Thermodynamics - 2 ⟸ KTG (kintic Theory of Gases)

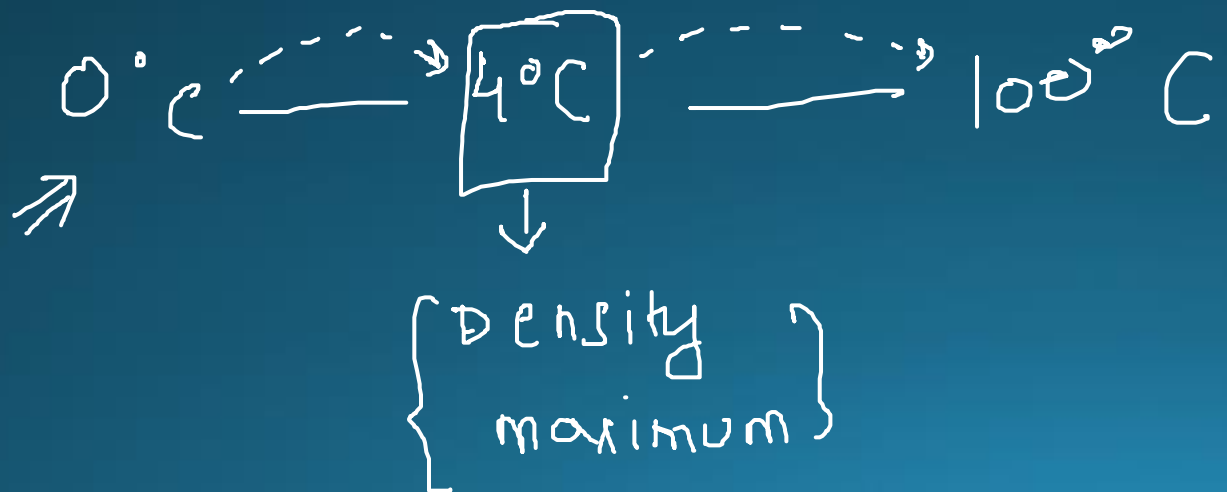
* Water → 0°C ⟶ 100°C तक गर्म किया जाता है।
तो उसका घनत्व (Density) –

(i) increase

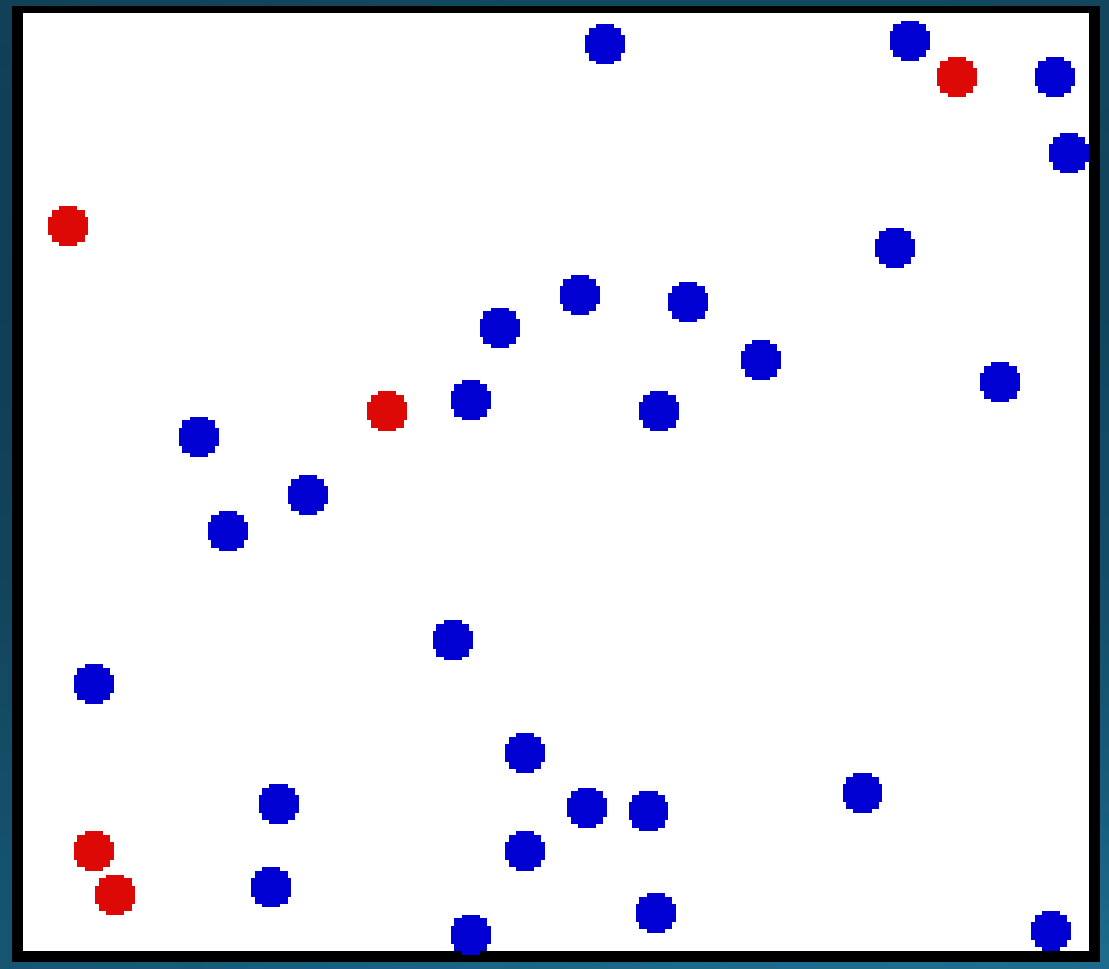
(ii) decrease

✓ (iii) increase upto 4°C then decr.

(iv) decr. upto 4°C then inc.



K. T. G.



⇒ IDEAL GAS (आदर्श गैस)

* Imagination (भ्रम).

⇒ Boyle's Law (बॉयल का नियम)

Charle's Law (चार्ल्स " ") ⇒ ideal Gas

⇒ Avogadro Law | Hypothesis (एवोगैड्रो " ")

⇒ H_2, N_2, O_2, He ⇒ Real Gas

⇒ Ideal Gas equation :-

आदर्श गैस समीकरण ⇒

$$PV = nRT$$

$$R = \frac{PV}{nT}$$

⇒ P → Pressure दाब

V → Volume आयतन

n → no. of moles (मोलों की संख्या)

R → Universal Gas Constant

T → Temp.

