Gaseous State

Matter

	Solid	liq	gas.
Intermolecular force	large	Small	almost zero
vol	fixed	fixed	varies with container
Geometry	Definite	not definite	not definite.
Thermal Energy	almost zero	greater	High
Compressibility	Not Compressible	not easily compressible	compressible
density	high	Intermediate.	low

Thermal energy

- directly proportional to temperature.
- T ↑ random motion ↑ KE of particle ↑ Thermal Energy ↑

Intermolecular force v/s Thermal Energy

Intermolecular force ↓ Keep molecules togather

Thermal Energy ↓ keep molecules apart

Solid liq gas →

Intermolecular force decreases.

→

Thermal energy increases.

Gaseous state

only 11 elements exists as gases.

H N O F He
Cl Ne
Ar
Kr
Xe
Rn

physical proties of gas

- Highly compressible.
- exert pressure equally in all direction.
- low density than solid/liq.
- Vol & Shape is not fixed (Vol of container dependent)
- intermix evenly & completely ~~without~~ (Homogeneous mixture)

Parameter to define properties of a gas

Pressure :- $\boxed{P = \frac{F}{A}}$ newton/m² (N/m²) or Pascal (Pa) → S.I Unit

Dyne → CGS unit

$\boxed{\text{Other unit} \rightarrow \text{atm}}$

$1\,\text{atm} = 1.013 \times 10^5\,\text{Pa} = 1.013\,\text{bar} = 760\,\text{torr}, = 760\,\text{mm of Hg} = 76\,\text{cm of Hg}$

Volume :- SI unit → m^3

$1\,m^3 = 1000\,dm^3 = 1000$ litre

~~1 dm~~ $1\,dm^3 = 1$ litre $= 1000\,ml = 1000\,cm^3 = 1000\,cc$

Temp :- SI unit → kelvin (K)

$\boxed{T_K = T_C + 273}$ $\boxed{\frac{C}{5} = \frac{F-32}{9}}$

amount of substance

unit = mol

$\boxed{\text{mole} = \frac{\text{mass}}{\text{molar mass}}}$

Gas laws

① **Boyle's law** → $\boxed{P \propto \frac{1}{V}}$

Temp const

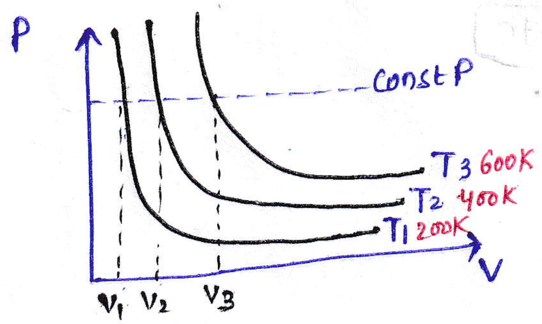
mole const

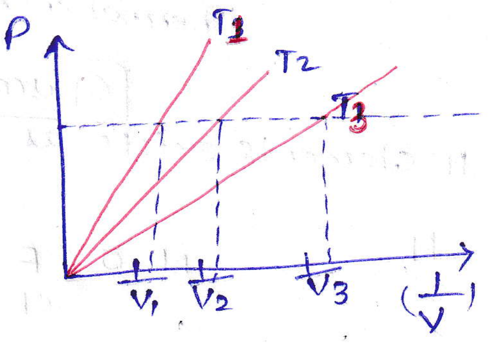
→ isotherm

$P = K\frac{1}{V}$ → depends on T, mole of gas

$PV = K$

$\boxed{P_1V_1 = P_2V_2}$





$PV = nRT$

$P = \text{const}$

$\boxed{V \propto T}$

$V_3 > V_2 > V_1$

$\boxed{T_3 > T_2 > T_1}$

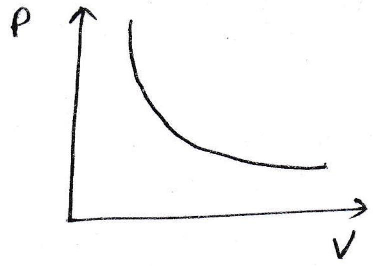
$\frac{1}{V_1} < \frac{1}{V_2} < \frac{1}{V_3}$

