ARJUNA NEET BATCH

States of Matter

LECTURE - 8

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Quick Recap.

→ S, L, G

→ P, V, T, n

→ $\boxed{PV = nRT}$

→ $\boxed{d = \frac{PM}{RT}}$

→ KTG → $\boxed{K.E. = \frac{3}{2} KT}$

→ Manwell Boltzmann

→ Mol. Speed

$V_{rms} = \sqrt{\frac{3RT}{M}}$

$V_{aver} = \sqrt{\frac{8RT}{\pi M}}$

$V_{MPS} = \sqrt{\frac{2RT}{M}}$

Objective of today's class

BEHAVIOUR OF REAL GASES: DEVIATION FROM IDEAL GAS BEHAVIOUR

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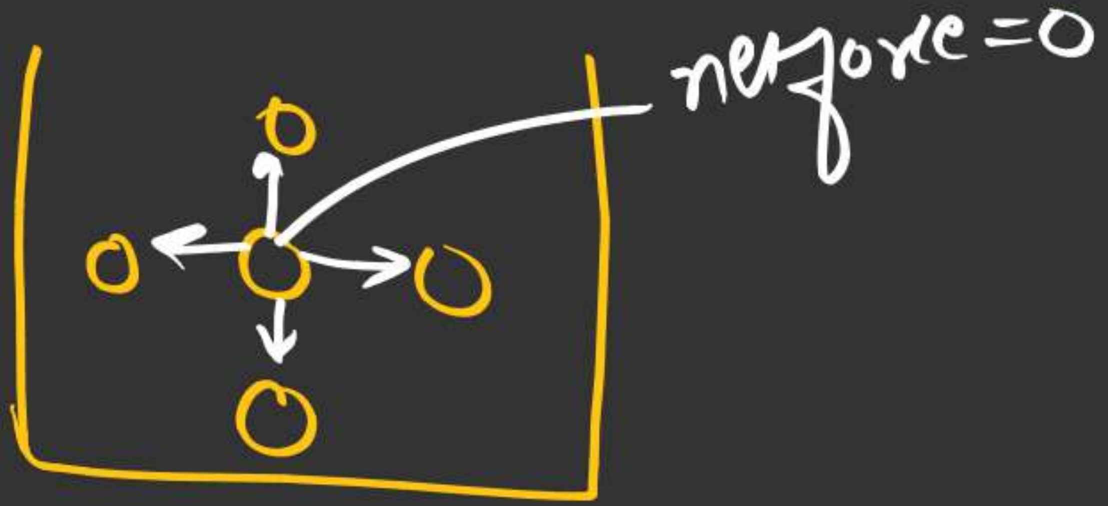
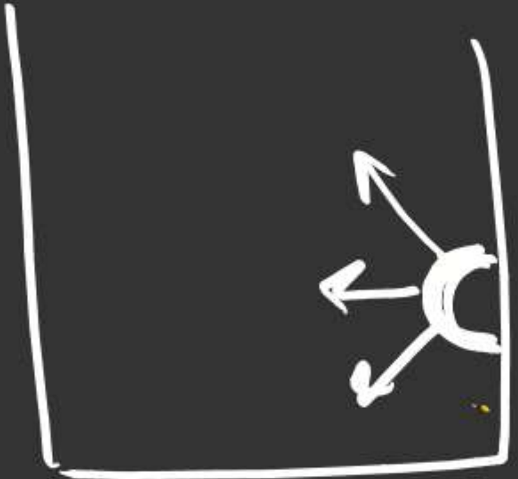
KTG

① There is no FOA b/w gas molecules.



