Thermodynamic

- ✓ **Heat** is the transfer of thermal energy between systems.
- ✓ **work** is the transfer of mechanical energy between two systems.

Closed system

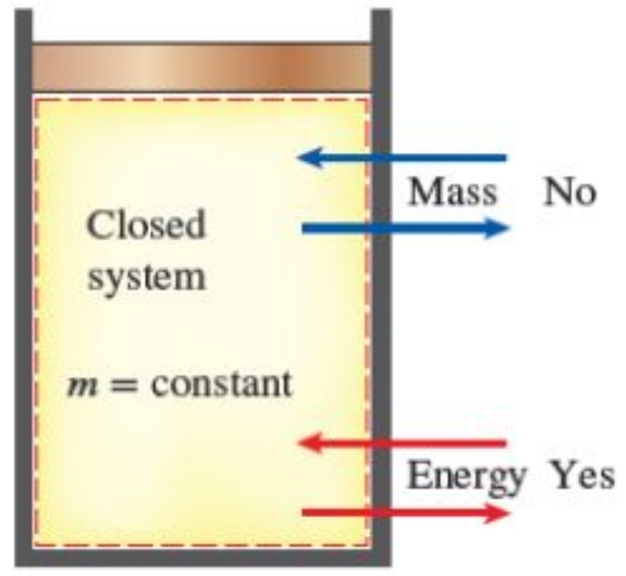
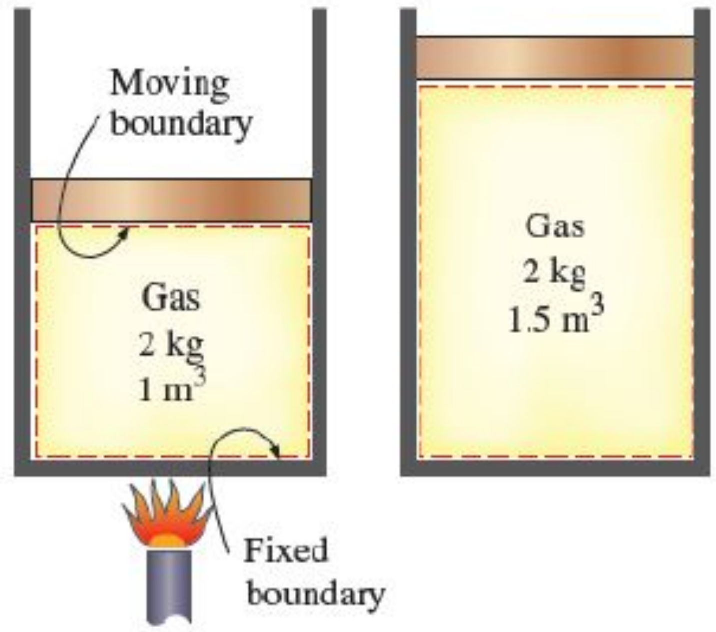
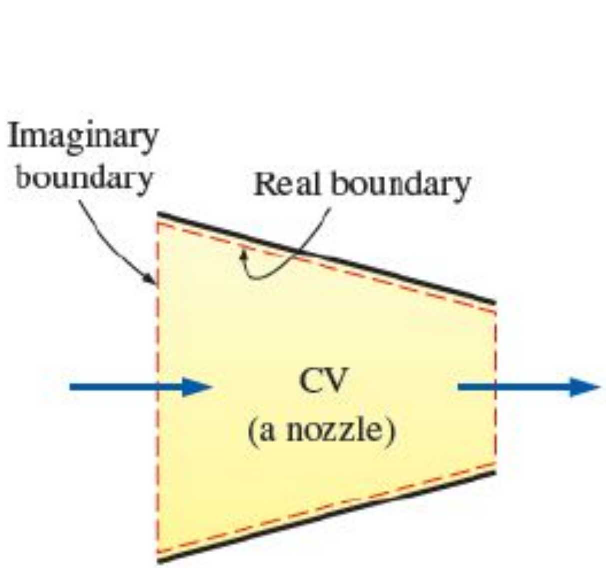


Figure 1-6: Closed system.

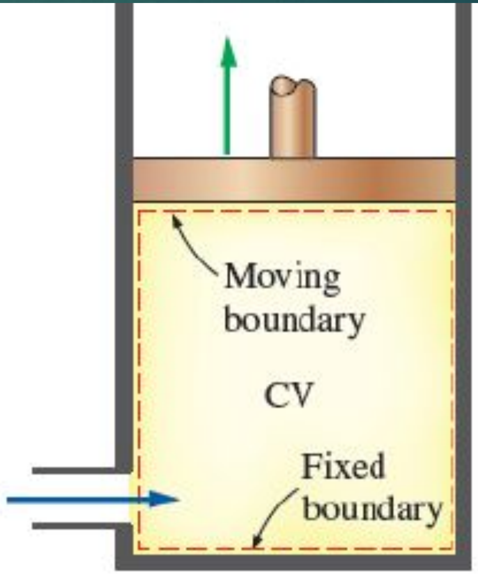


7: A closed system with a moving boundary.

Open system



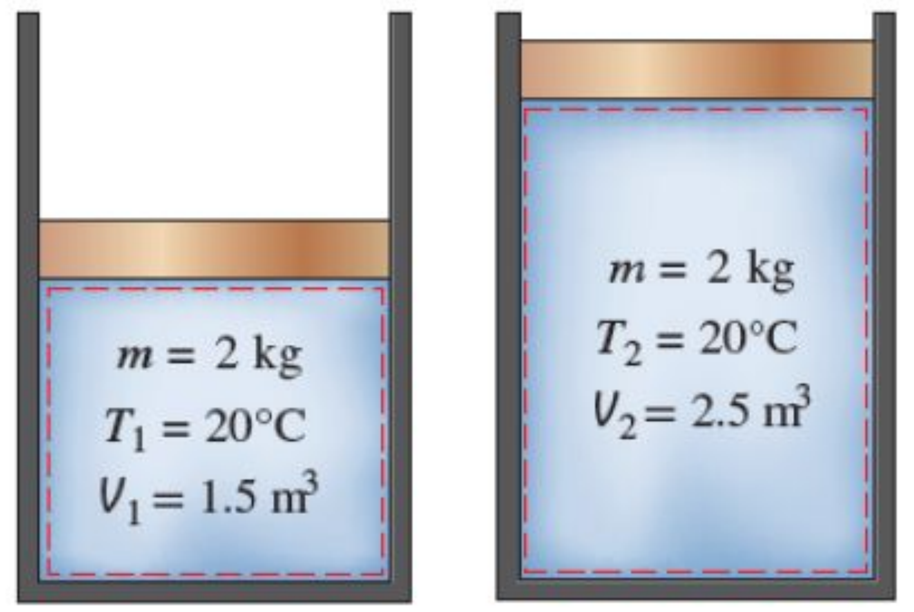
(*a*) A control volume (CV) with real and imaginary boundaries



(*b*) A control volume (CV) with fixed and moving boundaries as well as real and imaginary boundaries

Figure 1-8: Open system.

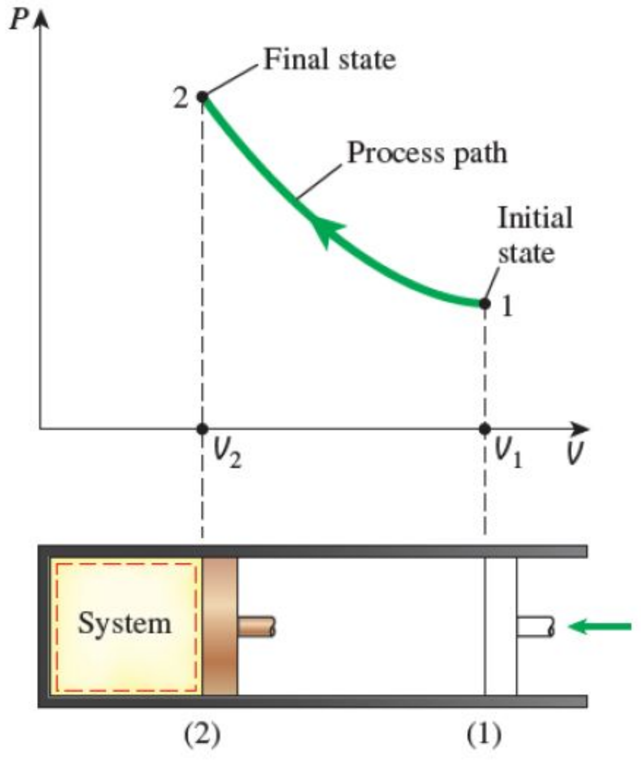
- State

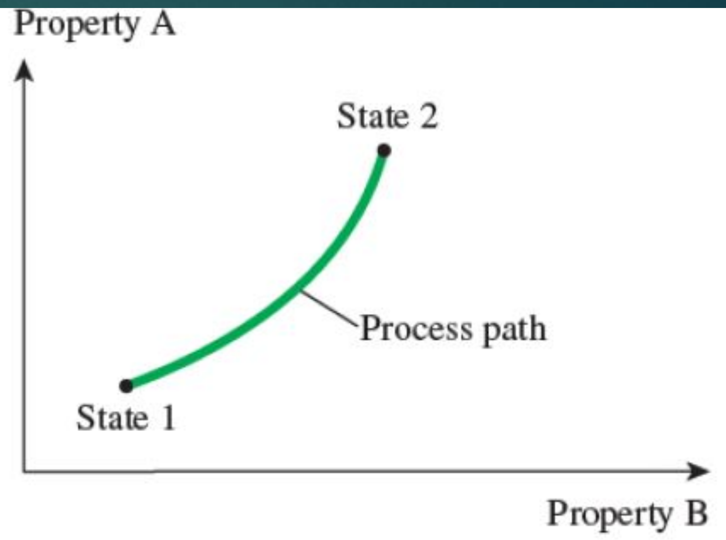


(a) State 1 (b) State 2

Process

shows the P-V diagram of a compression process of a gas.