$R = \frac{1}{4} \simeq 0.08 \ \frac{\text{atm-Lt}}{\text{mol-kel.}}$

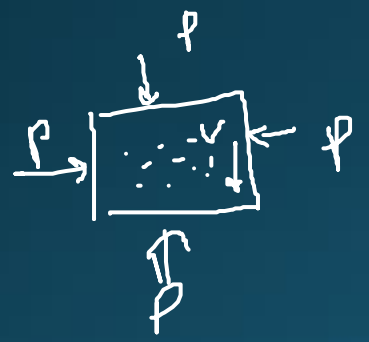
$R = 2 \ \text{cal/mol-K.}$

$R = 8.3 \ \text{J/mol-K.}$

$PV = nRT$ →

BOYLE'S LAW

- Boyle's law is a gas law which states that the pressure exerted by a gas (of a given mass, kept at a constant temperature) is inversely proportional to the volume occupied by it. Temp. → Constant
- इसके अनुसार, नियत ताप पर गैस का आयतन दाब के व्यूत्क्रमानुपाती होता है। जहाँ P गैस का दाब है , V गैस का आयतन है, और k एक नियतांक है।



$$PV = nRT$$

$$PV = \text{Constant}$$

$$P = k/V$$

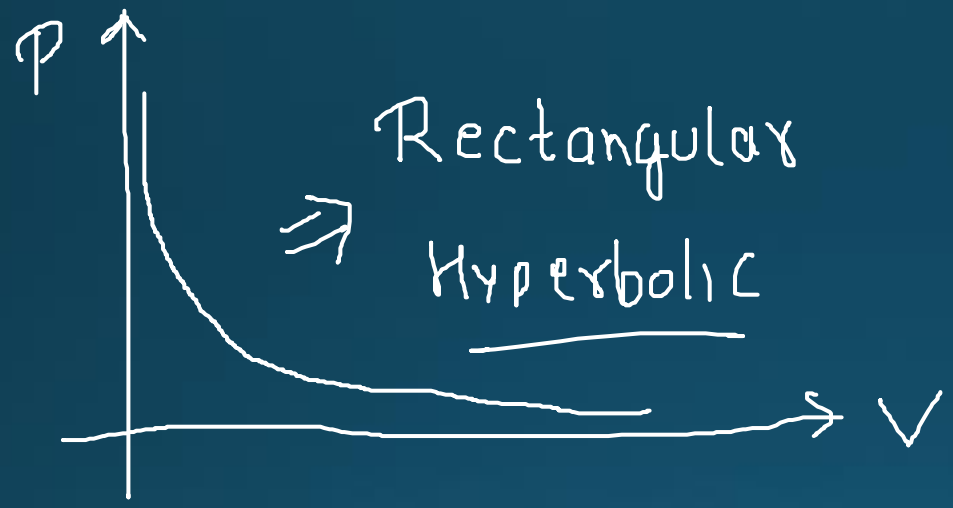
$$P \propto \frac{1}{V}$$

$$\frac{P_1}{P_2} = \frac{V_2}{V_1}$$

* $PV = \text{Constant}$ (नियतांक)

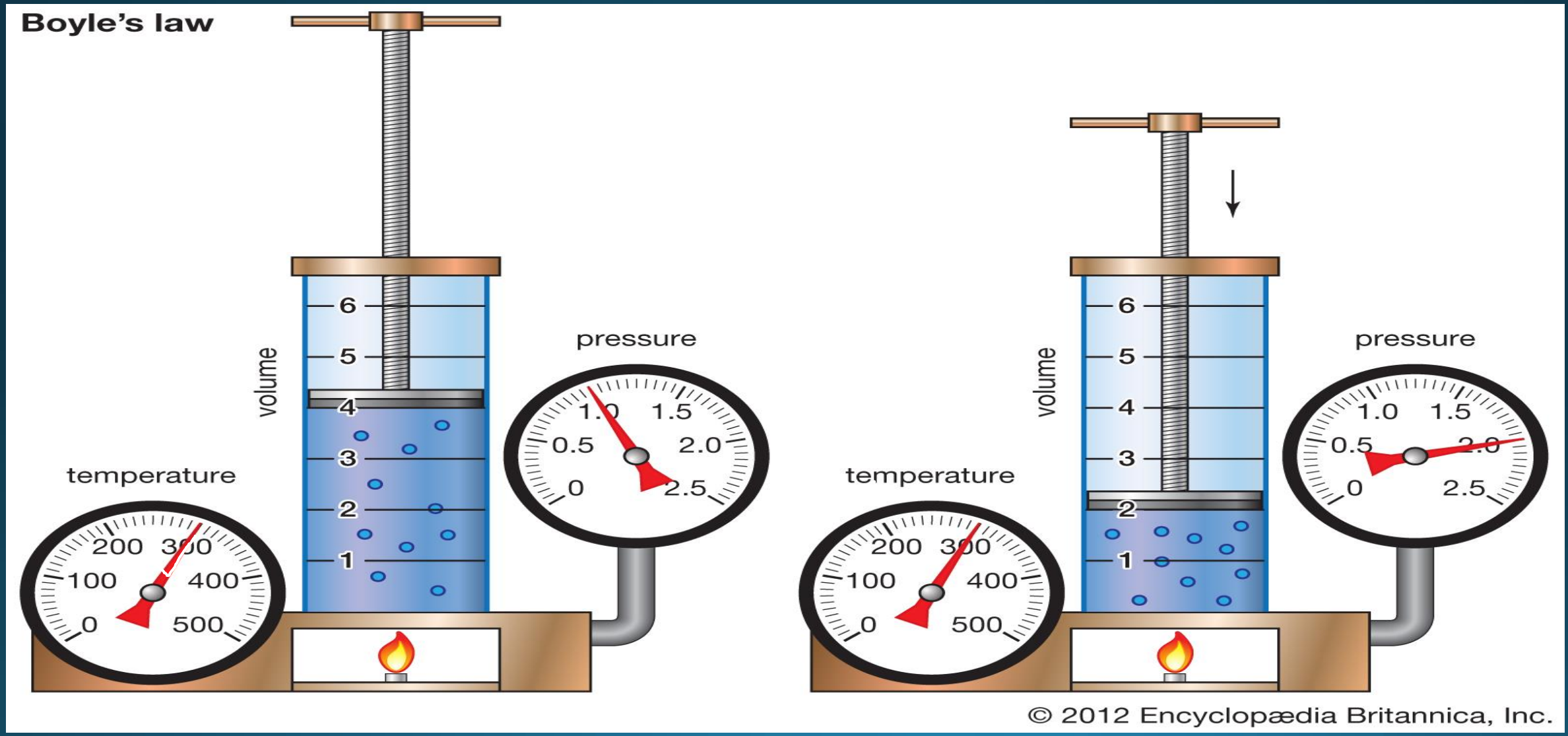
$xy = \text{constant}$

⇒ Graph:-



⇒ Rectangular Hyperbolic

$PV = \text{Constant}$


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

CHARLE'S LAW

- Charles law states that the volume of an ideal gas is directly proportional to the absolute temperature at constant pressure.