at const P

$V \propto T$

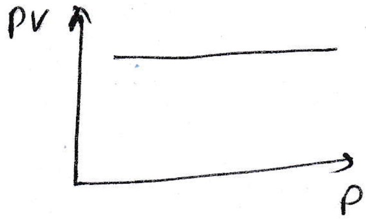
$V_3 < V_2 < V_1$

$\boxed{T_3 < T_2 < T_1}$



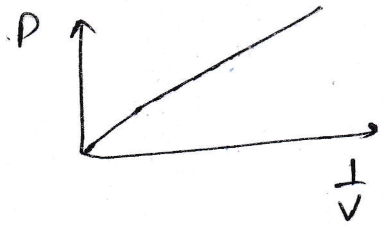
$\underline{PV=C}$

$\underline{xy=C}$

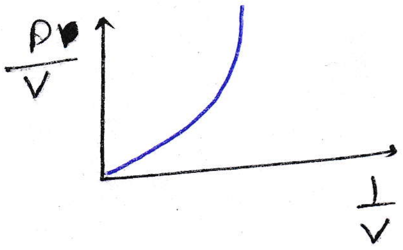


$PV=C$

$y=\text{const}$



$P=\frac{C}{V}$ $\underline{y=mx}$

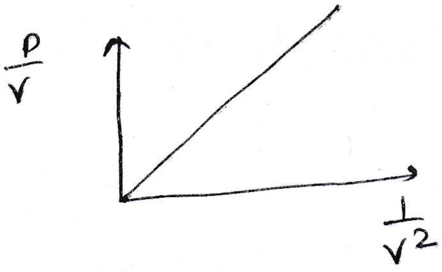


$PV=C$

$\frac{PV}{V^2}=\frac{C}{V^2}$

$\frac{P}{V}=C\frac{1}{V^2}$

$y=mx^2$



$\frac{P}{V}=C\cdot\frac{1}{V^2}$

$y=mx$

Relation b/w density & pressure using Boyle's law

$PV = K$; $d = \frac{m}{V} \Rightarrow \boxed{V = \frac{m}{d}}$

$$P \times \frac{m}{d} = K$$

$$P = \frac{K}{m} d$$

$$P = K' d \quad \Rightarrow \boxed{P \propto d}$$

⇒ This means at high pressure gases become more denser.

Que A ballon is filled with Hydrogen at room temp, it will burst if Pressure exceeds 0.2 bar if at 1 bar pressure gas occupies 2.27 Litre volume upto what vol can the ballon be expanded.

⇒ Temp Const → $P_1V_1 = P_2V_2$

$P_1 = 1$ bar
$V_1 = 2.27\,l$
$P_2 = 0.2$ bar
$V_2 = ??$

$$V_2 = \frac{1\,\text{bar} \times 2.27}{0.2\,\text{bar}}$$

$$= 11.35 \text{ litre}$$

Que 103 ml of CO_2 is collected at 27°c and 760 mm pressure, what will be its volume is pressure is changed to 721 mm at the same temp.

⇒ Temp → const - 27°c
$P_1 = 760$
$V_1 = 103$ ml
$P_2 = 721$
$V_2 = ??$

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1V_1}{P_2} = \frac{763 \times 103}{721} = 109 \text{ ml}$$

Que a ballon contains some solid marbles each of volume 10 ml. If initial pressure is 2 atm & volume is 1 Litre. If pressure is increased to 4 atm. The volume of balloon becomes 625 ml. Find number marbles present in balloon.

⇒ no of marble = n
vol of marble = 10 ml
Total vol of marble = (10n) ml

$$P_1V_1 = P_2V_2$$

$$2(1000 - 10n) = 4(625 - 10n)$$

$$2000 - 20n = 2500 - 40n$$

$$20n = 500$$

$$n = 25$$

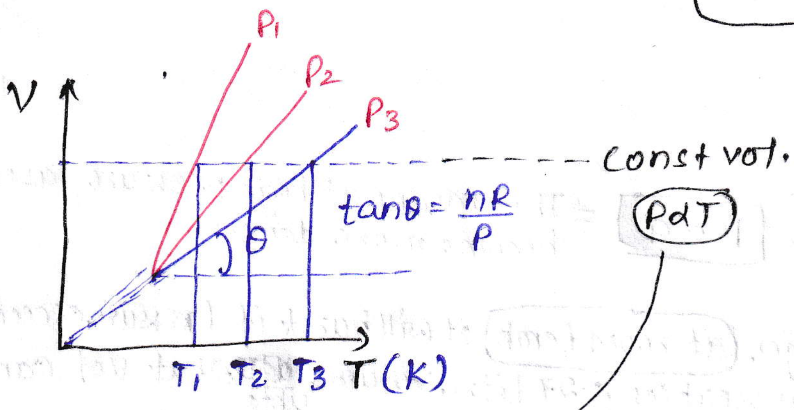
Charle's law

{ Pressure - const
n - const }

$\boxed{V \propto T}$ → Temp in kelvin

$\boxed{V = KT}$ → depends on Pressure & mole of gas.

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



$V = \left(\frac{nR}{P}\right) T$

$y = mx$

$T_3 > T_2 > T_1$

$P_3 > P_2 > P_1$

This is called isobar

−273.15°C → 0 kelvin

absolute zero → lowest hypothetical or imaginary temp at which gases are supposed to occupy zero vol is called absolute zero.

Que At temp 23.4°c, vol of ballon is 2 Litre. what will be final vol of balloon when temp goes to 26.10°c. (pressure const)

$V_1 = 2\,l$ $V_2 = ??$

$T_1 = 23.4 + 273$ $T_2 = 299.1\ K$

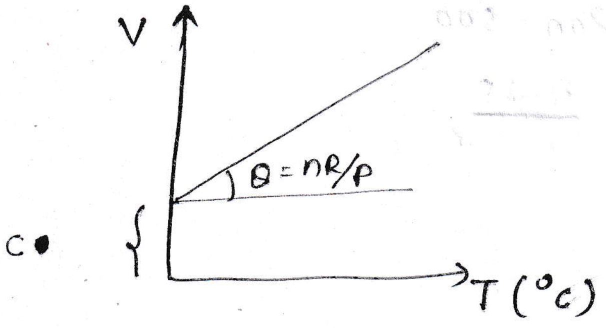
$= 296.4\ K$

Charle's law $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$V_2 = \frac{V_1}{T_1} \times T_2$