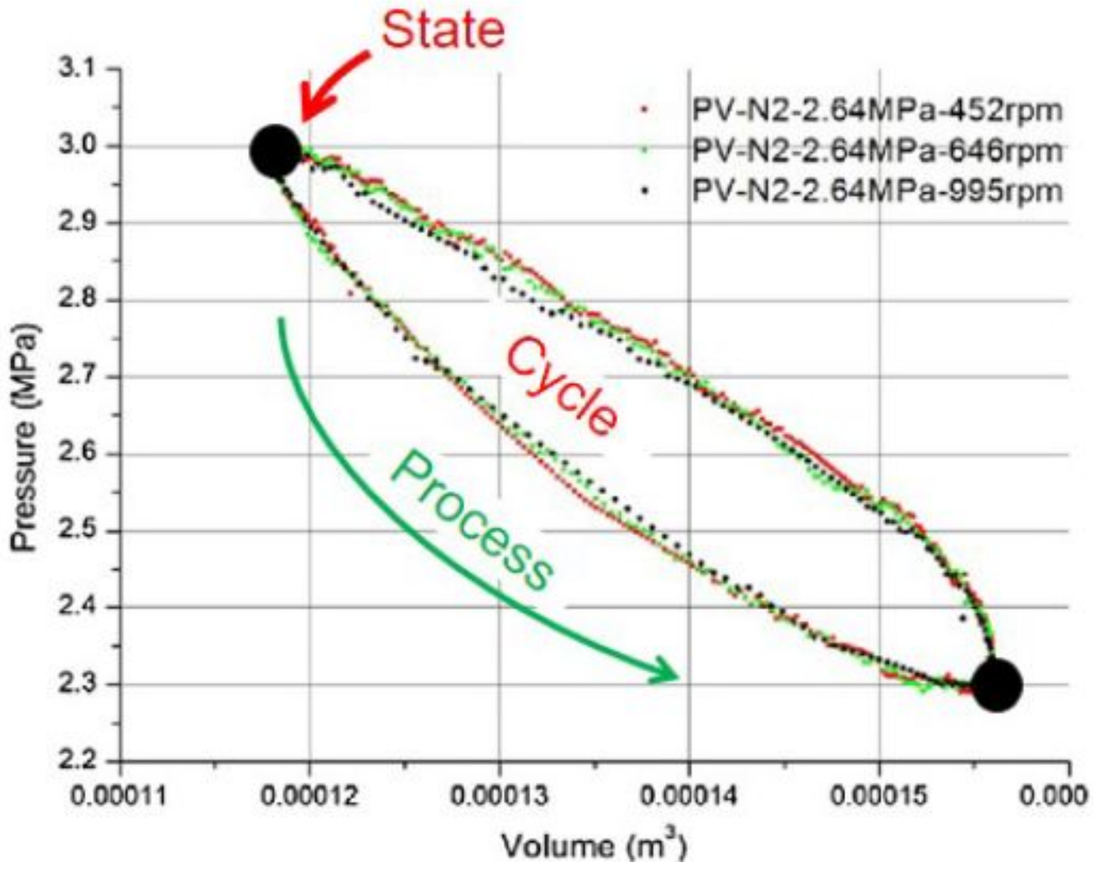




A process between states 1 and 2 and the process path.

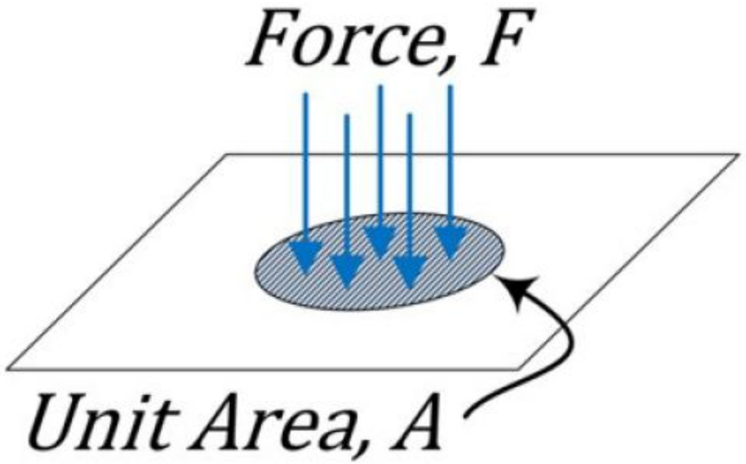
Cycle

►


State
Cycle
Process
PV-N2-2.64MPa-452rpm
PV-N2-2.64MPa-646rpm
PV-N2-2.64MPa-995rpm
Pressure (MPa)
Volume (m^3)
3.1
3.0
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
0.00011
0.00012
0.00013
0.00014
0.00015
0.000

Pressure

Pressure (P)



Pressure : is the force acting on unit area normal on it. (i.e.) $P = \frac{F}{A}$

The unit of pressure is N/m^2 $(Pascal - Pa)$; KN/m^2 (KPa), Since the pressure has always has big values, lead to use bigger unit of pressure which is: bar

1 bar = 10^5 N/m^2 = 10^2 KN/m^2 = 10^2 KPa

$P_{atm} = 101,325$ Pa

Absolute, gage, and vacuum pressures are related to each other by:

$$P_{gage} = P_{abs} - P_{atm}$$

$$P_{vac} = P_{atm} - P_{abs}$$

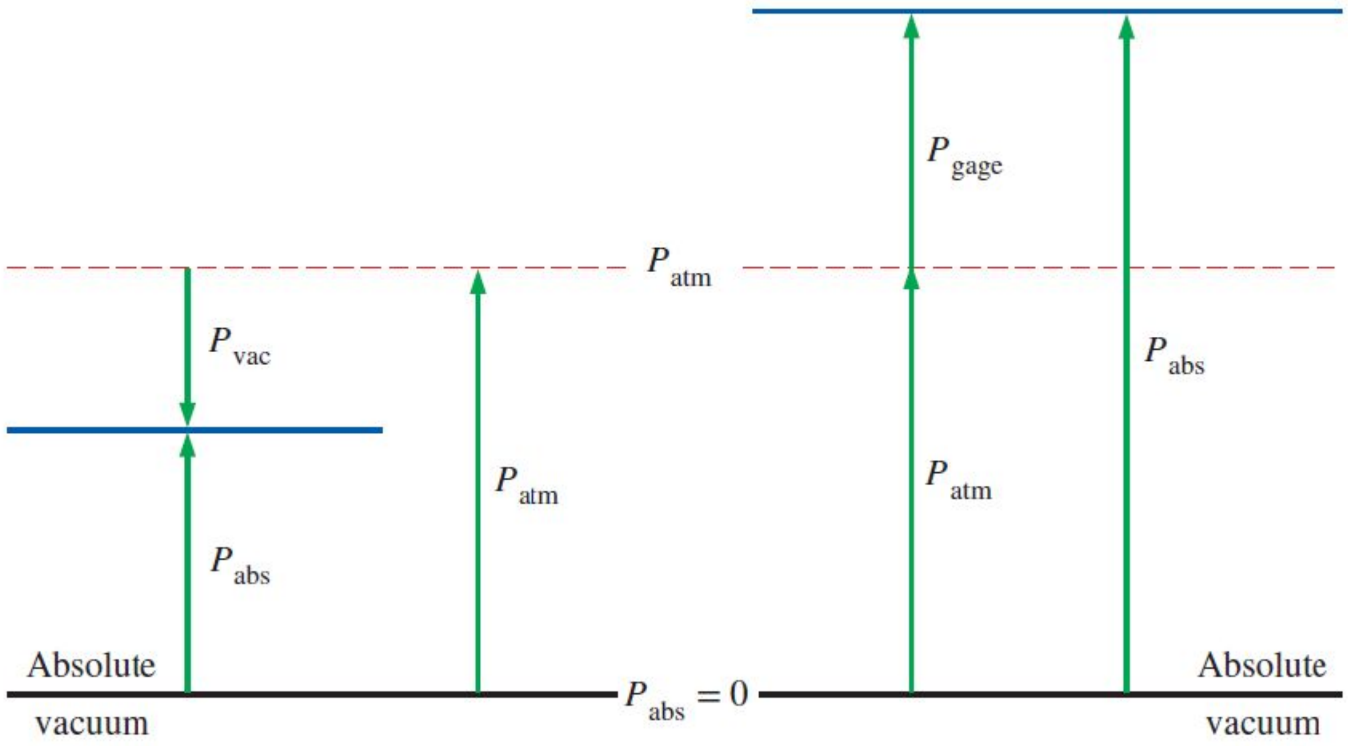


Figure 1-18: Diagram of absolute, gage, and vacuum pressures.

$$P = P_{atm} + \rho g h \quad or \quad P_{gage} = \rho g h$$

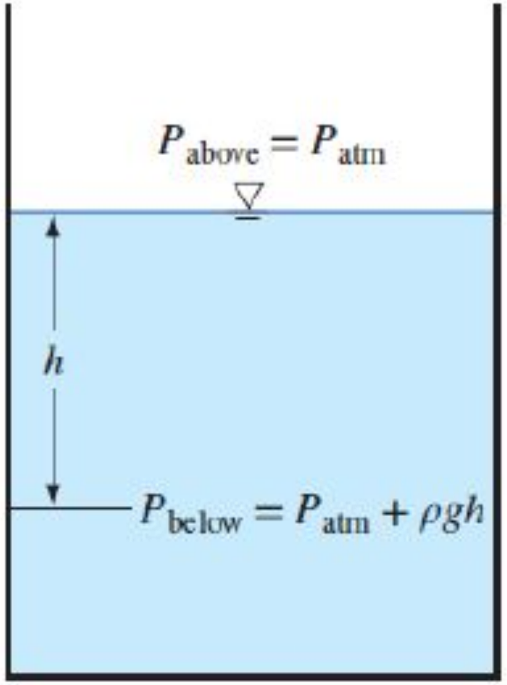


Figure 2 : Mercury Column Manometer

Figure 1-19: Pressure at a specific depth.