VANDERWAAL

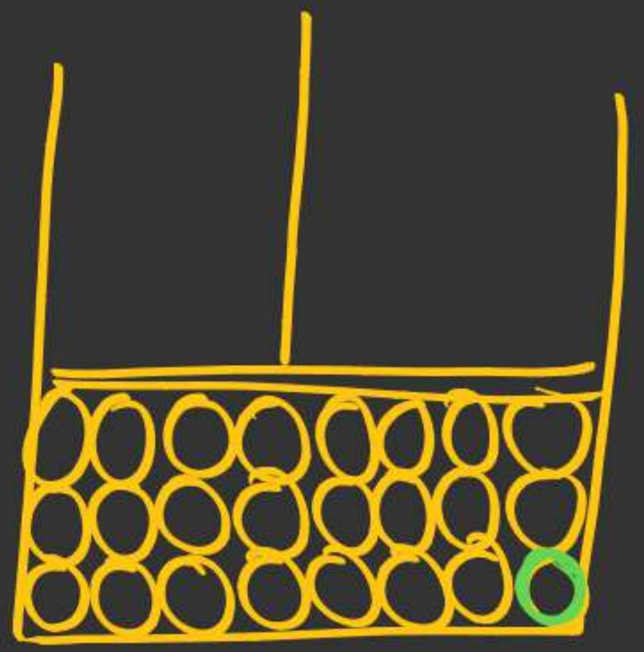
①



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

KTG

(2) ~~The~~ Volume of a gas molecule is negligieble as compared to total Volume of gas



Co-Volume
or
Excluded

IDEAL GAS

→ Those gases which obeys Ideal gas Equation at all conditions of temp. & pressure.

→ There is no force of attraction b/w gas molecules.

→ The Volume occupied by a gas molecule is negligieble as compared to total Volume of gas molecules.

REAL GAS

