching the kettle boiling in the fire. Watt (1736-1819) made great improvements to the steam engine, one of the most significant being the separate condenser. In 1774 he went into partnership with Matthew Boulton (1728-1809) the Birmingham manufacturer and entrepreneur.

World History Archive

A brief history

The history of thermodynamics began in 1650 with Otto von Guericke, who built the first vacuum pump to disprove Aristotle's idea that nature abhors a vacuum. Robert Boyle and Robert Hooke later improved on this, leading to Boyle's Law. In 1679, Denis Papin developed a steam digester/ high-pressure cooker, inspiring Thomas Savery (1697) and Thomas Newcomen (1712) to create early steam engines. Joseph Black and James Watt advanced steam efficiency, and in 1824, Sadi Carnot formalized thermodynamics with his work on heat, power, and engine efficiency, marking the discipline's modern foundation.

Primary Goal of Classical Thermodynamics

- A system in Equilibrium

  All measurable properties are independent of time

- Determination of the equilibrium state that eventually results when the system undergoes a change in state
- How and to what extent we can harvest energy from different sources

Initial equilibrium state

Final equilibrium state

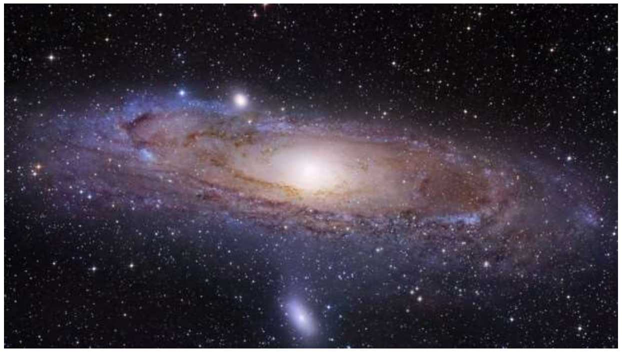
& The Tale of a Tea-kettle

Key features of classical thermodynamics

- System

  A part of the universe whose properties are being investigated
- Surrounding

  Rest of the universe
- Macroscopic dimensions
  - Length – 1 meter
  - Time – 1 minute
  - Number of particles - 6.023×10^{23}



- A system in Equilibrium

All measurable properties are independent of time

Equilibrium properties of macroscopic systems

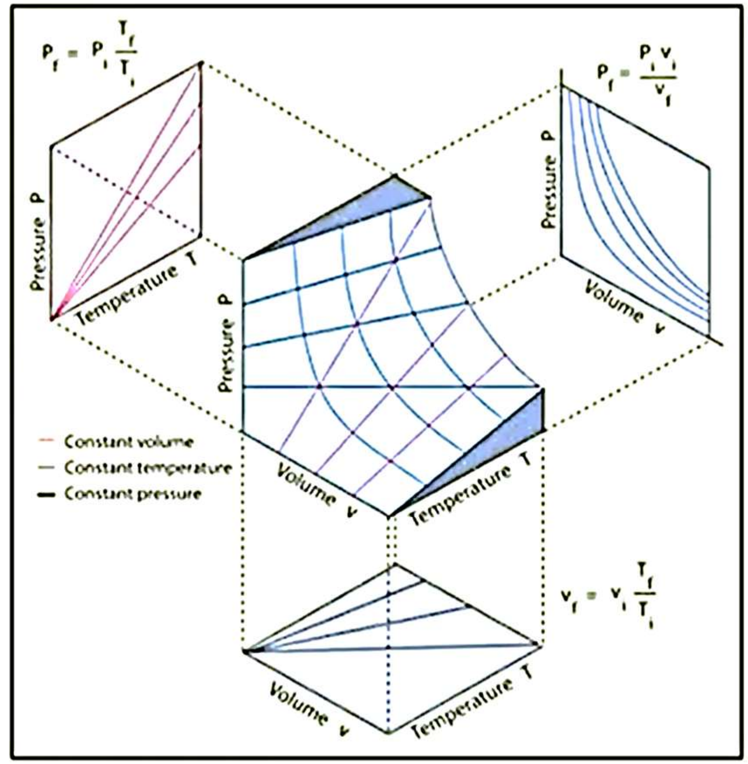
There exist particular states (called equilibrium states) of simple macroscopic systems that are characterized completely by three variables, such as