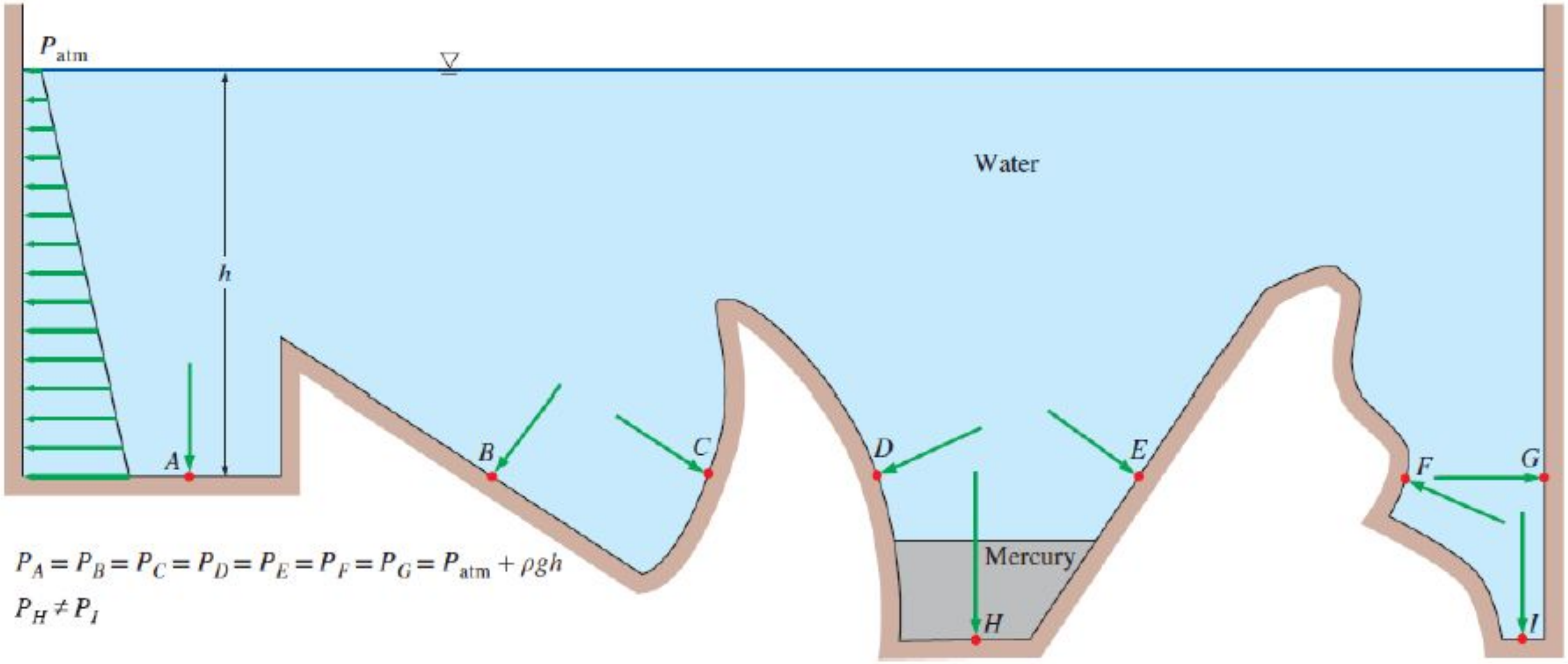
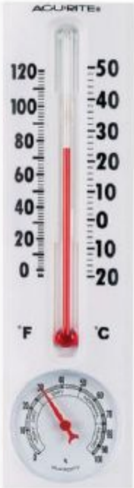
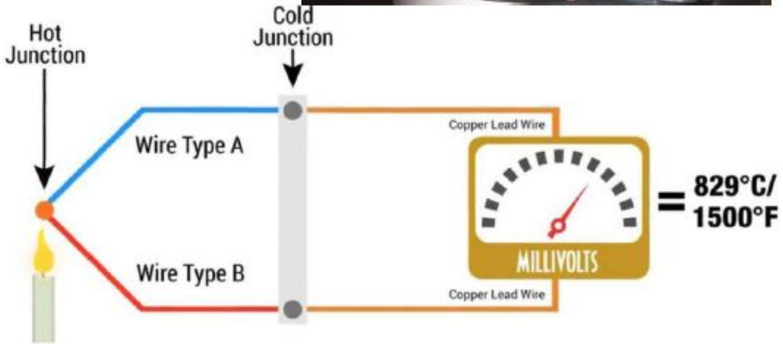


Figure 1-20: Pressure at different points in a specific system.

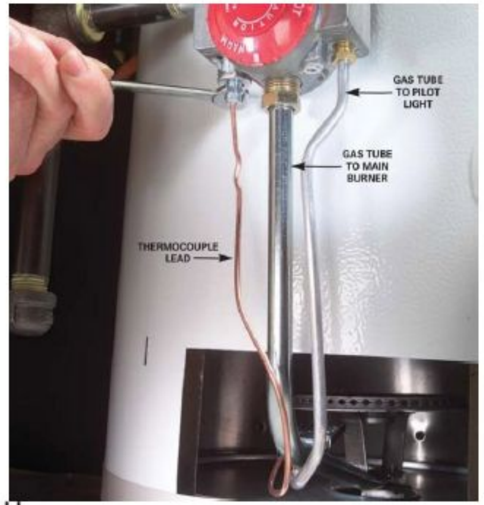
Measurement of Temperature (T):

Thermometers

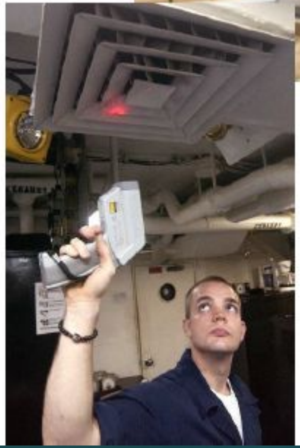




Thermocouple



Pyrometer



The Ideal-Gas Equation of State

Perfect Gas……Ideal Gas

A gas at sufficiently low density such that the intermolecular forces and the associated energy are negligible small.

A perfect gas obeys all gas laws exactly under all conditions of pressure & temperature and has constant specific heats.

$$\frac{P.V}{R.T} = 1$$

Perfect Gas laws

Boyle's law

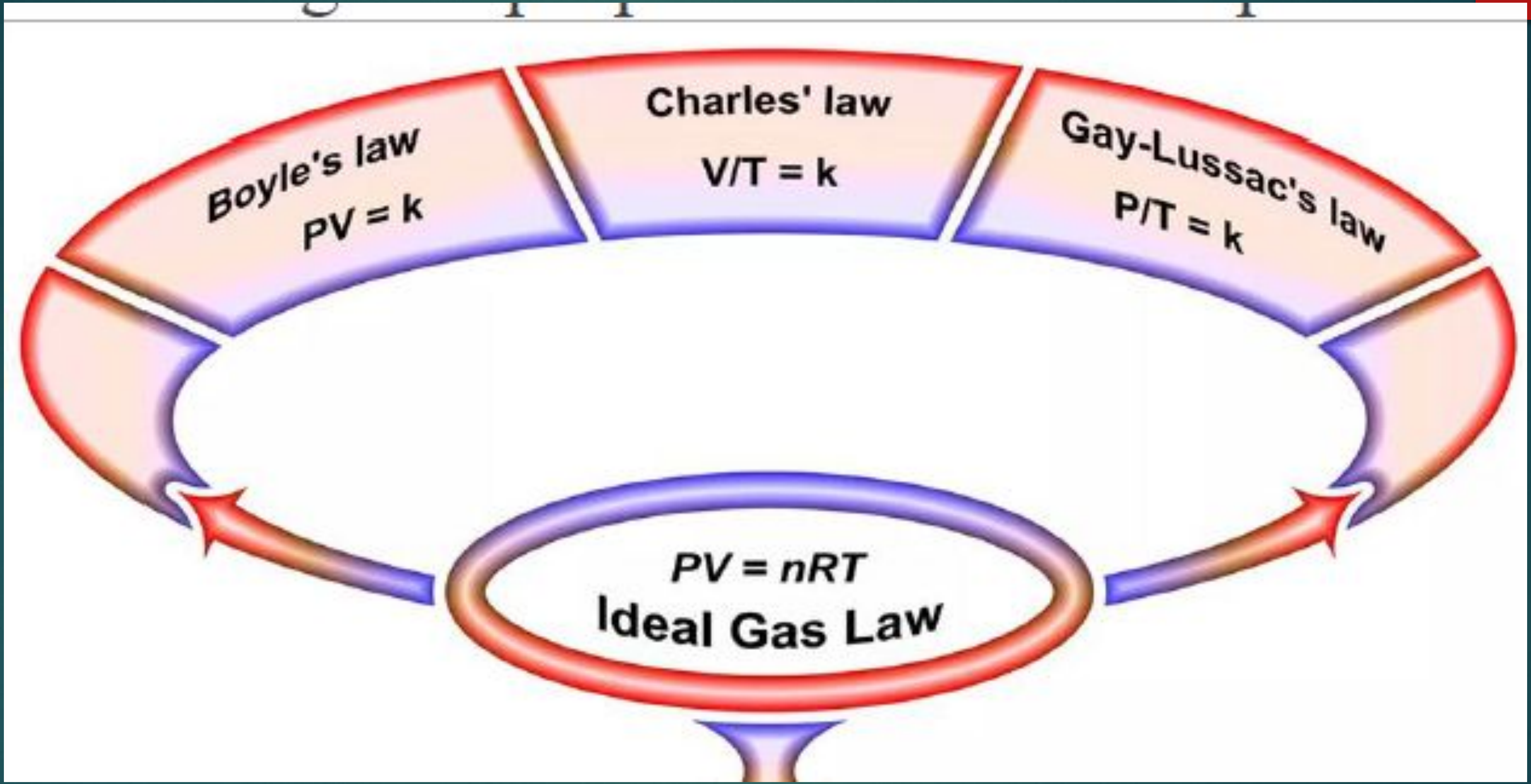
For fixed mass of gas under constant temp., the volume is inversely proportional to the absolute pressure.