- जब किसी शुष्क गैस को नियत दाब पर रखा जाता है तो केल्विन तापमान और आयतन एक दूसरे के अनुक्रमानुपाती होते हैं।

Constant (नियत) → Pressure (दाब)

$PV = nRT$

$\Rightarrow V \propto T$ | आयतन ∝ तापमान

$V_1 = KT_1$

$V_2 = KT_2$

$\Rightarrow \boxed{\frac{V_1}{V_2} = \frac{T_1}{T_2} \Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}}$

$V_1 = 2L$, $V_2 = ?$

$T_1 = 10°C$ $T_2 = 5°C$

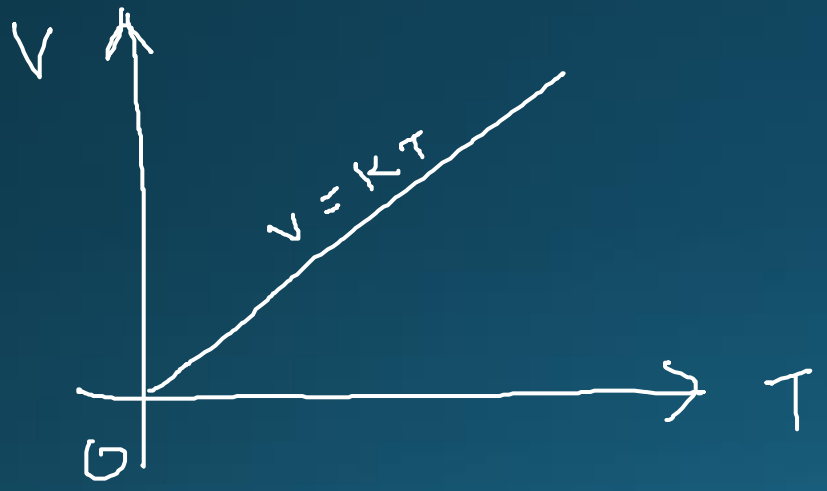
$\Rightarrow \frac{2}{10} = \frac{V_1}{5}$

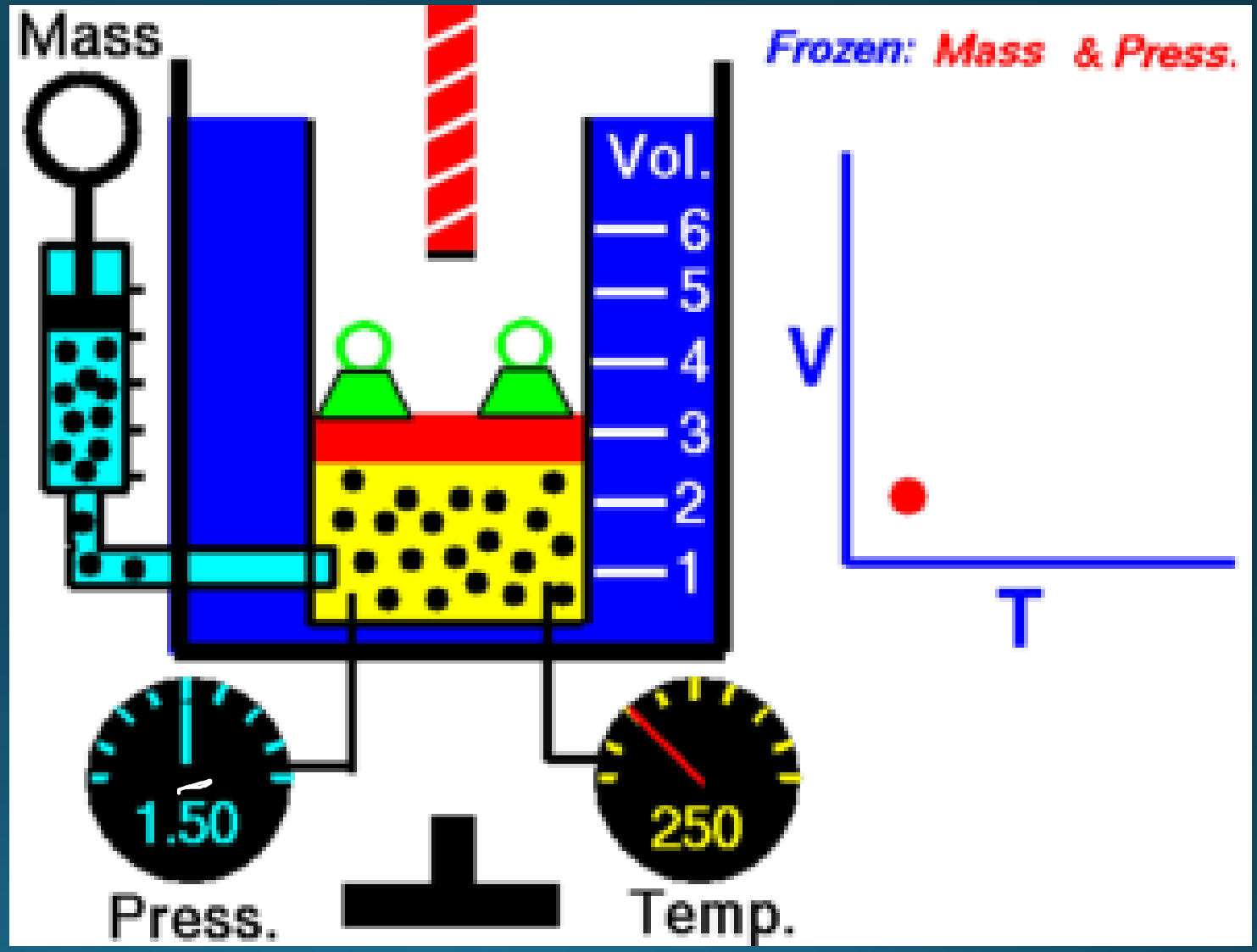
$V_2 = 10L$

⇒ Graph:- $V = KT$

$y = mx + c$

(voltage) $V = IR$




Mass
Frozen: Mass & Press.
Vol.
6
5
4
3
2
1
V
T
1.50
250
Press.
Temp.

AVOGADRO HYPOTHESIS

- Two dissimilar ideal gases occupying the same volume at a given (constant) temperature and pressure must contain an equal number of molecules.
- *समान ताप व दाब पर सभी आदर्श गैसों के समान आयतन में कणों या अणुओं की संख्या समान होती है।*