→ Those gas which not obey's Ideal gas Equation at any Condition of temp. & pressure.

* → There is negligieble FOA b/w the gas molecules.

* → The Volume occupied by a gas molecule is Comparable as compared to Total Volume of gas

Conditions favourable for Ideal behaviour

→ Low Pressure and high temperature

Conditions → Deviation from ideal gas behaviour

→ High Pressure and low temp.

→ There is no ideal gas.

Conditions favourable for Real gas behaviours.

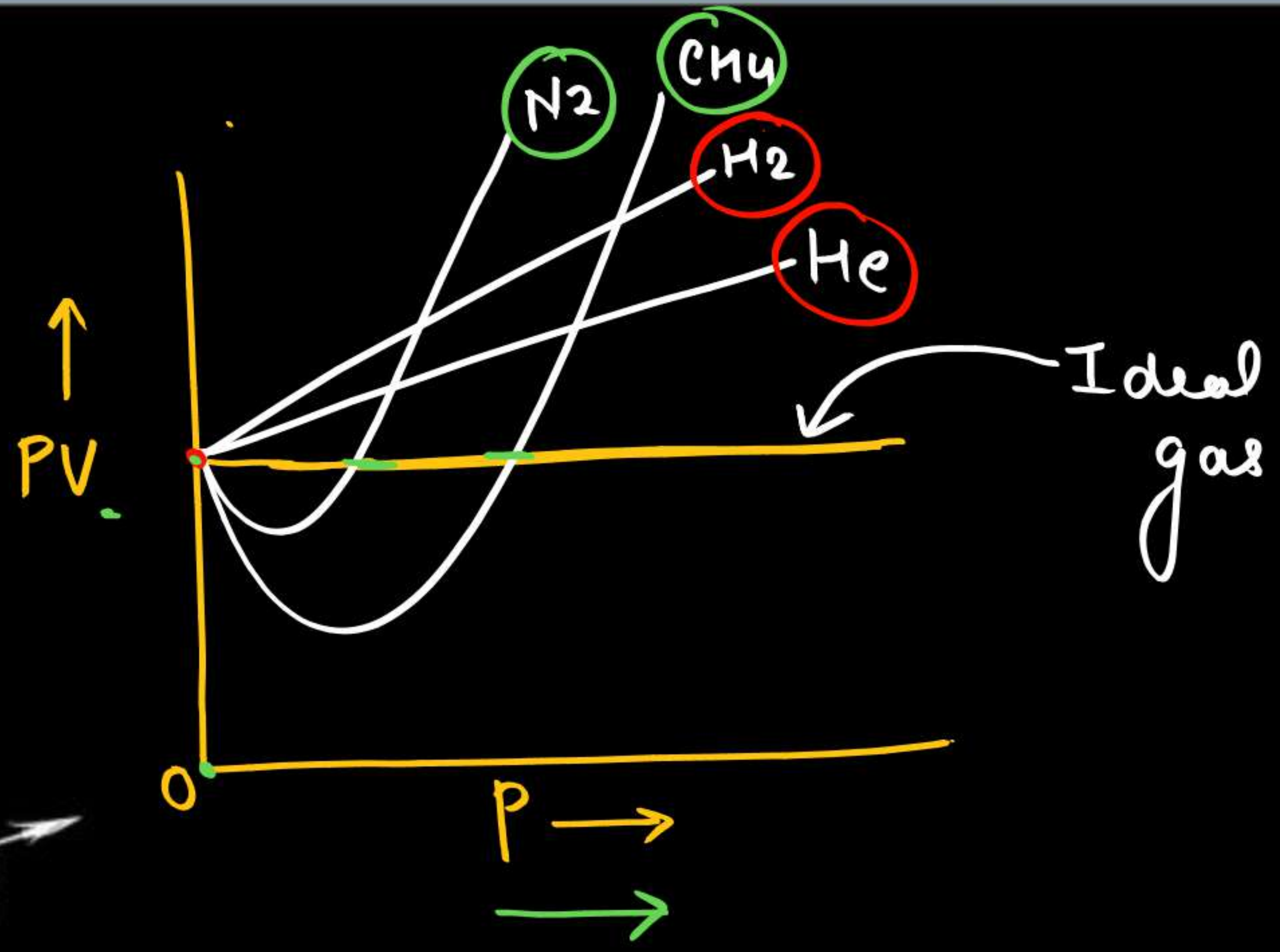
→ High Pressure and Low temp.