Charle's law

For fixed mass of gas under constant Pressure., the volume is directly proportional to the absolute temperature.

Gay-lussac's law

For fixed mass of gas under constant volume, the pressure is directly proportional to the absolute temperature.


Boyle's law
PV = k
Charles' law
V/T = k
Gay-Lussac's law
P/T = k
PV = nRT
Ideal Gas Law

Boyle law

Boyle's Law

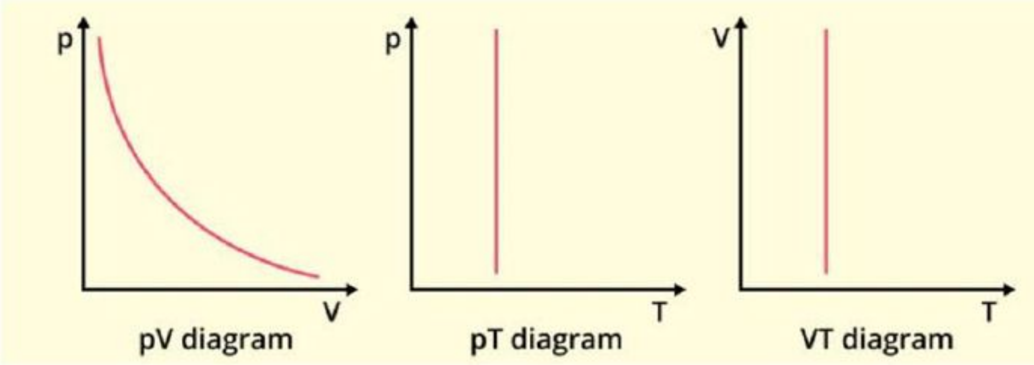
This law describes the inversely proportional relationship between absolute pressure and volume at a constant temperature for a fixed amount of gas.

$$V \propto \frac{1}{P}$$

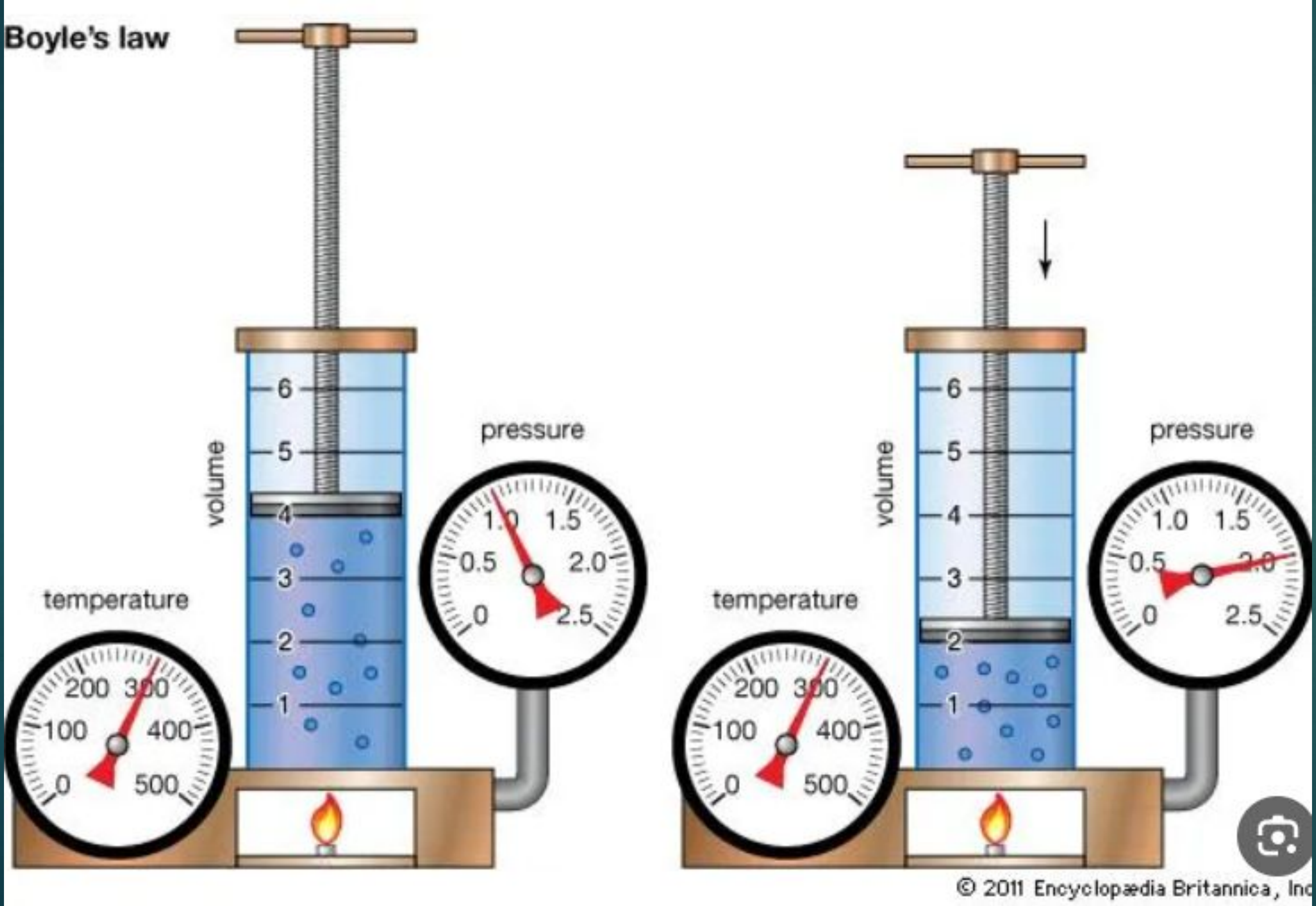
$$V = \frac{c}{P}$$

$$\therefore PV = c$$

$$\therefore \; P_1V_1 = P_2V_2 = PV = constant$$



BOYLE'S LAW


Boyle's law
volume
6
5
4
3
2
1
pressure
0
0.5
1.0
1.5
2.0
2.5
temperature
0
100
200
300
400
500
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Charles law

Charles's Law

This law describes the directly proportional relationship between the volume and temperature at a constant pressure for a fixed amount of gas.

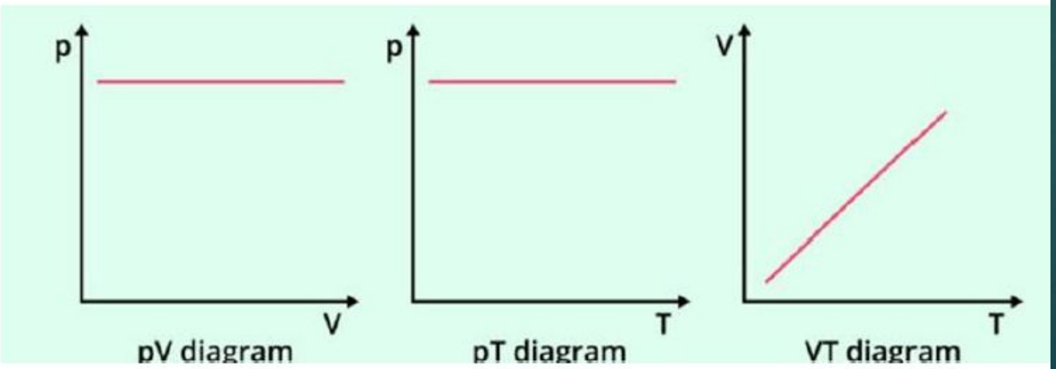
$$V \propto T$$

$$V = cT$$

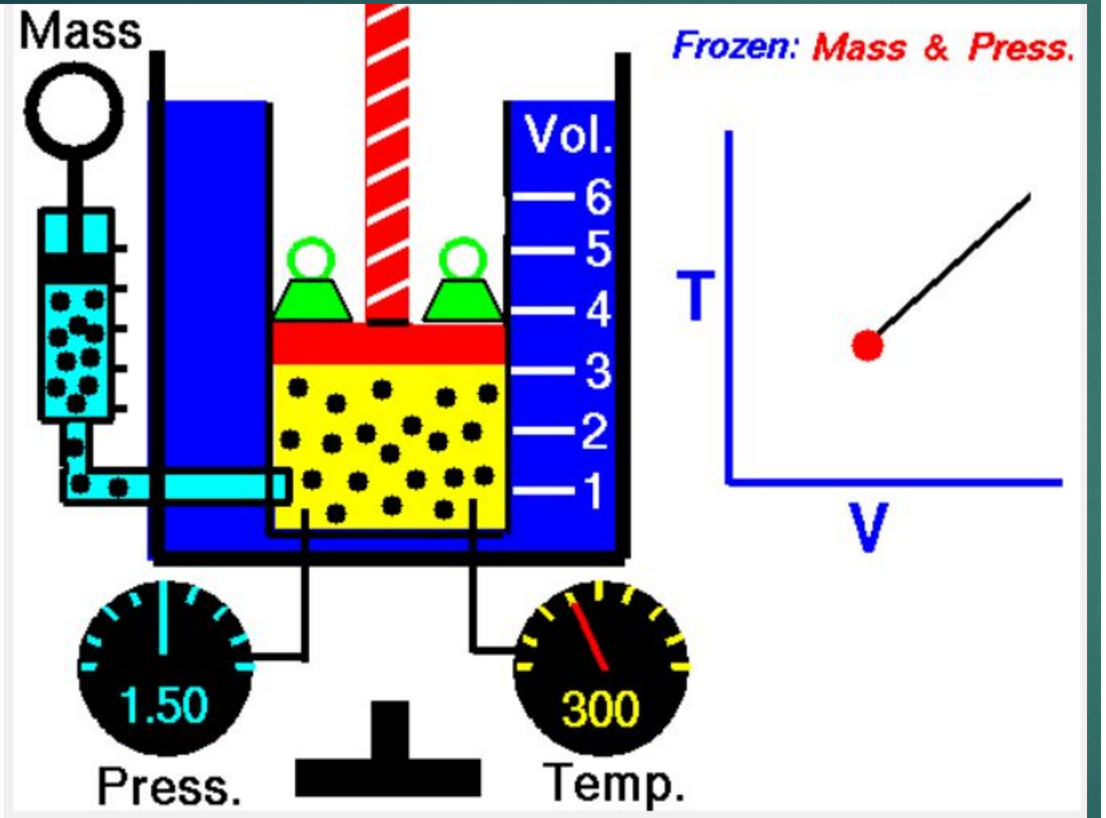
$$\therefore \frac{V}{T} = c \quad or \quad \frac{T}{V} = c$$