- ✓ Internal energy, U
- ✓ Volume, V
- ✓ Number of particles, N

For multi-component systems, instead of N, one uses numbers of each species, $N_1, N_2, \ldots \ldots$

Equation of State

This is a mathematical relationship between appropriate thermodynamic variables of a system at equilibrium



http://hyperphysics.phy-astr.gsu.edu/hbase/Kinetic/idegas.html

Example

- Ideal gas equation of state

$$pV = nRT$$

- van der Waals equation of state

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Isothermal, Isobaric, Isochoric, Adiabatic, Exothermic, Endothermic, Cyclic, Reversible, and Irreversible Processes

Properties of a System

1. Extensive Properties

Properties that **depend on the amount of material** or the **size of the system**.

•**Examples:** Mass, volume, total energy, heat capacity, entropy, free energy

•**Characteristic:** If you divide the system into two equal parts, each part will have half of the extensive property.

•**Example:** If a gas has a total energy of 100 J and you split it into two equal halves, each half will have 50 J.

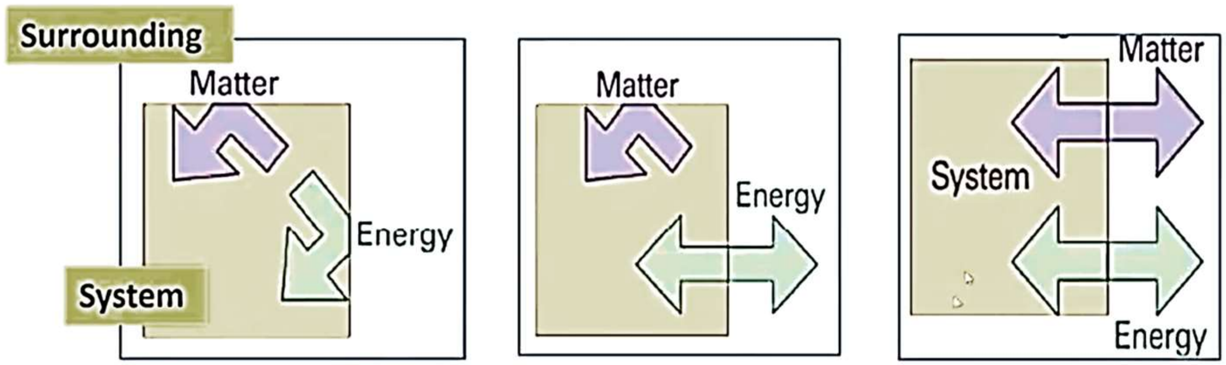
2. Intensive Properties

•**Definition:** Properties that **do not depend on the size or amount of material** in the system.

•**Examples:** Temperature, pressure, density, specific heat, refractive index, molar volume, molar heat capacity & other molar thermodynamic properties.

•**Characteristic:** Remains the same regardless of system size. The temperature of a gas in a container remains the same even if you take half of it.

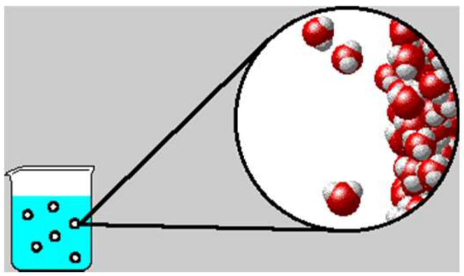
System and its Interaction with the Surroundings