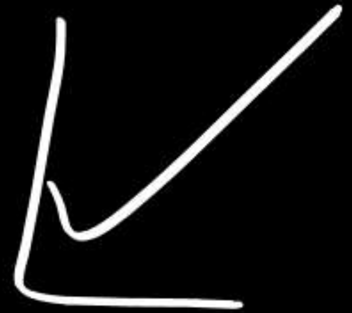
Conditions favourable from Deviation from Real gas behaviour

→ Low Pressure and high temp.

→ All gases are Real gases.

Pressure (P) volume (V) versus Pressure (P) Plot :

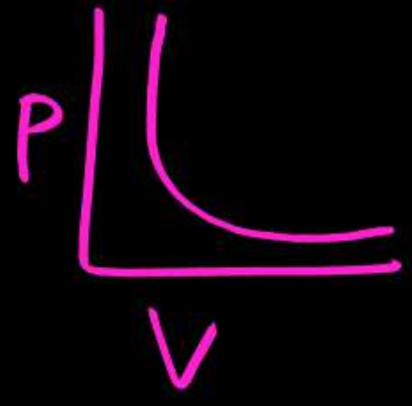




$P \propto \frac{1}{V}$

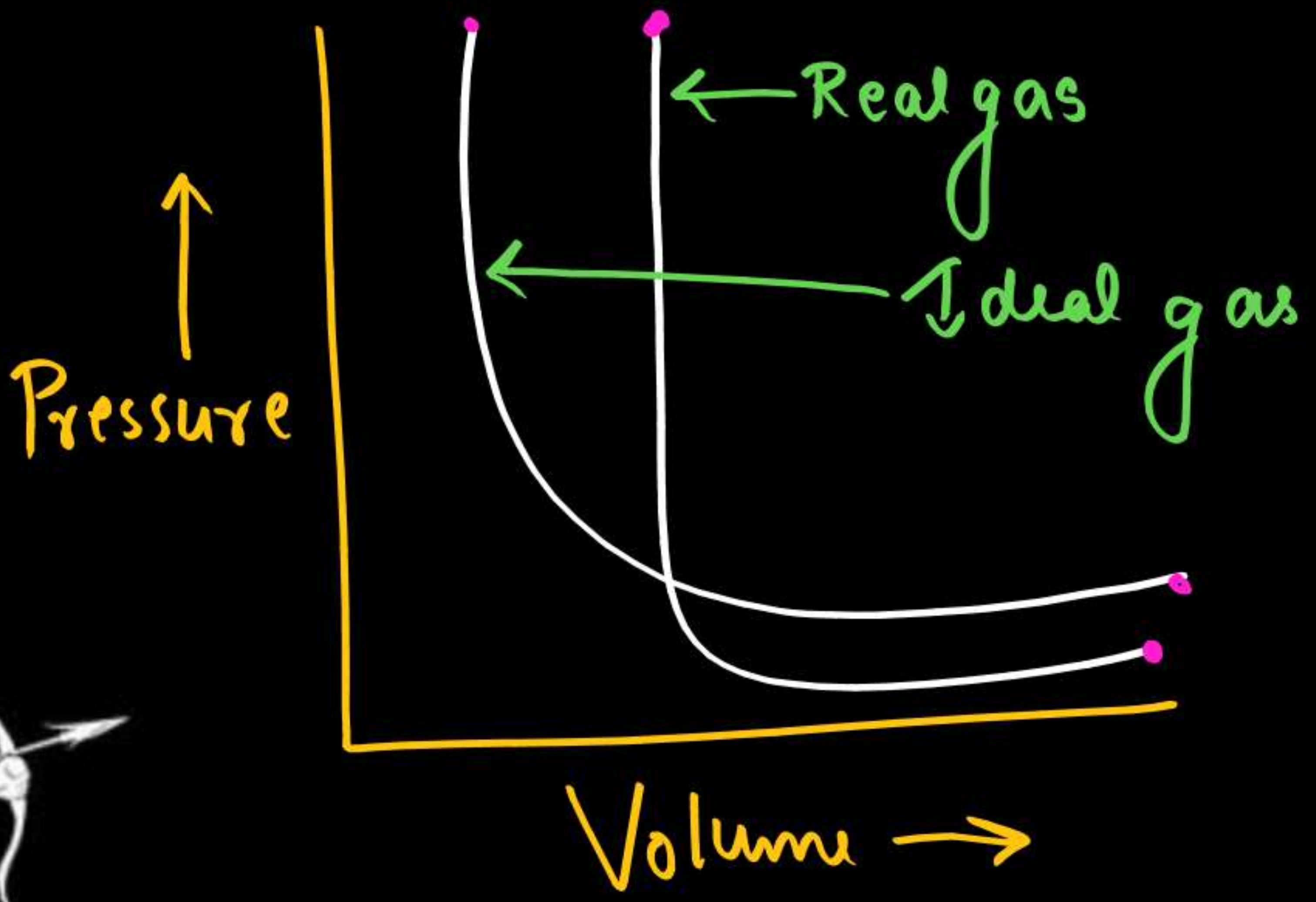
$P = \frac{K}{V}$

$\boxed{PV = \text{Constant}}$



Pressure (P) versus volume (V) Plot :

❖ It is apparent from the graph that real gases show a different curve from the curve of ideal gases.



EXPLANATION FOR THE DEVIATION FROM IDEAL GAS BEHAVIOUR

⇒ TWO FAULTY STATEMENTS OF KTG

(i) **Postulate 1 :** The forces of attraction between gas molecules are zero.

Explanation for its objection :

The above assumption is not valid at all pressure and temperatures values. This is because at high pressure and low temperature (Kinetic energy decreases), the molecules come close to each other. When the molecules are close to each other then the presence of intermolecular forces cannot be ruled out. Generally we see that both attractive and repulsive forces operate between the molecules.