$$\therefore \frac{V_1}{T_1} = \frac{V_2}{T_2} = \frac{V}{T} = constant$$

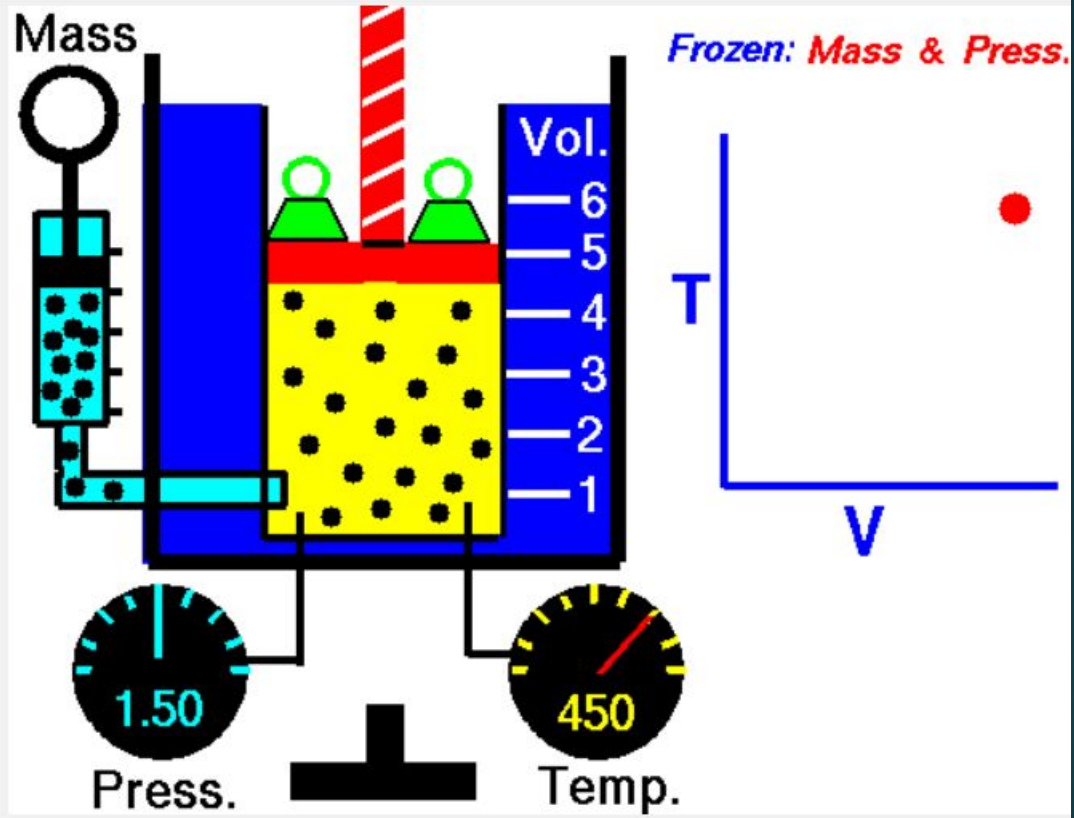
$$or \ \frac{T_1}{V_1} = \frac{T_2}{V_2} = \frac{T}{V} = constant$$



Charles Law Gif



Charles Law Gif



Charles Law Gif

Gay Lussac law

Gay-Lussac's Law

This law describes the directly proportional relationship between the absolute pressure and temperature at a constant volume for a fixed amount of gas.

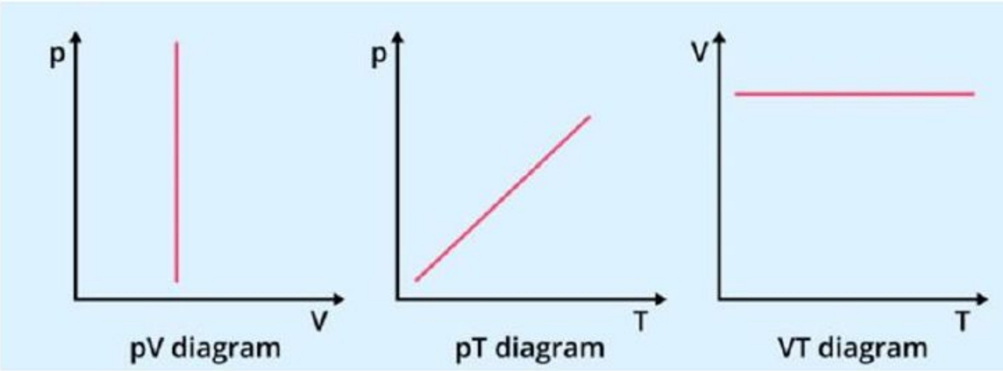
$$P \propto T$$

$$P = cT$$

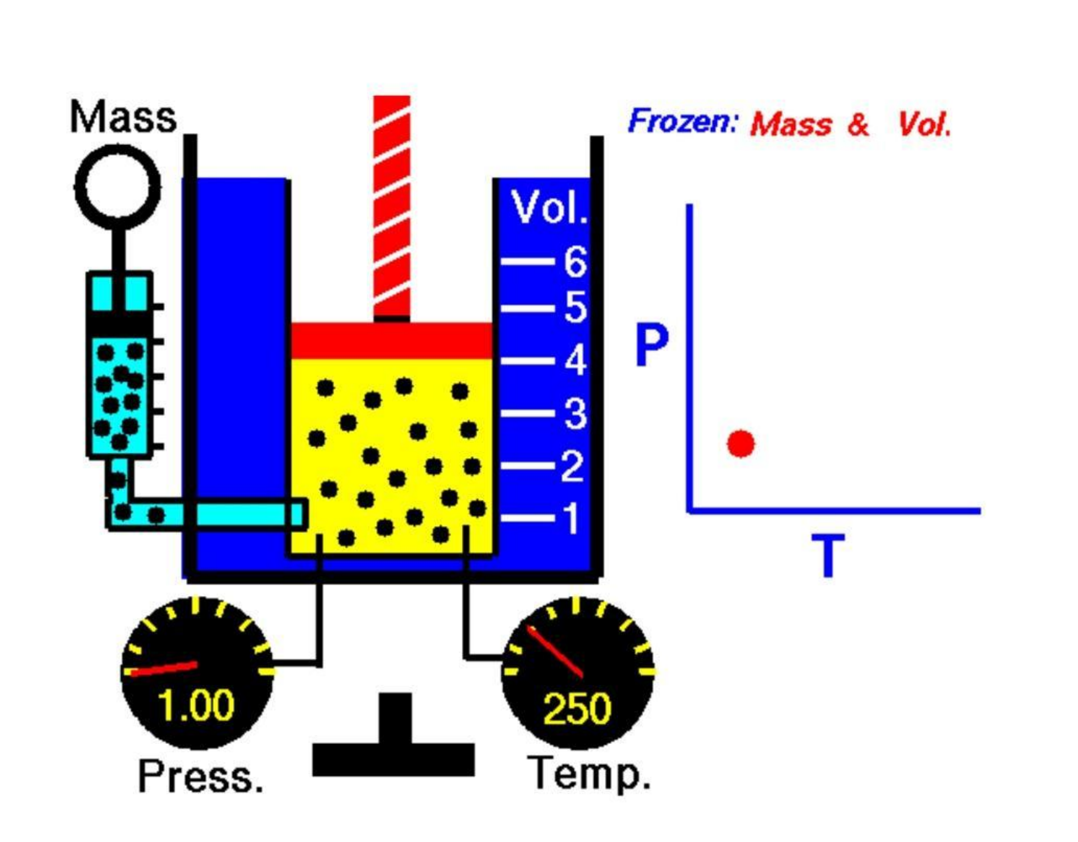
$$\therefore \frac{P}{T} = c \quad or \quad \frac{T}{P} = c$$