Isolated

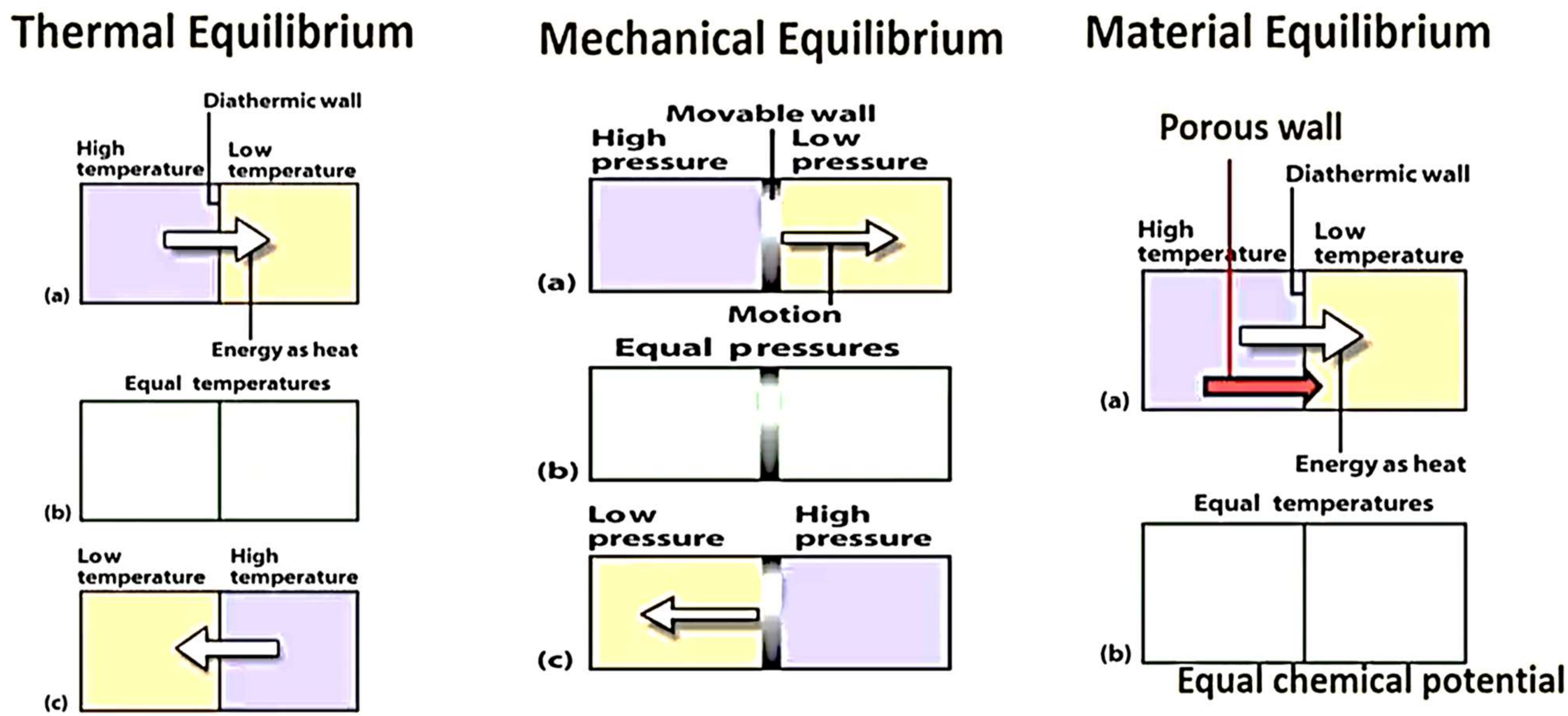
Closed

Open



	Isolated	Closed	Open
Boundary/Wall	Adiabatic Rigid, Impermeable	Diathermal Rigid, Impermeable /Flexible	Diathermal Rigid, Permeable
	U, V, N	T, V, N,/ T, P, N	T, V,μ

Types of Equilibrium



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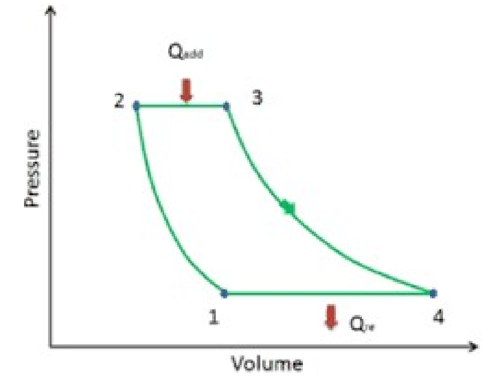
Thermodynamic Processes



It is the method of operation by which the system comes back to its initial state.

<u>Path</u>: It is sequence of intermediate steps arranged in order for the system to follow from intial equilibrium state to the final one, or final to initial.

(i) <u>Cyclic Process→</u> After a series of changes, the system comes back to its initial state.
(ii) <u>Adiabatic Process</u>→ Heat exchange is not allowed with surroundings during the process. T will vary.
(iii) <u>Isothermal Process</u>→ Temp (T) remains const & thus heat exchange continues. This occurs when the system is perfectly conducing.
(iv) <u>Isobaric Process</u>→ Pressure (P) remains const. But, V will vary.
(v) <u>Isochoric Process</u>→ Volume (V) remains constant. So, P will vary.