$= \left(\frac{2}{296.4} \times 299.1\right) l$

$= 2.018$ Litre



$V \propto T_K$

$V \propto (T_c + 273)$

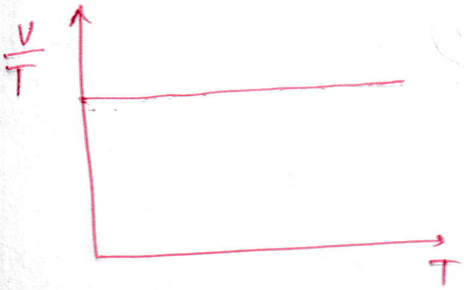
$y = mx + c$

③

Que if the temp of a particular amt of gas is increased from 27°c to 57°c. Find final volume of gas if initial vol is 1 Litre & pressure is const.

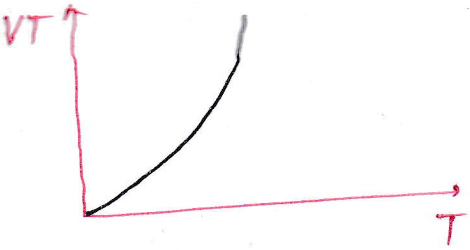
⇒ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$\frac{1}{300} = \frac{V_2}{(273+57)}$ ⇒ $\frac{1}{300} = \frac{V_2}{330}$ ⇒ $V_2 = \frac{330}{300} = 1.14\ l$



$V = KT$

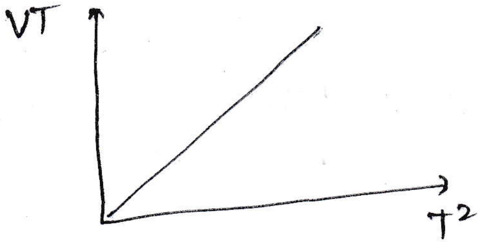
$\frac{V}{T} = K$



$V = KT$

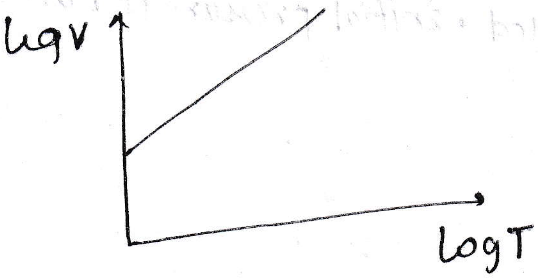
$VT = KT^2$

$y = x^2$



$VT = KT^2$

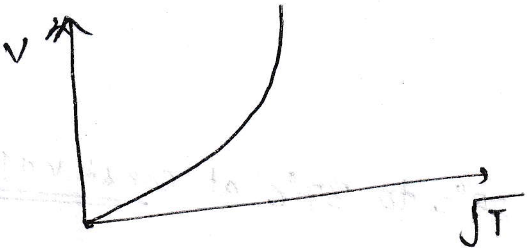
$y = x$



$V = KT$

$\log V = \log K + \log T$

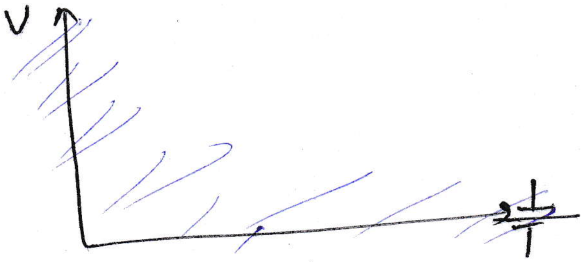
$y = c + x$



$V = K\,T$

$V = K(\sqrt{T})^2$

$y = K x^2$



~~$V = KT$~~

~~$\frac{V}{T}$~~

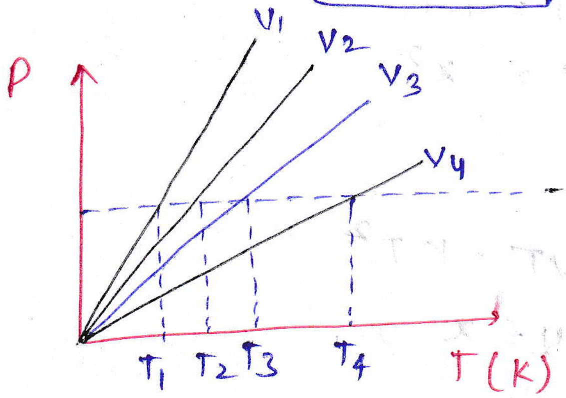
Gay-Lussac law

const vol $\rightarrow$ isochor
const mole

$$P \propto T\,(K)$$

$$P = KT$$

$$\boxed{\frac{P_1}{T_1} = \frac{P_2}{T_2}}$$



Const P

$V \propto T$

$T_4 > T_3 > T_2 > T_1$

$$\boxed{V_4 > V_3 > V_2 > V_1}$$

Que Temp of certain mass of gas is doubled. initial pressure is 1 atm. find final pressure. (vol-const)