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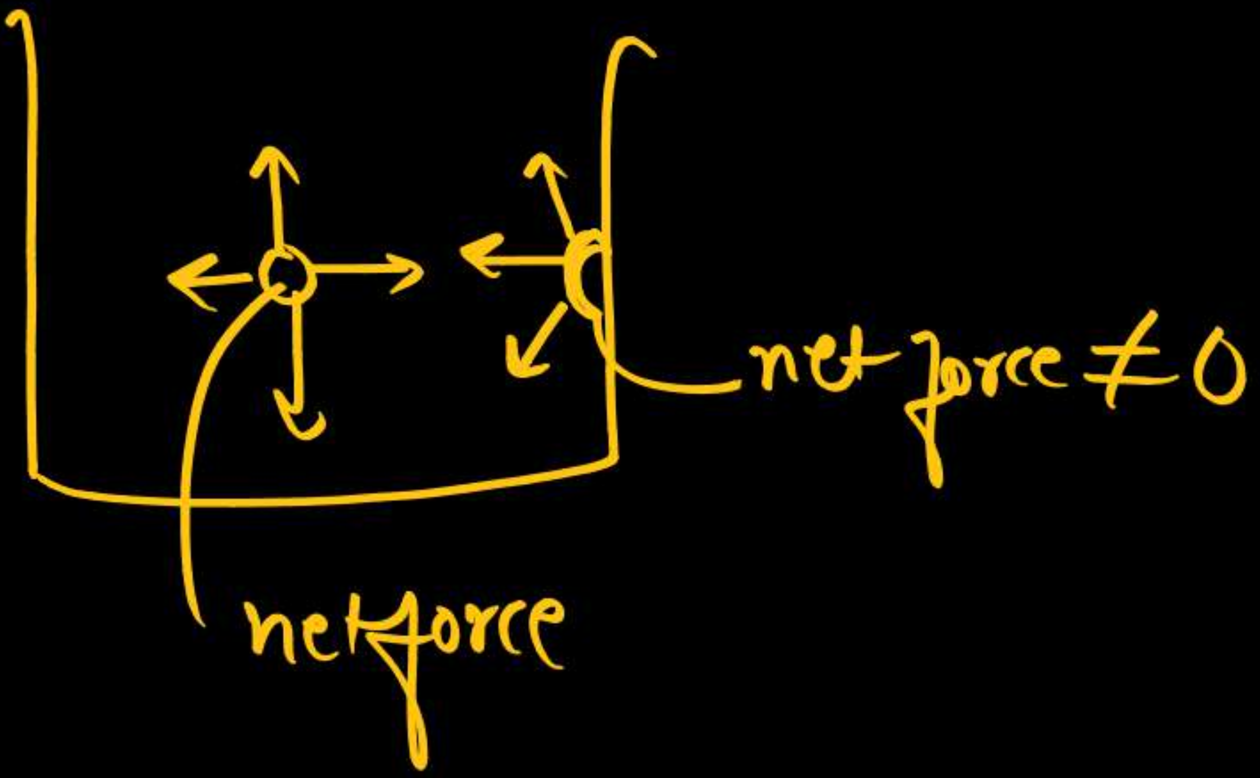
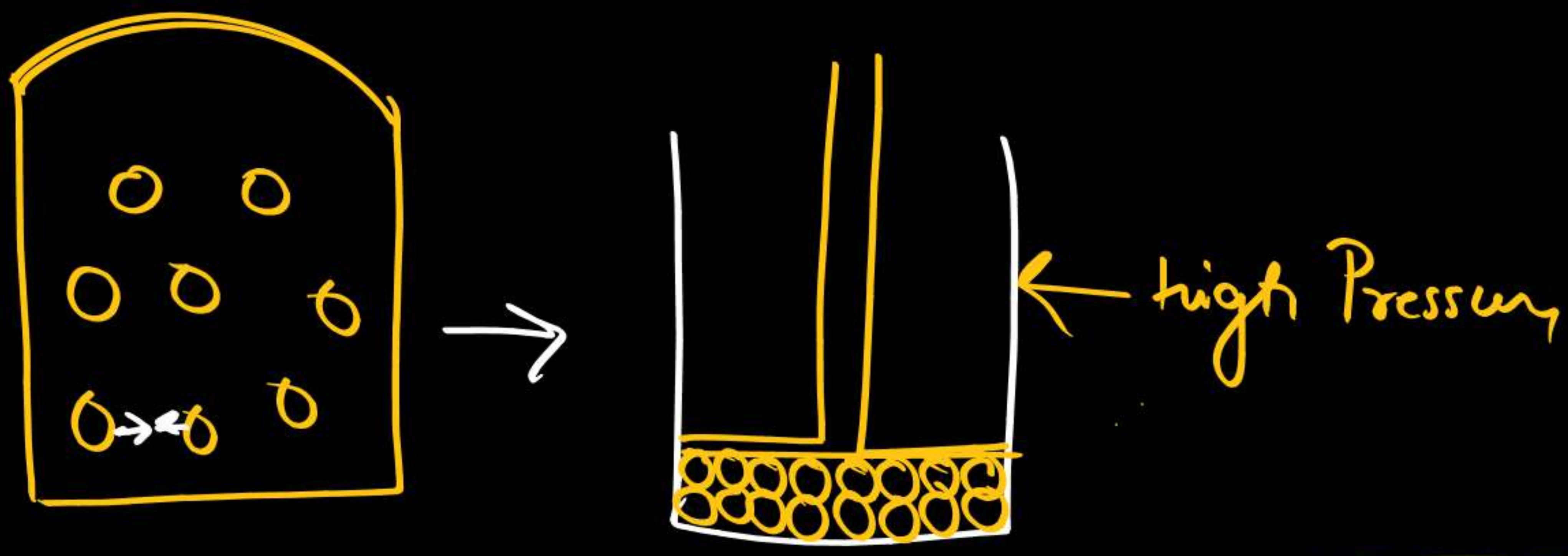
Repulsive force : Repulsive force operate between the molecules at very high pressures when molecules come very close to each other.