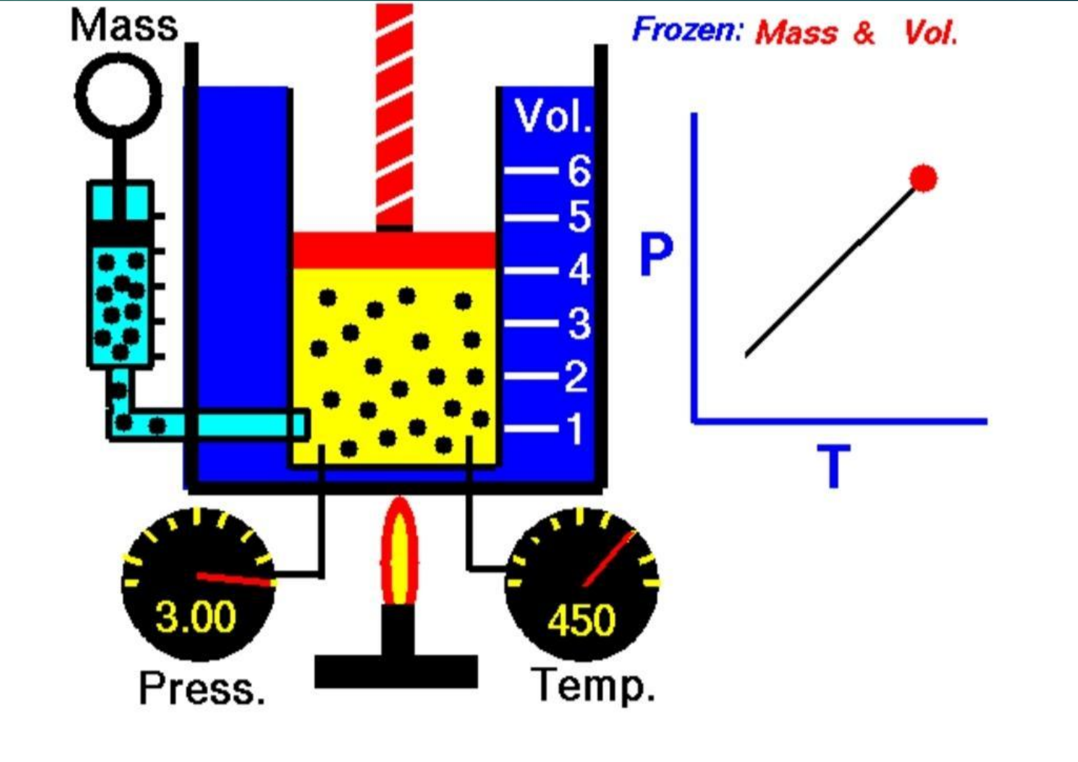
$$\therefore \frac{P_1}{T_1} = \frac{P_2}{T_2} = \frac{P}{T} = constant$$

$$or \ \frac{T_1}{P_1} = \frac{T_2}{P_2} = \frac{T}{P} = constant$$



Gay Lussac Law

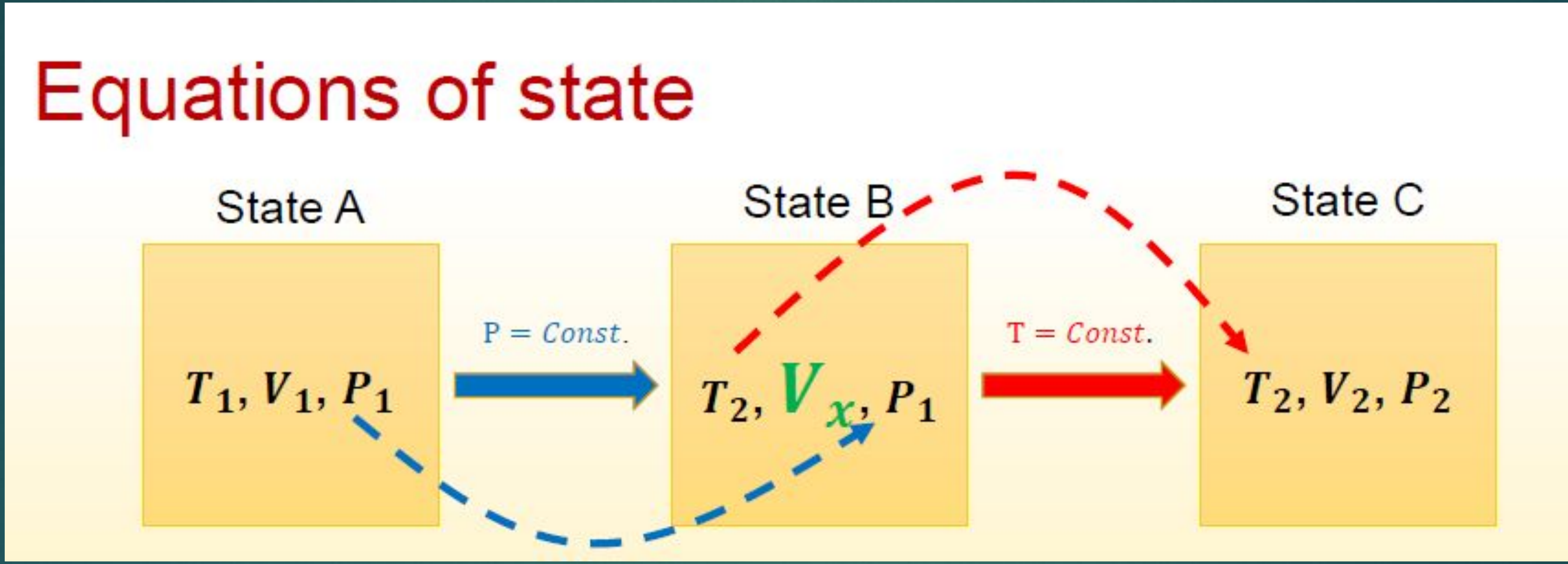


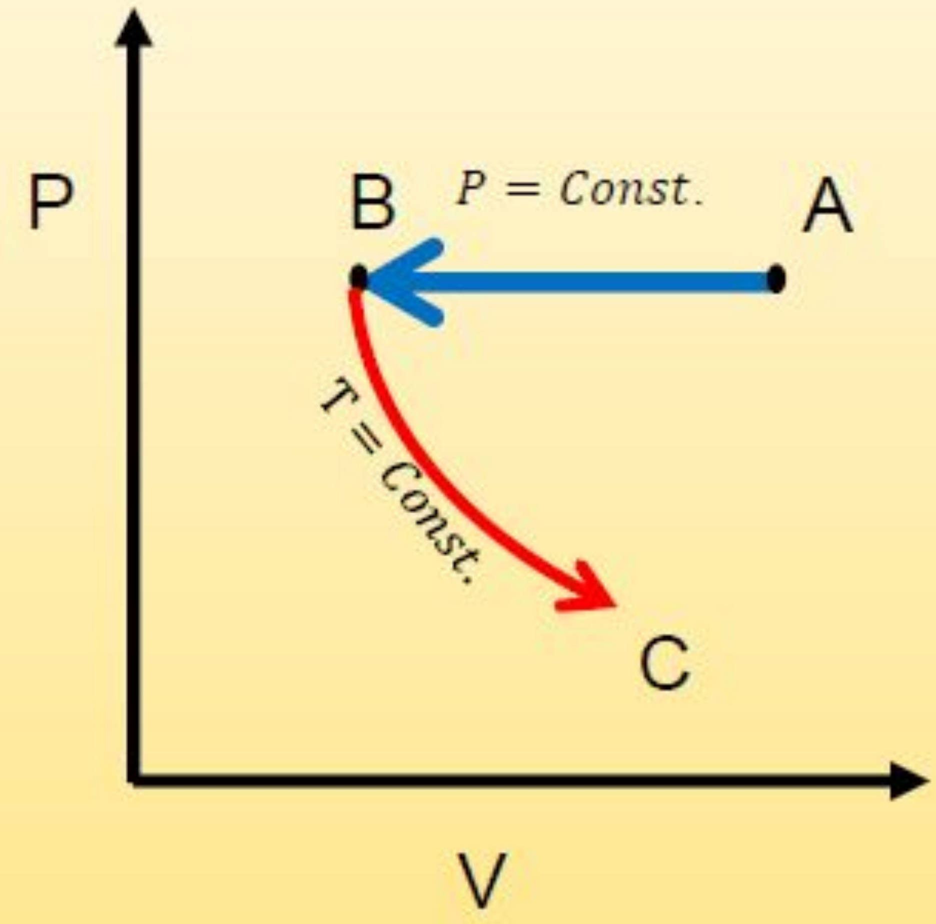


Gay-Lussac's Law (Source)

The Ideal-Gas (Equation of State)

- Any equation that relates the pressure, temperature, and specific volume of a substance is called an equation of state.





$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \frac{PV}{T} = const.$$

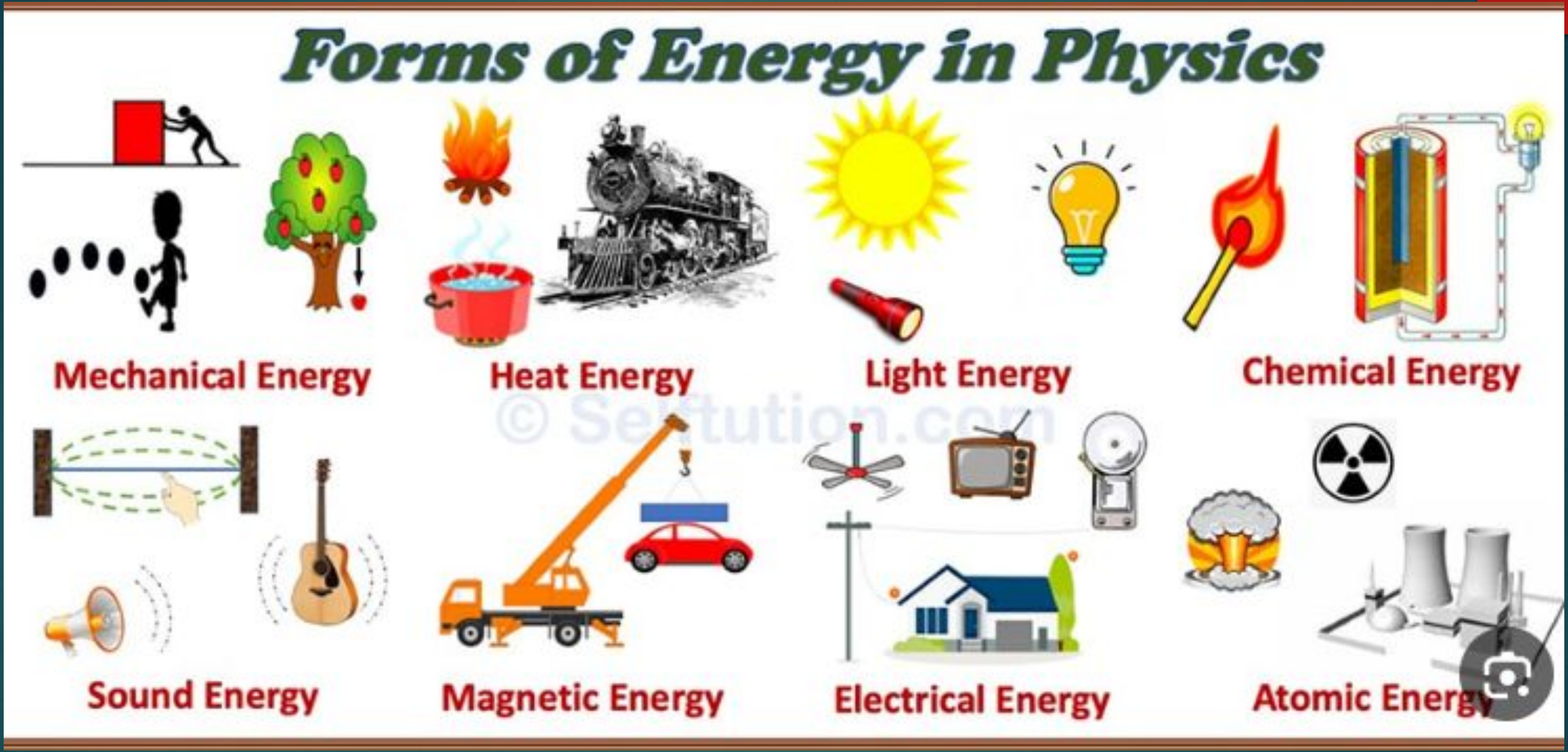
Ex.1/ A gas whose original pressure and volume were 300 kN/m^2 and 0.14 m^3 is expanded until its new pressure is 60 kN/m^2 . While its temperature remains constant. What is the new volume? Draw the P-V diagram.