$\Rightarrow$ $\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$

$$\frac{1}{\cancel{T}} = \frac{P_2}{2\cancel{T}}$$

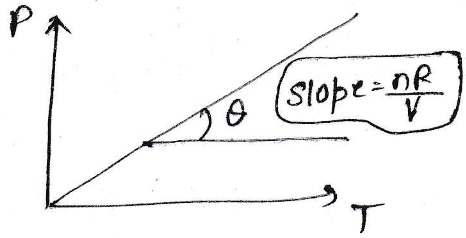
$$\boxed{P_2 = 2\,atm}$$

Que Temp of a gas was increased from 27°c to 37°c at const vol. what will be pressure of gas:-

$\Rightarrow$ $\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$

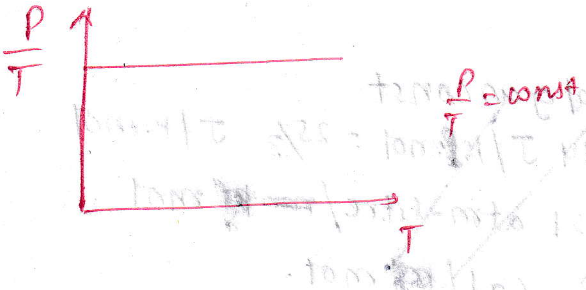
$$\frac{P_1}{300} = \frac{P_2}{310}$$

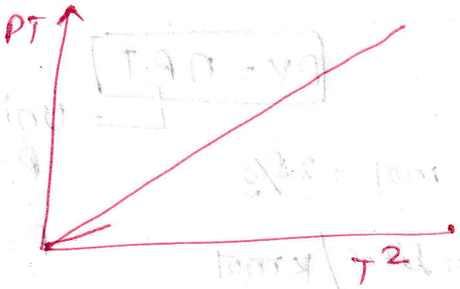
$$\frac{P_2}{P_1} = \frac{310}{300} \Rightarrow \boxed{P_2 = \frac{31}{30}P_1}$$



$P \propto T$

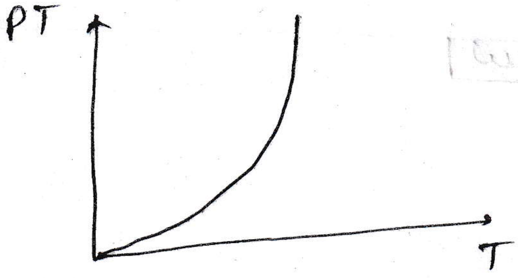
$P = \left(\frac{nR}{V}\right) T$





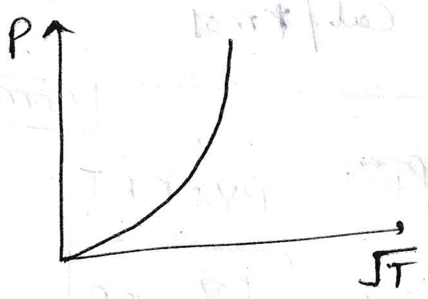
$P = KT$

$PT = KT^2$



$PT = KT^2$

$y = x^2$



$P = KT$

$P = K(\sqrt{T})^2$

$y = x^2$

Avogadro law

P → const
T → const

$V \propto n$

equal vol of all gases, contain equal number of molecules. (P, T → const)

$V = Kn$

$\boxed{\frac{V_1}{V_2} = \frac{n_1}{n_2}}$ or $\boxed{\frac{V_1}{n_1} = \frac{V_2}{n_2}}$

$\boxed{V \propto n}$

$V = Kn$

$V = K\frac{m}{M}$

$M = K\frac{m}{V}$

$\boxed{M = Kd}$

Ideal gas equation

Ideal gas → gas that follow Boyle's law, Charle's law, Avogadro law is called ideal gas.

B. Law → $V \propto \frac{1}{P}$ (const T) → ①

C. Law → $V \propto T$ (const P) → ②

Av. law → $V \propto n$ (const P & T) → ③

Combining ① ② ③

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

$$V = R\frac{nT}{P}$$

$$\boxed{PV = nRT}$$ → Universal gas const

$R = 8.314$ J/K mol = 25/3 J/K mol

$R = 0.0821$ atm-litre/~~mo~~ mol

$R = 1.98$ cal/ mol.

$R = 8.314$ J/Kmol = 25/3

$R = 0.082$ atm litre/Kmol

$R = 1.98$ Cal/Kmol

Combined gas law

$$PV = nRT$$

at fixed amount of gas.

$$\boxed{\frac{PV}{T} = nR}$$

$$\boxed{\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2} = \text{const}}$$ → Combined gas law

Que at 25°c and 760 mm Hg Pressure, a gas occupies 600 ml volume. what will be its pressure at a height where temp is 10°c & vol of gas is 640 ml.

⇒ $P_1 = 760$ mm Hg.
$V_1 = 600$ ml
$T_1 = 298$ K

$P_2 = ??$.
$V_2 = 640$ ml
$T_2 = 283$ K.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$P_2 = \frac{P_1V_1}{T_1} \times \frac{T_2}{V_2}$$

$$= \frac{760 \times 600 \times 283}{298 \times 640}$$

$$= \underline{676.6 \text{ mm Hg}}$$

Que at 27°c & one atm pressure & a gas volume V. what will its vol at 177°c and Pressure 1.5 atm ?