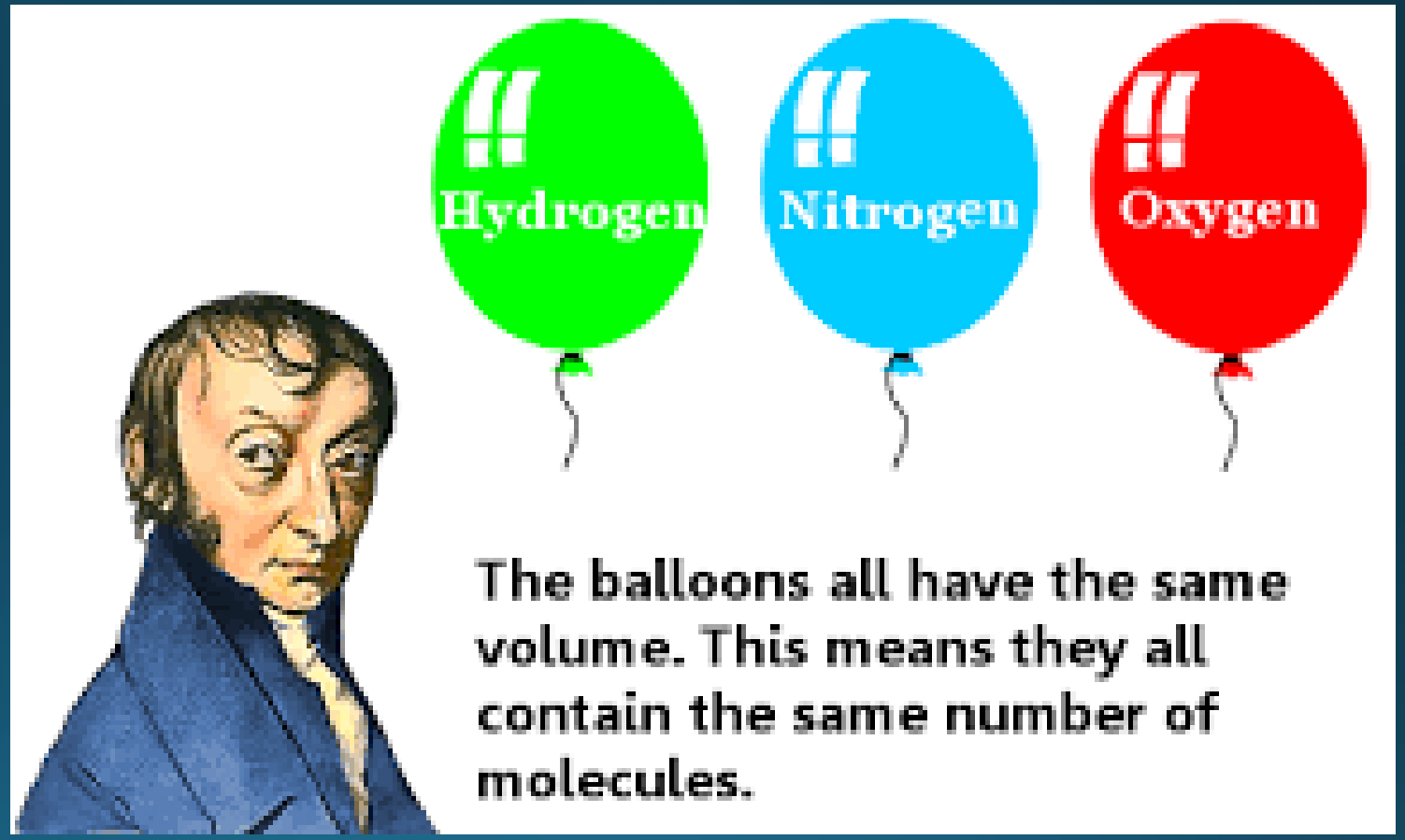
$PV = nRT$

$V \propto n$

आयतन ∝ मोलों की संख्या

आयतन ↓ मोल ↓

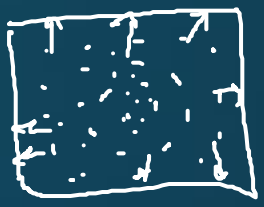
आयतन ↑ मोल ↑


Hydrogen
Nitrogen
Oxygen
The balloons all have the same volume. This means they all contain the same number of molecules.

KINETIC THEORY

⇒ (1) Total energy ⇒ Kinetic energy

कुल ऊर्जा ⇒ गतिज ऊर्जा



(2) K.E. (गतिज ऊर्जा) depends on ⇒ Absolute Temp (तापमान)

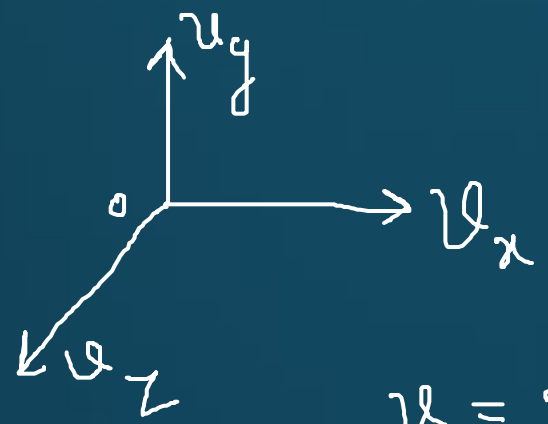
(3) Collission :- (i) b/w molecules (अणुओं के मध्य)

(संघट्ट) =

(ii) b/w molecule & wall of the container.

⇒ elastic (प्रत्यास्थ) टक्कर

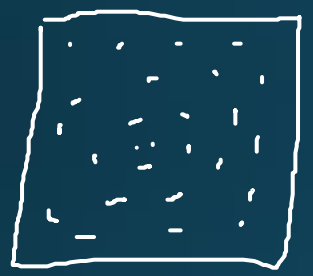
$\Rightarrow$



$$v = v_x = v_y = v_z$$

सभी दिशाओं में समान अणु से चलता है।

* "Total volume of the gas molecules is negligible in comparison to the volume of Gas."

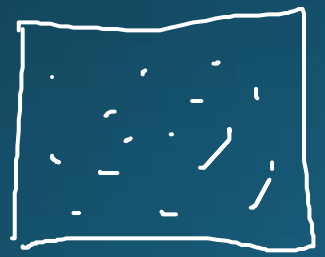


V आयतन

⇒

V' <<<<< V

⇒



inter molecular force ← न्यूनतम least

अन्तराण्विक बल

$PV = nRT$ ✓

$PV = \frac{1}{3} m n v_{rms}^2$ → वर्ग माध्य मूल मान

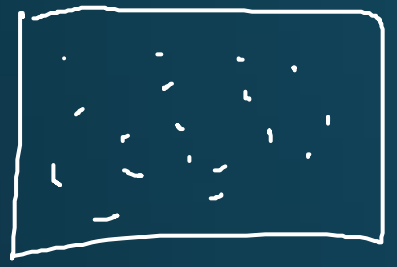
n → no. of moles

Root mean square of Velocity

m → mass (अणु का द्रव्यमान)

$$v_{rms} = \sqrt{\frac{3Pv}{mn}}$$

$$\Rightarrow \boxed{\sqrt{\frac{3RT}{m}} = v_{rms}}$$



$$\Rightarrow v_{rms}^2 = \frac{v_1^2 + v_2^2 + \dots + v_n^2}{n}$$

$$\Rightarrow v_{rms} = \sqrt{\frac{v_1^2 + v_2^2 + \dots + v_n^2}{n}}$$

$$\Rightarrow \boxed{v_{rms} = \sqrt{\frac{3RT}{M}}}$$

$$\Rightarrow \boxed{v_{rms} \propto \sqrt{T}}$$

$$\boxed{\frac{v_{rms_1}}{v_{rms_2}} = \sqrt{\frac{T_1}{T_2}}}$$

* $v_{rms} = \sqrt{\frac{3RT}{m}}$

$v_{rms} \propto \frac{1}{\sqrt{m}}$

$$\frac{v_{rms1}}{v_{rms2}} = \sqrt{\frac{m_2}{m_1}}$$

✳ Average Velocity :- औसत वेग :-

$$\bar{v} = \frac{v_1 + v_2 + \ldots + v_n}{n}$$

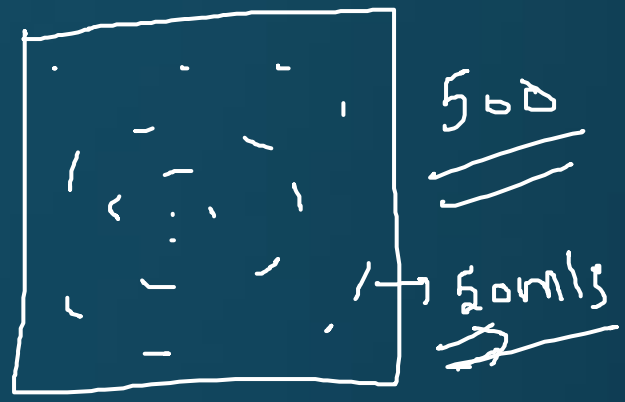
$$\Rightarrow$$

$v_{avg} \Rightarrow \langle v \rangle \Rightarrow \bar{v}$

$$\boxed{v_{avg} = \sqrt{\frac{8RT}{\pi m}}}$$

* v_{mps} ⇒ (most Probable speed)