Ex.2/ A quantity of gas whose original volume and temperature are 0.2 m^3 and 303 ℃ , respectively. Cooled at constant pressure until its volume becomes 0.1 m^3 . What will be the final temperature of the gas? Draw the P-V diagram.

Q1/ volume of the gas tank in petroleum station is 6 m^3 with pressure 7 bar , is expanded until its new pressure is 4 bar . While its temperature remains constant. What is the V2=?

Draw the P-V diagram.

Q2/ 1.25 m^3 volume of gas with temperature 295 ℃ , respectively. Cooled at constant pressure until its volume becomes 0.15 m^3 . What will be the final temperature of the gas? Draw the P-V diagram.



Forms of Energy in Physics
Mechanical Energy
Heat Energy
Light Energy
Chemical Energy
© Selftution.com
Sound Energy
Magnetic Energy
Electrical Energy
Atomic Energy

1- Potential Energy (P.E.)

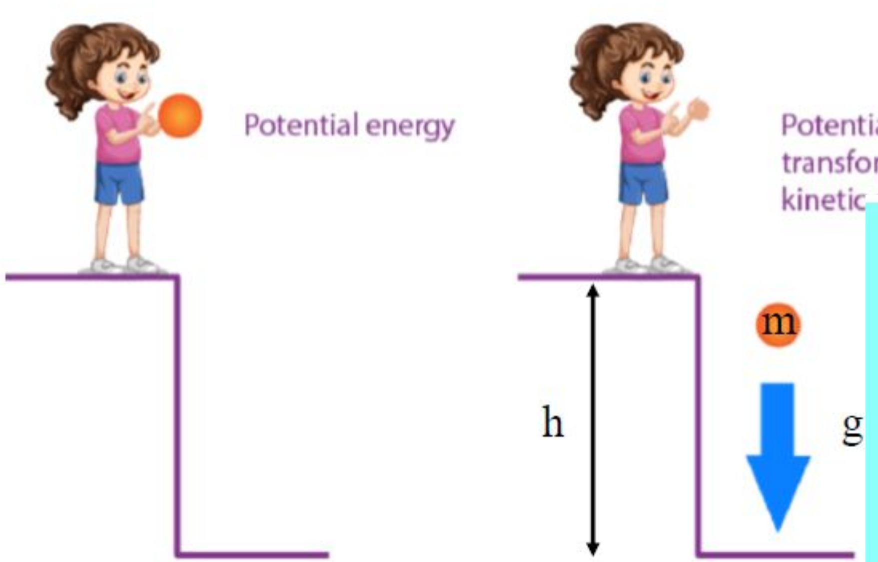
Potential energy is the ***energy of an object that is stored in it due to its position, state or arrangement.***

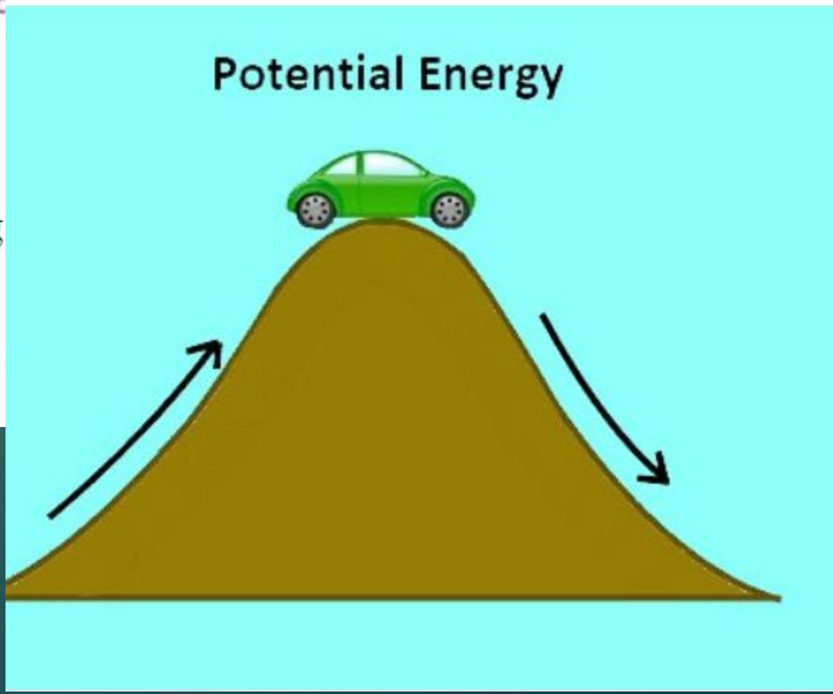
It is the energy stored in a system due to its height from the earth's surface. Also, it is known as Gravitational potential energy.

$$P.E. = mgh$$

$$= m\,(\text{kg})\; g\,(\text{m/s}^2)\; h\,(\text{m})$$

$$= \text{N.m} = \text{J}$$





2- Kinetic Energy (K.E.)

It is the energy needed to move a mass at a given speed.

$$K.E. = \frac{1}{2}\, m\, C^2$$

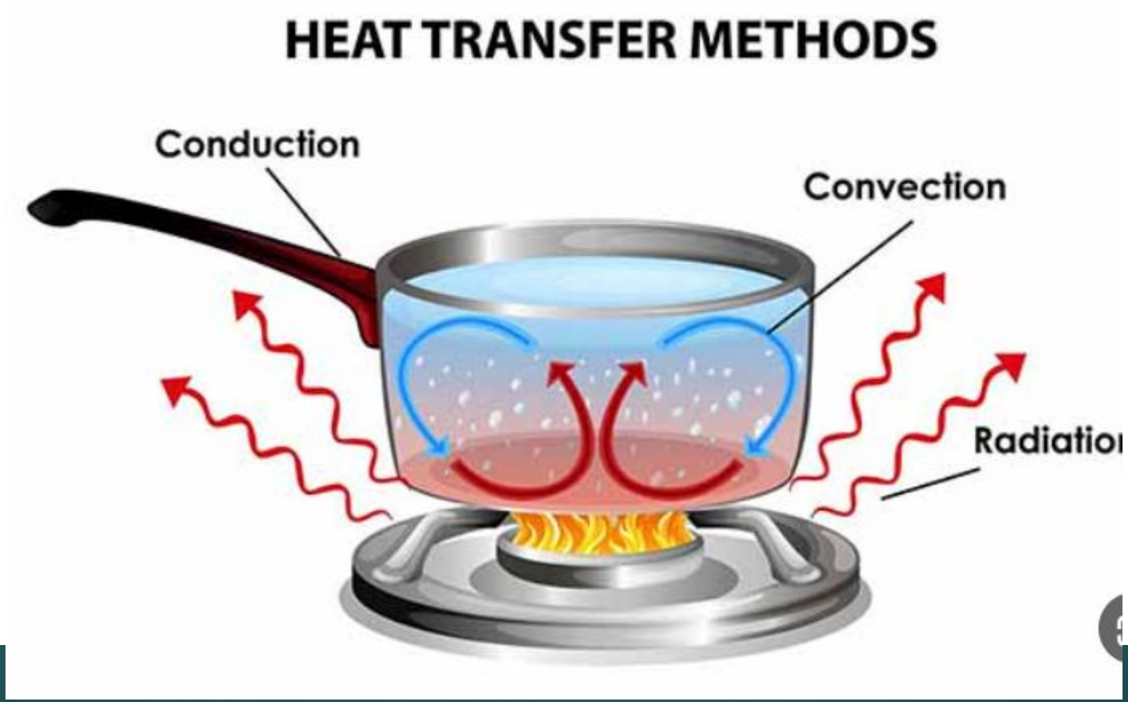
$$= \frac{1}{2}\, m\, (kg)\, C^2\, (\frac{m^2}{s^2})$$

$$= N.m = J$$

3- Heat (Q)

It is the energy transfer across the system due to the temperature difference.

- Heat is taken (+), when heat is added to the system.
- Heat is taken (-), when heat is removed from the system.