⇒

$V_1 = V$ $\qquad$ $V_2 = ?$

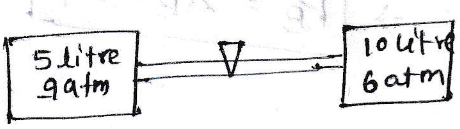
$P_1 = 1\,atm$ $\qquad$ $P_2 = 1.5\,atm$

$T_1 = 300K$ $\qquad$ $T_2 = 450K$.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{1\times V}{\cancel{300}_{2}} = \frac{1.5\times V_2}{\cancel{450}_{3}} \Rightarrow \boxed{V_2 = V}$$

Que The stopcock connecting the two bulbs of vol 5 litre & 10 litre, containing ideal gas at 9 atm & 6 atm respectively is opened. What is the final pressure if the temp remain same.



$$P_f = \frac{n_{final}\, \overset{\rightarrow const}{RT}}{V_{final}}$$

$$= \frac{(n_1+n_2)RT}{V_1+V_2}$$

$$= \frac{\left(\frac{9\times5}{RT} + \frac{10\times6}{RT}\right)RT}{(10+5)}$$

$$\Rightarrow \frac{\left(\frac{45}{RT}+\frac{60}{RT}\right)RT}{15} \Rightarrow \frac{105}{15} = 7\,atm$$

[Relation b/w molar mass & density]

$PV = nRT$

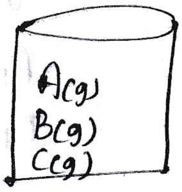
$n = \frac{m}{M}$

$$PV = \frac{m}{M}RT \rightarrow PM = \frac{m}{V}RT \rightarrow \boxed{PM = dRT} \quad \boxed{M = \frac{dRT}{P}}$$

Dalton's law of Partial Pressure

In a mixture of non reactive gases, total pressure of mixture is sum of (partial pressure) of indivisual gases.

$$\boxed{P_{Total} = P_A + P_B + P_C}$$



$$P_A = \frac{n_A RT}{V}$$

$$P_B = \frac{n_B RT}{V}$$

$$P_C = \frac{n_C RT}{V}$$

$$P_{Total} = \frac{(n_A+n_B+n_C)RT}{V}$$

Partial pressure

$$\frac{P_A}{P_T} = \frac{n_A}{n_A+n_B+n_C} = X_A \Rightarrow \boxed{P_A = X_A \cdot P_T}$$

$$\frac{P_B}{P_T} = \frac{n_B}{n_A+n_B+n_C} = X_B \Rightarrow \boxed{P_B = X_B \cdot P_T}$$

$$\frac{P_C}{P_T} = \frac{n_C}{n_A+n_B+n_C} = X_C \Rightarrow \boxed{P_C = X_C \cdot P_T}$$

Que A Ne + O_2 mixture contain 70.6 gm O_2 and 167.5 gm Ne. if Pressure of mix of gases is 25 bar. what's Partial Pressure of O_2 & Ne.

$\Rightarrow$

Ne + O_2

$$n_{Ne} = \frac{167.5}{20} = 8.37 \qquad n_{O_2} = \frac{70.6}{32} = 2.21$$

$$P_{O_2} = X_{O_2} \cdot P_T$$

$$= \left(\frac{2.21}{2.21+8.37} \times 25\right) \text{bar}$$

$$= 5.25 \text{ bar}$$

$$P_{Ne} = X_{Ne} \cdot P_T$$

$$\left(\frac{8.37}{2.21+8.37} \times 25\right) \text{bar}$$

$$= 19.7 \text{ bar}$$

Que a mixture of gas at 760 torr contains 55% nitrogen, 25% oxygen and 20% Carbondioxide by mole. what is partial pressure of each gas in torr.

⇒ $n_{N_2} = 55$ $\quad P_{N_2} = \frac{55}{55+25+20} \times 760 \text{ torr} = 418 \text{ torr}$

$n_{O_2} = 25$

$n_{CO_2} = 20$ $\quad P_{O_2} = \frac{25}{100} \times 760 \text{ torr} = 190 \text{ torr}$

$P_{CO_2} = \frac{20}{100} \times 760 \text{ torr} = 152 \text{ torr}$

Que Equal masses of O_2 and N_2 are present in a container, then find ratio of their partial pressure.

⇒ $P_{O_2} = X_{O_2} \cdot P_T$ $\qquad P_{N_2} = X_{N_2} \cdot P_T$

$$\frac{P_{O_2}}{P_{N_2}} = \frac{X_{O_2}}{X_{N_2}} = \frac{\frac{n_{O_2}}{\cancel{n_{O_2}+n_{N_2}}}}{\frac{n_{N_2}}{\cancel{n_{O_2}+n_{N_2}}}} = \frac{n_{O_2}}{n_{N_2}} = \frac{\frac{\cancel{m_{O_2}}}{M_{O_2}}}{\frac{\cancel{m_{N_2}}}{M_{N_2}}} = \frac{M_{N_2}}{M_{O_2}}$$

$$= \frac{28}{32} = \frac{7}{8}$$

Que In a container equal masses of He, O_2, N_2 are present, then find fraction of partial pressure exerted by O_2.