$$v_{mps} = \sqrt{\frac{2RT}{M}}$$



(1) v_{rms}, v_{mps}, v_{avr}

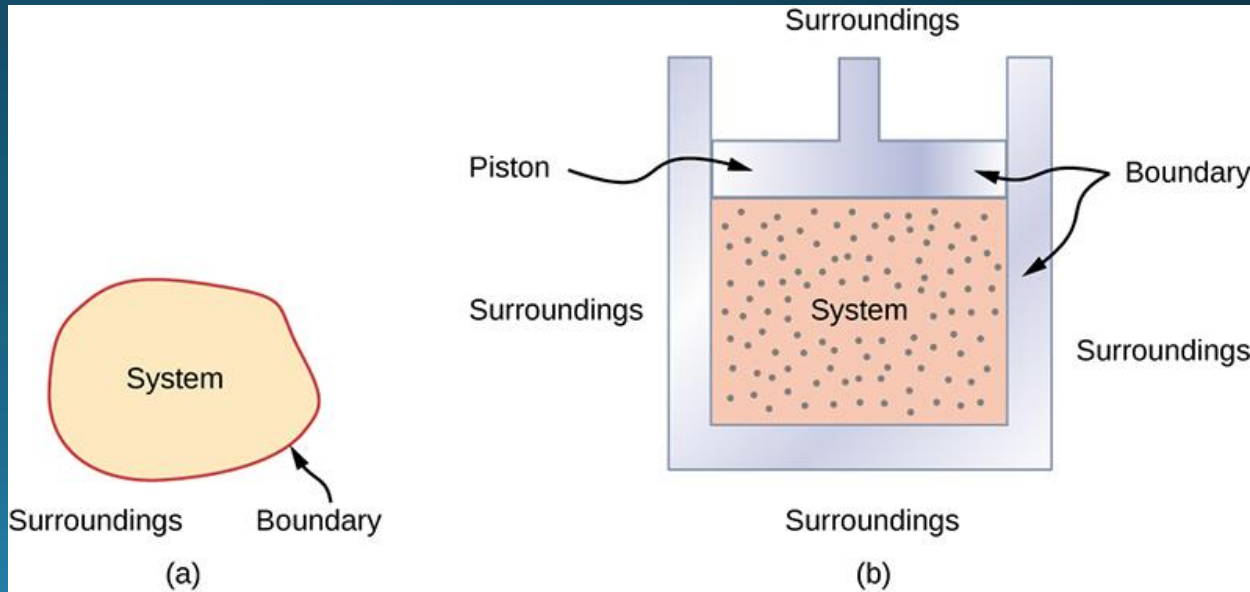
Ans → $v_{rms} > v_{avr} > v_{mps}$

ऊष्मागतिकी

Thermodynamical System

An assembly of an extremely large number of particles whose state can be expressed in terms of pressure, volume and temperature, is called thermodynamic system.

ऊष्मागतिकी विज्ञान की वह शाखा है जिसमें यान्त्रिक कार्य तथा ऊष्मा में परस्पर सम्बन्ध का वर्णन किया जाता है, यह प्रमुख रूप से यान्त्रिक कार्य तथा ऊष्मा के परस्पर रुपान्तरण से सम्बन्धित है।



- Thermodynamic system is classified into the following three systems

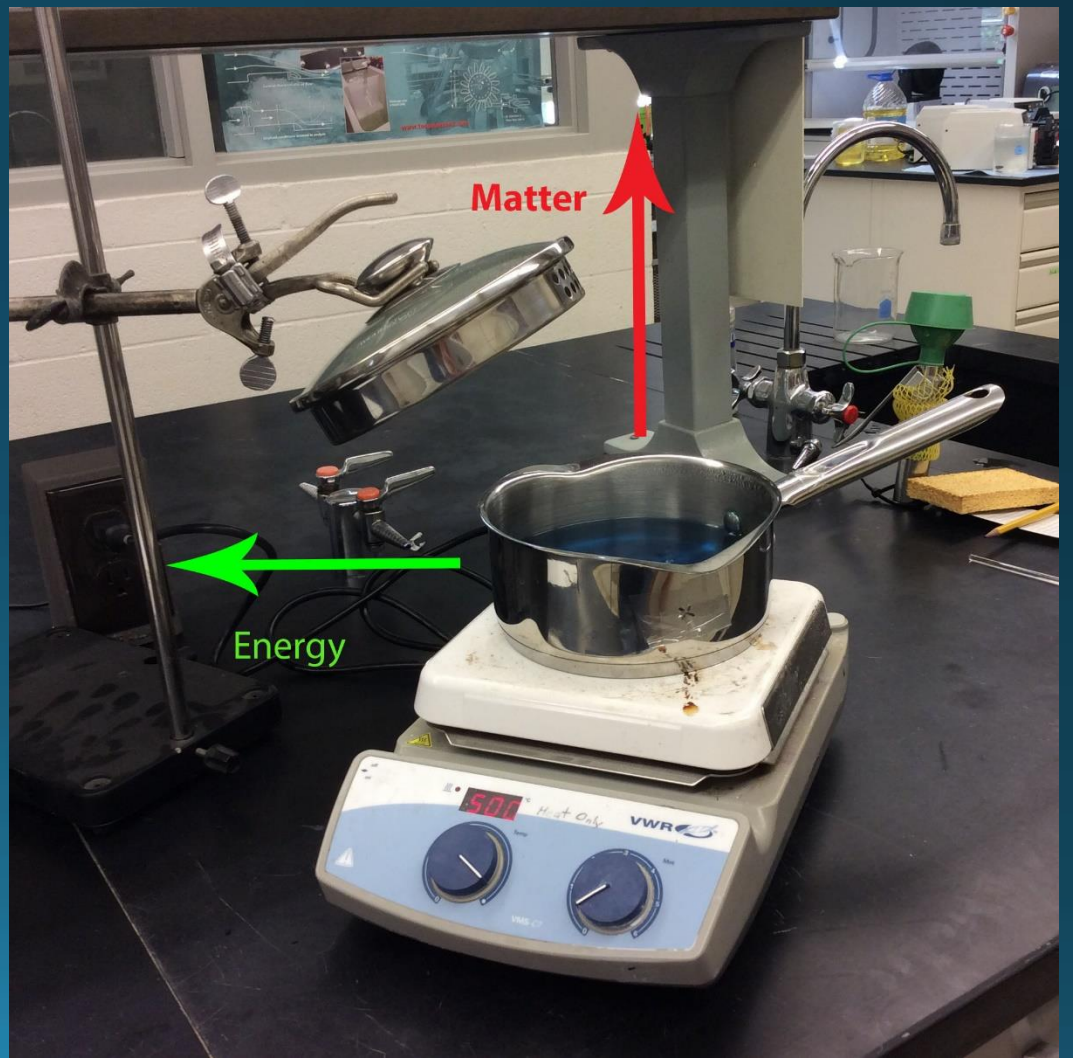
खुला सिस्टम

- (i) **Open System** It exchange both energy and matter with surrounding.