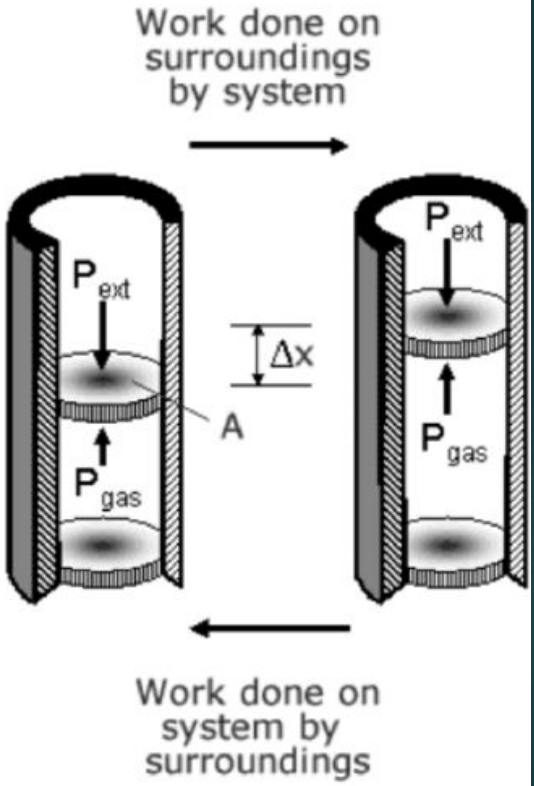


4- Work (W)

It is a mechanical energy transfer across the system.

$$W = F\,x$$
$$= F\,(N)\,x\,(m)$$

- Work is given (+), if it is done by the system on the surrounding.
- Work is given (-), if it is done on the system from the surrounding.



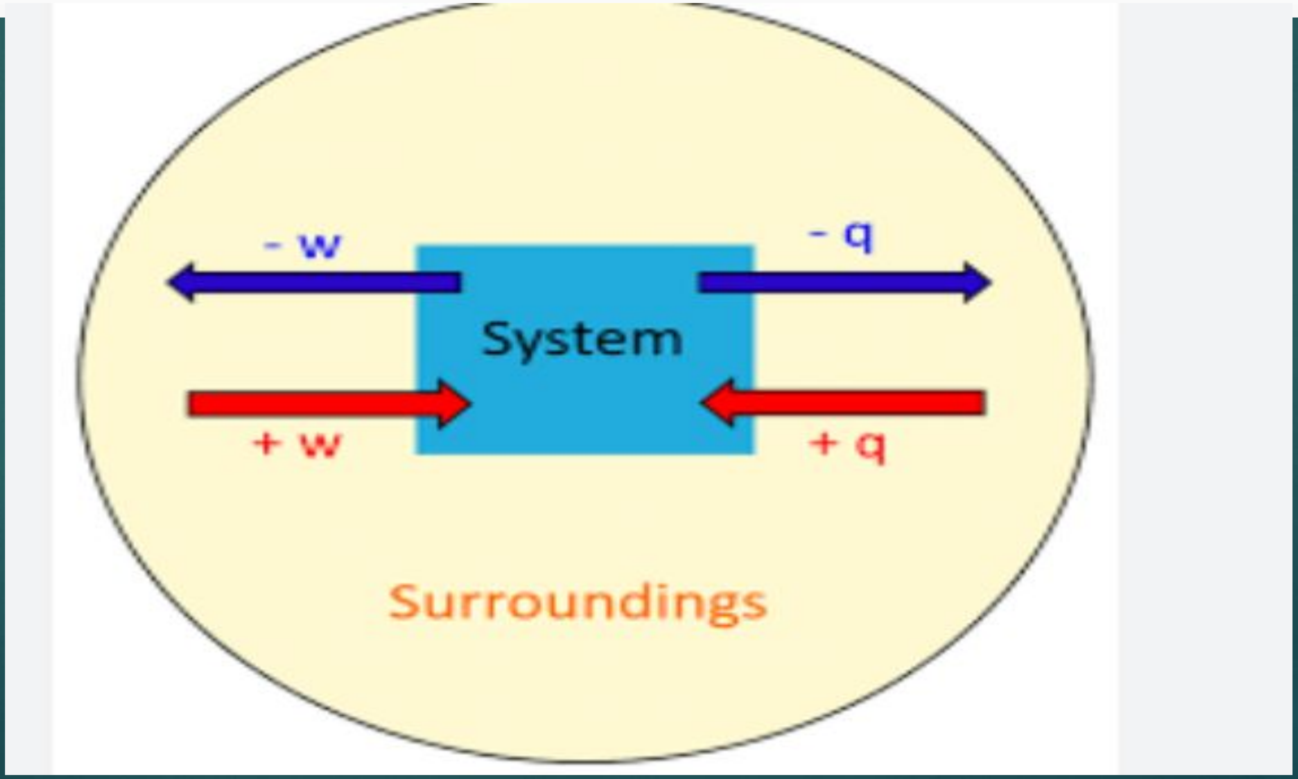
Energy, work, & heat
(E) (*w*) (*q*)

the ability to do work (*w*) or produce heat (*q*)

$$\Delta E = w + q$$

+ w = work is done ON the system (compression)
- w = work is done BY the system (expansion)

+ q = heat is absorbed
- q = heat is released



5- Internal Energy (U)

It is the energy stored in a mass of a system and appear only at a special action.

$$\Delta U = m\,Cv\,(T_2 - T_1)$$
$$= m\,(kg) Cv\,(\frac{J}{kg\,K})(T_2 - T_1)(K)$$

where Cv is a specific heat at a constant volume.

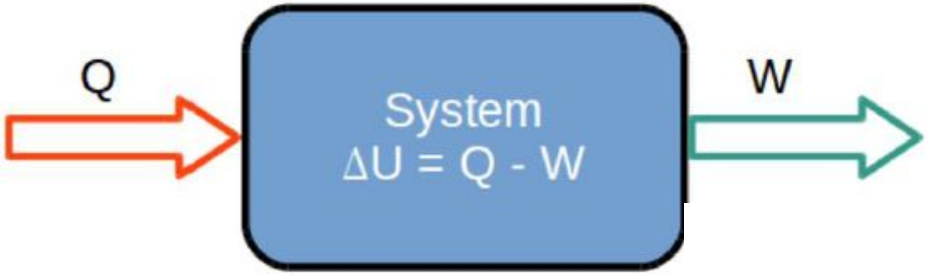
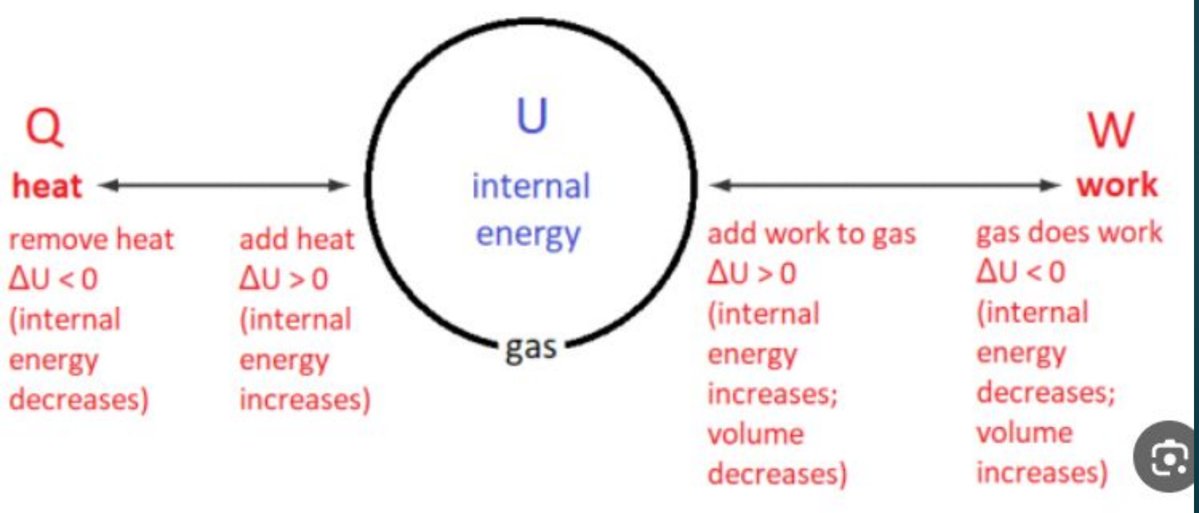


Image: Internal energy



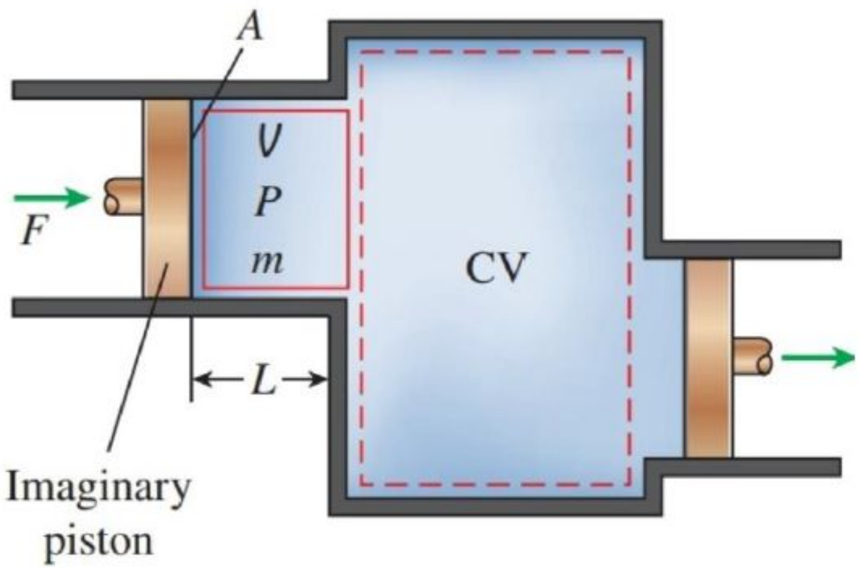
6- Flow Energy (F.E.)

It is the energy required to move gas at a steady rate without changing its state.

$$F.E. = p\,A\,L$$

$$F.E. = p\,V$$

$$= p\left(\frac{N}{m^2}\right) A\,(m^2) L$$



7- Enthalpy(H)

It is the energy that represents the summation of both flow and internal energies.

$H = U + PV$