⇒ $P_{O_2} = X_{O_2} \cdot P_T$

$$\frac{P_{O_2}}{P_T} = ??$$

$$= X_{O_2}$$

$$= \frac{n_{O_2}}{n_{He} + n_{O_2} + n_{N_2}} = \frac{\frac{m}{32}}{\frac{m}{4} + \frac{m}{32} + \frac{m}{28}} = \frac{\frac{m}{32}}{\frac{56m + 7m + 8m}{224}}$$

$$= \frac{\frac{m}{32}}{\frac{71m}{224}} \Rightarrow \frac{\cancel{m}}{\cancel{32}_{1}} \times \frac{\overset{7}{\cancel{224}}}{71\cancel{m}} = \boxed{\frac{7}{71}} \text{ Ans}$$

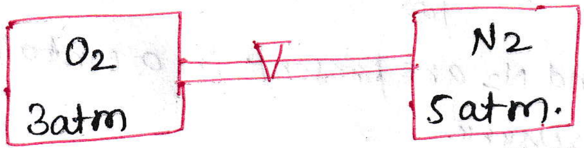
When gas is collected over water

$$P_{dry\,gas} = P_{total} - \text{Aqueous tension}$$

Aq. tension = pressure of water vapour

~~Kinetic theory of gases~~

Graham's Law of diffusion



when we remove stopper → diffusion takes place.

~~flow will be from both sides, N_2 & O_2 will try to equalize its partial pressure~~

Graham's law of diffusion : Const T & P
rate of diffusion is inversely proportional to sq root of density.

$$r \propto \frac{1}{\sqrt{d}}$$

$$\frac{r_1}{r_2} = \underbrace{\sqrt{\frac{d_2}{d_1}} = \sqrt{\frac{M_2}{M_1}}}_{\substack{PM = dRT \\ \boxed{M \propto d}}} = \underbrace{\sqrt{\frac{VD_2}{VD_1}}}_{VD = \frac{M}{2}}$$

Kinetic theory of gases

- Gases consists of very small ~~particles~~ atoms/molecules, whose volume is negligible compared to vol of container. → explains compressibility of gases.
- There is no interaction between gaseous particles → (due to this gases expand and occupy all space b/w them.)
- The gaseous molecules are under continuous state of random motion.
  ↳ (explains → gases have no fixed shape)
- Due to random motion, gas particle collide with walls of container & ~~hence pressure~~ exert pressure.
- collision of gas molecule is perfectly elastic (Total energy of molecule before & after remains same).

- molecules move with different speed, however speed of each molecule keeps onchanging as collision occurs.
- The avg kinetic energy depends on Temp.

Kinetic gas eqn

$$PV = \frac{1}{3} m N V_{rms}^2$$

m → mass of 1 molecule

N : no of molecule.

Que if a container of capacity 1 litre have 10^{23} molecule, each having mass 10^{-22} gram. If rms speed is 10^5 cm/sec then calculate pressure of gas.

→ 10^{-25} kg

10^3 m/s

⇒ ~~V = 1 litre~~

$$PV = \frac{1}{3} m N V_{rms}^2$$

$V = 1$ litre $= 10^{-3} m^3$

$N = 10^{23}$

$m = 10^{-22} gm = 10^{-25}$ kg

$V_{rms} = 10^5 cm/s = 10^3 m/s$

$P = ??$

$$P = \frac{\frac{1}{3} m N V_{rms}^2}{V}$$

$$= \frac{\frac{1}{3} \times 10^{-25} \times 10^{23} \times 10^{6}}{10^{-3}}$$

$$= \frac{1}{3} \times 10^{7} \text{ Pa}$$

Average kinetic En

$$PV = \frac{1}{3} m N V_{rms}^2$$

we have to find KE

$KE = \frac{1}{2} mv^2$ created करते हैं

~~$PV = \frac{1}{3} m N$~~ $PV = \frac{1}{3} N \frac{m V_{rms}^2}{2} \times 2$

$$PV = \frac{2}{3} \frac{N m V_{rms}^2}{2}$$

$$PV = \frac{2}{3} KE$$

av. kinetic Energy $\boxed{KE = \frac{3}{2} PV = \frac{3}{2} nRT}$

av KE ~~per molecule~~ of one mole

$$\boxed{\frac{3}{2} \times RT}$$

av KE of one molecule

$$\frac{3}{2} \frac{RT}{N_A}$$

$$\boxed{\frac{3}{2} KT}$$

$\frac{R}{N_A} = k$ Boltzman const

$k = 1.38 \times 10^{-23} J/K$

Molecularspeeds

$\rightarrow \sqrt{\frac{3RT}{mN_A}}$ $\frac{R}{N_A} = K$

Root mean Square Speed $V_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3kT}{m}}$

av speed $V_{av} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8PV}{\pi M}} = \sqrt{\frac{8kT}{\pi m}}$

most probable speed $V_{MP} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2PV}{M}} = \sqrt{\frac{2kT}{m}}$

$$V_{RAm} : V_{av} : V_{mp} = \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$$

$$\boxed{V_{RAm} > V_{av} > V_{MP}}$$

Que In a container of vol 1 litre, there are 10^{23} molecule each of mass 10^{-22} g. If rms speed is 10^5 cm/sec. Cal Pressure.

$\Rightarrow$ $V_{rms} = \sqrt{\frac{3PV}{M}}$

$$V_{rms}^2 = \frac{3PV}{m \cdot N}$$

$$P = \frac{m \cdot N \cdot V_{rms}^2}{3V}$$

10^3 m/s

$$= \frac{10^{-22} \times 10^{23} \times 10^6}{3 \times 1}$$

$$= \frac{10^7}{3} \text{ Pascal}$$

Ques Cal the pressure exerted by 10^{23} gas molecules each of mass 10^{-25} kg in a container of volume $10^{-3}m^3$ and having V_{rms} of $10^3 m/s$

1) also Cal total K.E.