matter ↑ पदार्थ

energy ↑ ऊर्जा

(ऊर्जा)



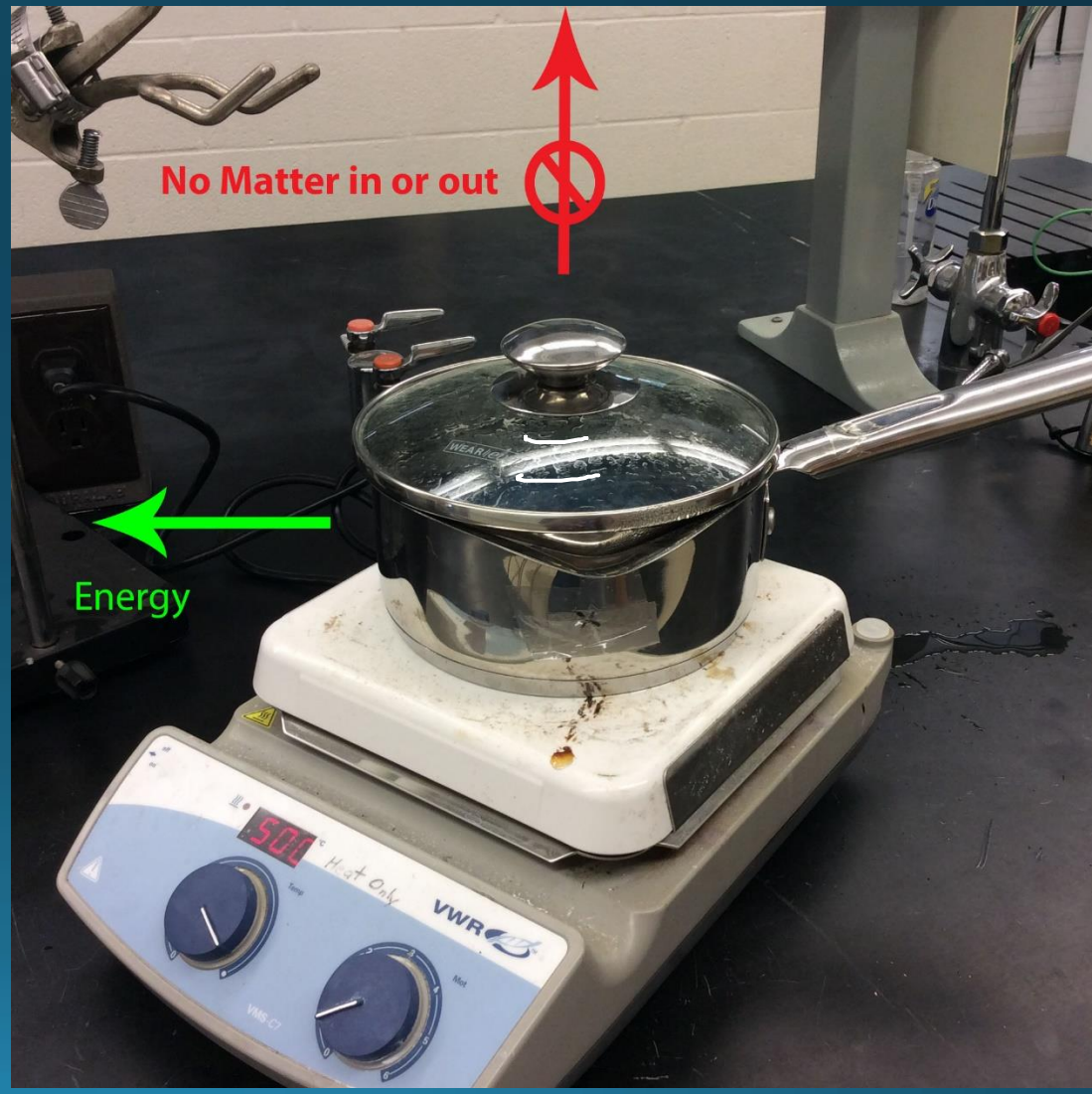
- (ii) **Closed System** It exchanges only energy (not matter) with surroundings.

बन्द ।।

ऊर्जा (आना) ↑

पदार्थ ✗

- .



- (iii) **Isolated System** It exchanges neither energy nor matter with the surrounding

आइसोलेटेड

energy ✗ ऊर्जा ✗

matter ✗ पदार्थ ✗

ideal isolated system

आदर्श " "

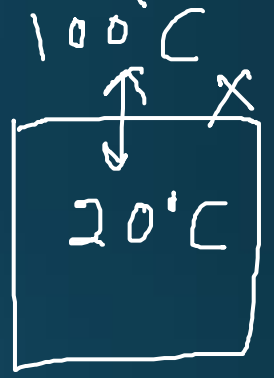
→ नहीं

- **(i) Isothermal Process** (एकसमान तापमान):
- A process taking place in a thermodynamic system at constant temperature is called an isothermal process.
- Isothermal processes are very slow processes.
- These process follows Boyle's law, according to which pV = constant.
- **Examples**
- (a) Melting process is an isothermal change, because temperature of a substance remains constant during melting.
- (b) Boiling process is also an isothermal operation.

- (i) समतापी प्रक्रम
- निरंतर तापमान पर एक थर्मोडायनामिक प्रणाली में होने वाली प्रक्रिया को समतापी प्रक्रम कहा जाता है।
- समतापी प्रक्रम बहुत धीमी प्रक्रियाएं हैं।
- यह प्रक्रिया बॉयल के नियम का अनुसरण करती है, जिसके अनुसार PV = स्थिर।
- उदाहरण
- (ए) पिघलने की प्रक्रिया एक समतापी प्रक्रम है क्योंकि पिघलने के दौरान किसी पदार्थ का तापमान स्थिर रहता है।
- (b) उबलने की प्रक्रिया भी एक समतापी प्रक्रम है।

- **(ii) Adiabatic Process**

- A process taking place in a thermodynamic system for which there is no exchange of heat between the system and its surroundings.



- Adiabatic processes are very fast processes.

- These process follows Poisson's law, according to which

- (ii) रुद्धोष्म प्रक्रम
- थर्मोडायनामिक प्रणाली में होने वाली एक प्रक्रिया जिसके लिए सिस्टम और उसके आस-पास गर्मी का आदान-प्रदान नहीं होता है।

- रुद्धोष्म प्रक्रम बहुत तेज प्रक्रियाएं हैं।
- ये प्रक्रिया पोइसन के नियम का पालन करती है,

- **(iii) Isobaric Process** A process taking place in a thermodynamic system at constant pressure is called an isobaric process.