Attractive Force: At very close distance molecules repel each other. But at a suitable distance, forces of attraction operate between the gas molecules.



(ii) Postulate 2 : The volume occupied by the molecules themselves is negligibly small as compared to the total volume occupied by the gas.

Negligieble



Explanation for its objection :

When the pressure is high and the temperature is lowered to a large extent then the total volume of the gas decreases because of decrease in the empty space between the gas molecules. Whereas the volume of the individual gas molecule remains the same because the molecules themselves are incompressible. Hence under such conditions the volume occupied by the gas molecules will no longer be negligible in comparison to the total volume of the gas.

Therefore this postulate is invalid at high pressure and low temperatures.

EQUATION OF STATE FOR REAL GASES (van der waals EQUATION)

(i) **Correction of Deviation:** The two faulty assumption or postulates have been identified. Now, there was need of correcting these two assumptions. So, suitable corrections made to the ideal gas equation to make it applicable for real gases also. The ideal gas equation was modified by J.D. van der waals by taking into consideration the intermolecular forces and the volume occupied by the molecules. So, he introduced two corrections.

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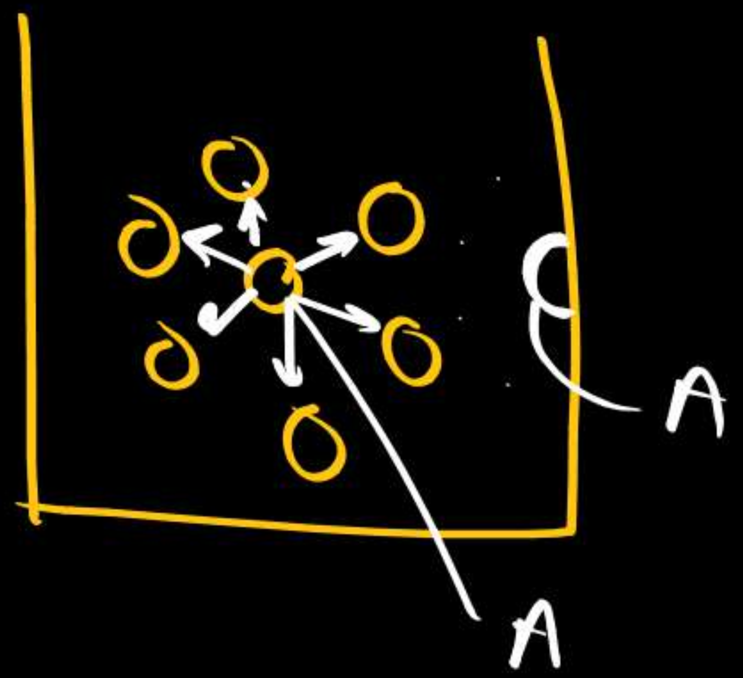
(i) Pressure correction (correction due to intermolecular forces of attraction):

→ In the derivation of ideal gas equation, it is assumed that there are no intermolecular forces of attraction. But as now we have identified this faulty assumption, so there is need to incorporate results obtained from the intermolecular force of attraction between the gas molecules.



For that let us take an example, molecule A (gas) when present in the midst of the vessel is attracted uniformly by the other molecules from all the distance. So, there is no net attractive force of the molecules but When this molecule approaches the wall of the vessel, then it only experiences attractive force from the bulk molecules behind it. So, now the molecule strikes the wall of the vessel with a lower velocity as it is dragged back by the other molecules. Therefore, the pressure exerted by the molecule now is lower than it would have excerted if there was no force of attraction. In other words we can say that the pressure exerted by a real gas is less than that excerted by an ideal gas. Therefore we need to add the pressure correction term to make the ideal gas equation fit for real gases also.

$$\boxed{P_{\text{corrcted}} = P + \frac{an^2}{V^2}} \qquad \text{.........} \; (1)$$

Here 'a' is van der waals constant

$P = P + p_i$

$p_i \Rightarrow$ additional pressure

$p \propto \frac{n}{V}$ (no. of collisions per unit Volume)

$p \propto \frac{n^2}{V^2}$

$p = \frac{an^2}{V^2}$

'a' → Vanderwaal Constant

$\boxed{\text{Unit of } a : atm\ L^2\ mol^{-2}}$

$a = \frac{pV^2}{n^2}$

Physical Significance of "a"

[Order of "a" → $He < H_2 < F_2 < N_2 < O_2 < CH_4 < CO_2 < HCl < HBr <$
$HI < NH_3 < H_2O < HF < Cl_2 < SO_2$]

⇒ 'a' Signifies the magnitude of attractive forces

[2:00 → 4:30]

(ii) Volume correction (correction due to volume of gas molecules):

Ideal gas equation assumes molecules to be point masses. But at high pressure we have learnt that the volume of the gas molecules cannot be neglected in comparison to the volume of the container in which gas is kept. So, volume correction is applied. 'V' term in the ideal gas equation is the volume of the vessel in which gas molecules are free to move. But as the molecules themselves take up space. So, now molecules instead of moving in volume 'V' are only restricted to volume (V - nb). nb is the volume which is incompressible as molecules are impenetrable spheres.

$$\boxed{V_{\text{corrcted}} = V - nb} \quad \text{.........} \text{(ii)}$$

Where, b is van der waals constant

n is number of moles of gas

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

if $n=1$ (no. of mole $=1$)

$$\left[\left(P+\frac{a}{V^2}\right)\left(V-b\right)=RT\right]$$ Vanderwaal gas eqn.

$P \rightarrow$ Pressure

$V \rightarrow$ Volume

$n \rightarrow$ no. of mole

$T \rightarrow$ Temp.

$R \rightarrow$ gas const

'a' & 'b' Vanderwaal gas const.

thanks for watching

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