2) Temp of gas.

⇒

~~$M = N \cdot m$~~

~~$M = 10^{23} \times 10^{-25}$~~

~~$M = 10^{-2}$ kg~~

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

$$V_{rms}^2 = \frac{3PV}{m \cdot N}$$

$$P = \frac{m \cdot N \cdot V_{rms}^2}{3V}$$

$$P = \frac{10^{-22} \times 10^{23} \times 10^6}{3}$$

$$P = 10^7/3 \text{ Pascal}$$

(ii) K.E

$$KE = \frac{3}{2}PV$$

$$= \frac{\cancel{3}}{2} \times \frac{10^7}{\cancel{3}} \times 10^{-3}$$

$$= 0.5 \times 10^4 \text{ Joule}$$

(iii)

$$KE = \frac{3}{2}nRT$$

$$T = \frac{2}{3}\frac{KE}{nR} \quad \left\{ n = \frac{10^{23}}{6 \times 10^{23}} \right\} \left\{ n = \frac{1}{6} \right\}$$

$$= \frac{2}{3} \times \frac{0.5 \times 10^4}{\frac{1}{6} \times 8.314}$$

$$= \frac{2}{\cancel{3}} \times \frac{0.5 \times 10^4 \times \overset{2}{\cancel{6}}}{8.314}$$

$$= \frac{2 \times 10^4}{8} = \frac{1}{4} \times 10^4 \simeq 0.25 \times 10^4$$

~~Beha~~ Realgas

gases which obey the gaslaws only at low pressure & high temp are real gases.
- Charle's law
- Boyle's law
- Gay lussac law
- Avogadro law

Real gas deviates from ideal gas because:-
1) Real gas molecules have finite vol.
2) Intermolecular attractn in real gas is not zero.

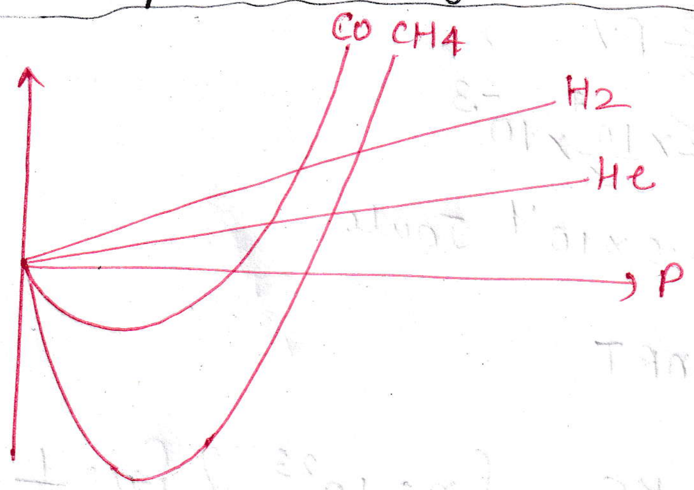
Deviation of Realgas

at const temp → Boyle's law
→ PV = const

if we draw PV v/s P graph → it should a straight line parallel to x axis.

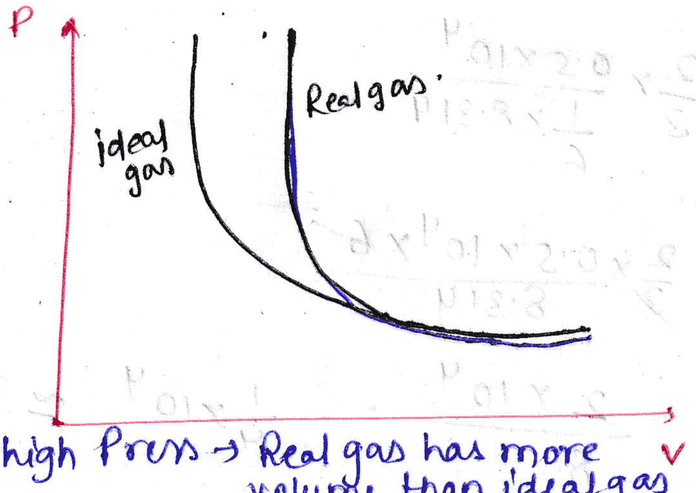
But
PV v/s P → Real gas → not straight line.
↓
Two types of curves are seen.

Experimental graph-1



Real gas do not follow ideal gas equation ~~perf~~ under all condn.