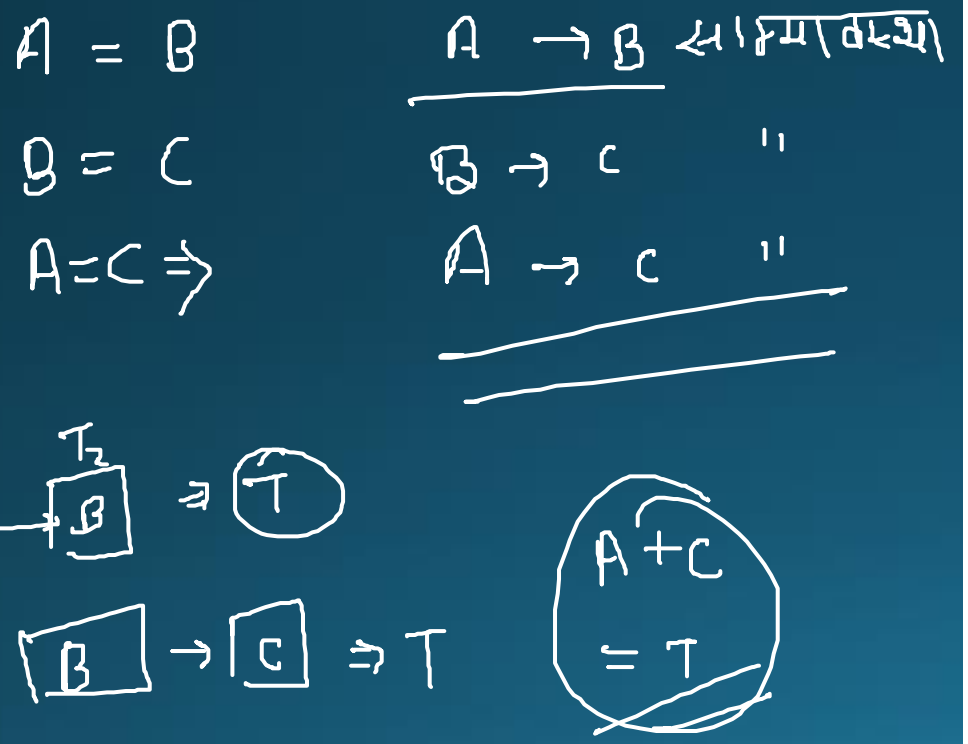
एकसमान दाब पर क्रिया का प्रक्रम

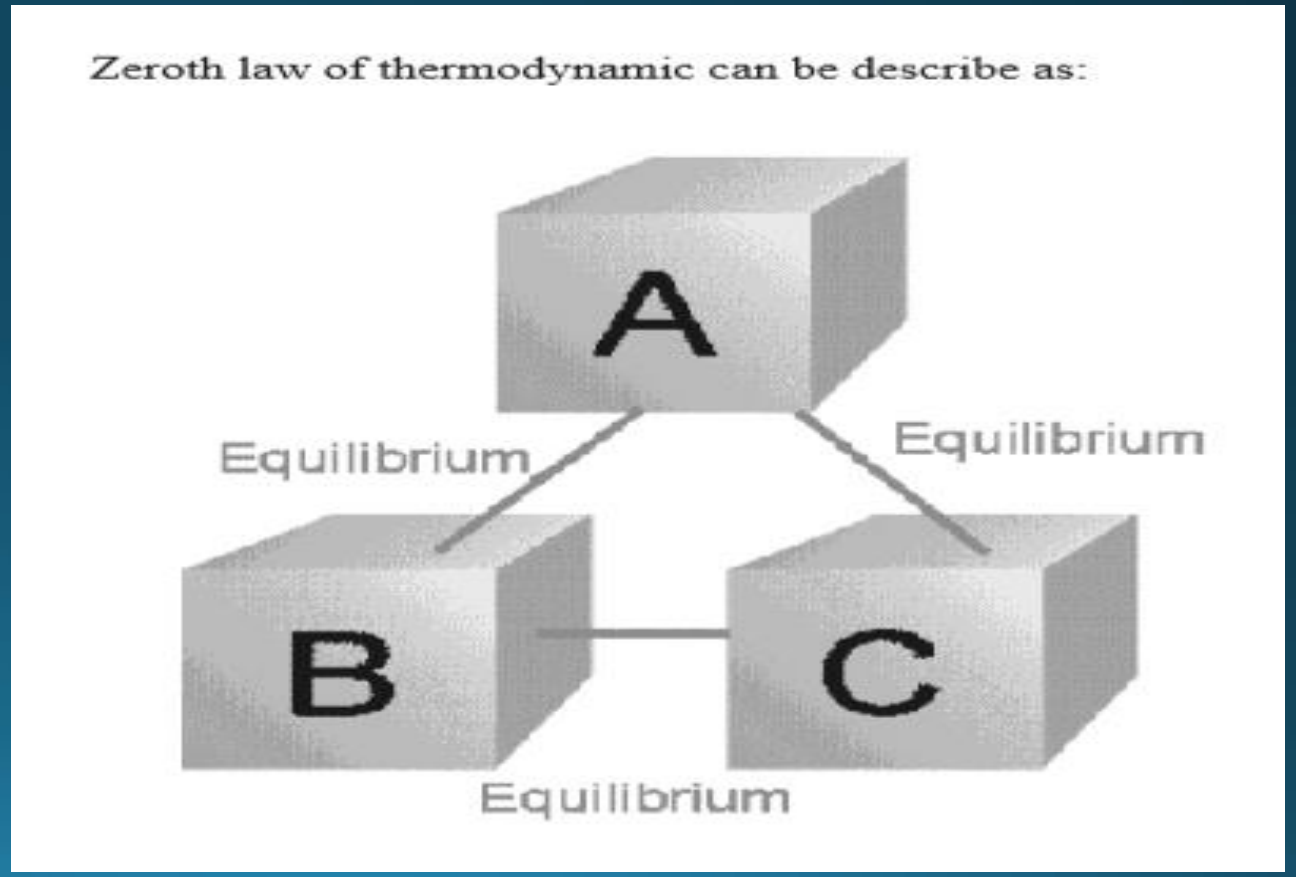
- **(iv) Isochoric Process** A process taking place in a tlaermodynars system at constant volume is called an isochoric process