Experimental graph-2



at high Press → Real gas has more volume than ideal gas
at low Pressu → both vol are same.

at high Pressure

① molecule of gases are very close to each other.
molecular attractive forces start operating
at high Pressure, molecules do not strike the walls of the container with full impact because of attractive force by other molecule.
therefore, Pressure exerted by real gases are lower than ideal gas.

$$P_{ideal} = P_{real} + \underbrace{\frac{an^2}{V^2}}_{\text{correction term}}$$

a → const

② at high Pressure
volume of gas molecules also become significant.

vol of gas molecules = nb (b → const)

Hence, new vol = $(V - nb)$

Vanderwall eqn

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

a, b → vanderwall's const

b → ~~effective~~ size of gas molecule

a ↳ mag of intermolecular attractive forces. (Independent of T & P)

unit of a

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

$$a = \frac{P \times V^2}{n^2}$$

$$= \frac{N/m^2 \times \ell^2}{(mol)^2}$$

$$= \frac{N \cdot \ell^2}{m^2 \times (mol)^2}$$

or $a = \frac{PV^2}{n^2}$

$$\frac{atm\ \ell^2}{mol^2}$$

unit of b

nb = volume

$$b = \frac{V}{n}$$

$$\frac{litre}{mol}$$

Compressibility factor

deviation from ideal gas can be explained by compressibility factor.

$$Z = \frac{(PV)_{real}}{(PV)_{ideal}} = \frac{(PV)_{real}}{nRT}$$

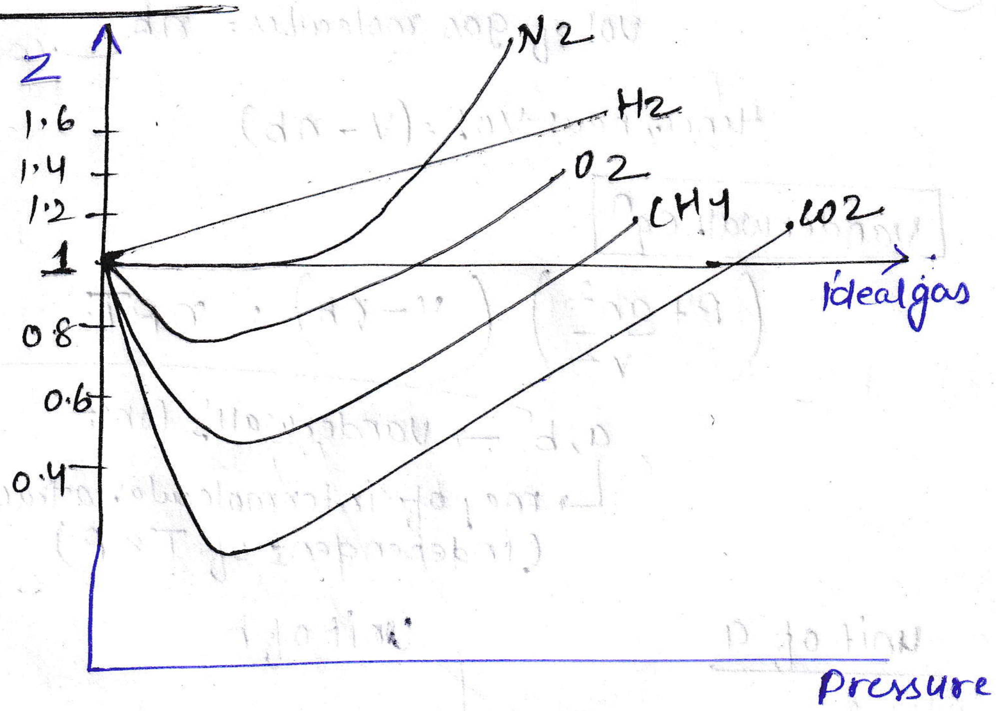
$Z = 1$ — ideal gas

$Z \neq 1$ — Real gas

$Z > 1$ — +ve deviation

$Z < 1$ — -ve deviation

~~deriv~~ derivation of Z through vanderwall



at low pressure all gas have $Z = 1$ and so behave as ideal gas.

at high pressure all gas have $Z > 1$

at intermediate pressure gas have $Z < 1$

Boyle temp / Boyle point → Temp at which real gas obeys ideal gas law over a range of Pressure.

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for n=1 $\left(P + \frac{a}{V^2}\right)(V - b) = RT$ a&b bothe are very small.

$$PV - Pb + \frac{a}{V} - \cancelto{0}{\frac{ab}{V^2}} = RT$$

$$PV = RT + Pb - \frac{a}{V}$$

$$PV = RT + Pb - \frac{a}{V}$$

$$\boxed{\frac{PV}{RT} = 1 + \frac{Pb}{RT} - \frac{a}{VRT}}$$

at low press

$$\frac{PV}{RT} = 1 + \overset{\text{negligible}}{\cancel{\frac{Pb}{RT}}} - \frac{a}{VRT}$$

$$\frac{PV}{RT} = 1 - \frac{a}{VRT} \qquad \boxed{(z<1)}$$

at high Press

$$\frac{PV}{RT} = 1 + \underbrace{\frac{Pb}{RT}}_{\text{high value}} - \overset{\text{negligible}}{\cancel{\frac{a}{VRT}}}$$

$$\boxed{\frac{PV}{RT} = 1 + \frac{Pb}{RT}} \qquad \boxed{(z>1)}$$

Liquefaction of gas

gas into liq (at high Pressure & low temp)

gas → liq
- → Pressure ↑
- → Temp ↓ (cooling)
- → both.

Critical Temp :- Temp above which a gas can't be liquified. the correspoindg Pressure is critical pressur. and corresponding vol is critical Volume.

$$T_c = \frac{8a}{27Rb} \qquad V_c = 3b$$

$$P_c = \frac{a}{27b^2} \qquad P_c V_c = \frac{3}{8} R T_c$$

for liquification $T < T_c$

$(P > P_c)$