एकसमान आयतन → ✓

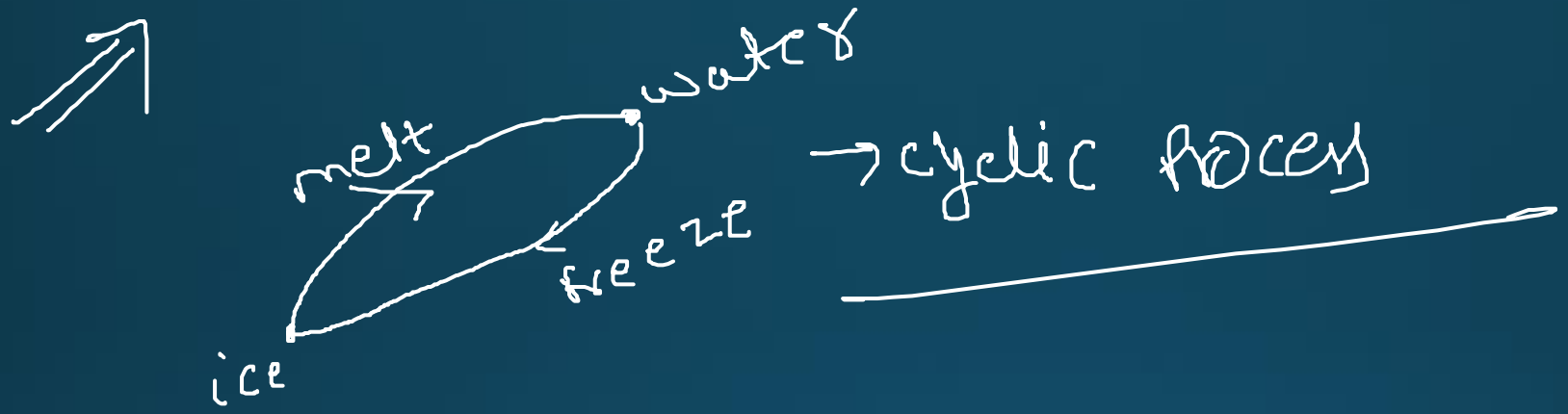
Zeroth Law of Thermodynamics

- According to this law, two systems in thermal equilibrium with a third system separately are in thermal equilibrium with each other. Thus, if A and B are separately in equilibrium with C, that is if T = T and T = T, then this implies that T = T i.e., the systems A and B are also in thermal equilibrium.



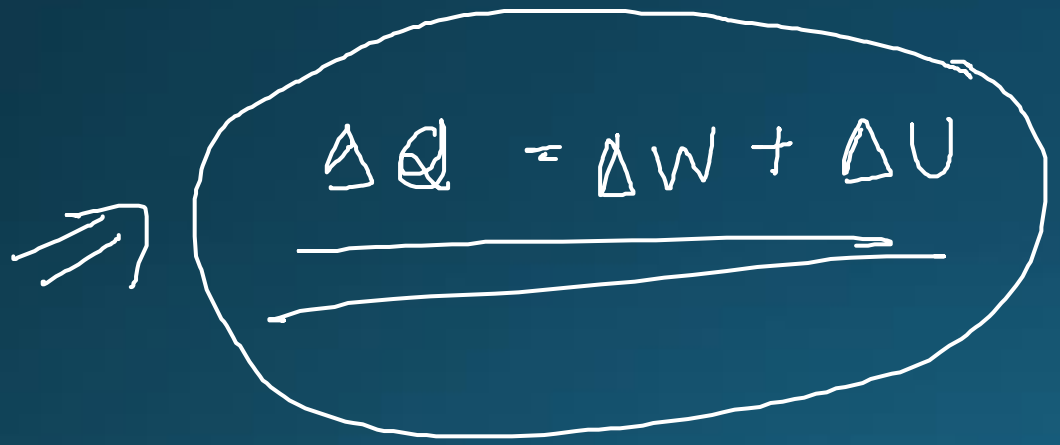


- **(v) Cyclic Process** When a thermodynamic system returns to its initial state after passing through several states, then it is called cyclic process.



First Law of Thermodynamics

- Heat given to a thermodynamic system (ΔQ) is partially utilized in doing work (ΔW) against the surrounding and the remaining part increases the internal energy (ΔU) of the system.
- Therefore, ΔQ = ΔU + ΔW



- पहला नियम लॉ ऑफ कंज़र्वेशन ऑफ एनर्जी (ऊर्जा का संरक्षण) का एक अनुकूलन है। लॉ ऑफ कंज़र्वेशन कहता है कि किसी पृथक सिस्टम की ऊर्जा कभी बदलती नहीं। वह हमेशा उतनी ही रहती है।
- ऊर्जा को बनाया या नष्ट नहीं किया जा सकता। उसे सिर्फ एक तरह से दूसरे तरह की ऊर्जा में परिवर्तित किया जा सकता है।
- जैसे किसी धनुष बाण में धनुष की स्थितिज ऊर्जा को बाण की गतिज ऊर्जा में परिवर्तित करते हैं।

- In isothermal process, change in internal energy is zero ($\Delta U = 0$). Therefore, $\Delta Q = \Delta W$

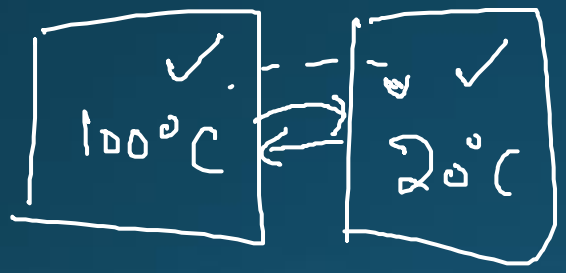
- In adiabatic process, no exchange of heat takes place, i.e., $\Delta\theta = O$. Therefore, $\Delta U = -\Delta W$

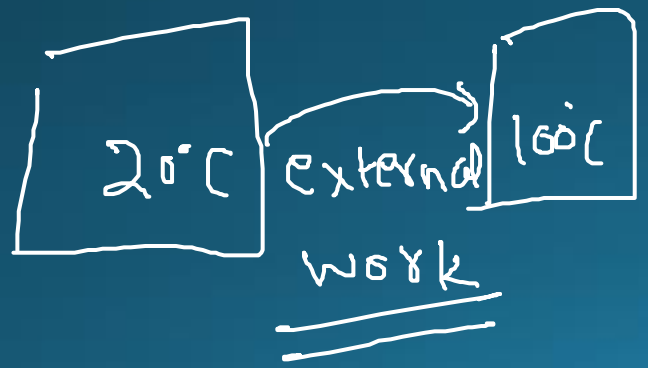
- In adiabatic process, if gas expands, its internal energy and hence, temperature decreases and vice-versa.

- In isochoric process, work done is zero, i.e., $\Delta W = 0$, Therefore $\Delta Q = \Delta U$

Second Law of Thermodynamics

- The second law of thermodynamics gives a fundamental limitation to the efficiency of a heat engine and the coefficient of performance of a refrigerator. It says that efficiency of a heat engine can never be unity (or 100%). This implies that heat released to the cold reservoir can never be made zero.





- **Kelvin's Statement**
- It is impossible to obtain a continuous supply of work from a body by cooling it to a temperature below the coldest of its surroundings.

- **Clausius' Statement**
- It is impossible to transfer heat from a lower temperature body to a higher temperature body without use of an extenal agency.

- **Planck's Statement**
- It is impossible to construct a heat engine that will convert heat completely into work.

- All these statements are equivalent as one can be obtained from the other.

Entropy

- Entropy is a physical quantity that remains constant during a reversible adiabatic change.
- Change in entropy is given by $dS = \delta Q / T$
- Where, δQ = heat supplied to the system and T = absolute temperature.
- Entropy of a system never decreases, i.e., $dS \geq o$.
- Entropy of a system increases in an irreversible process

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