Gas Laws

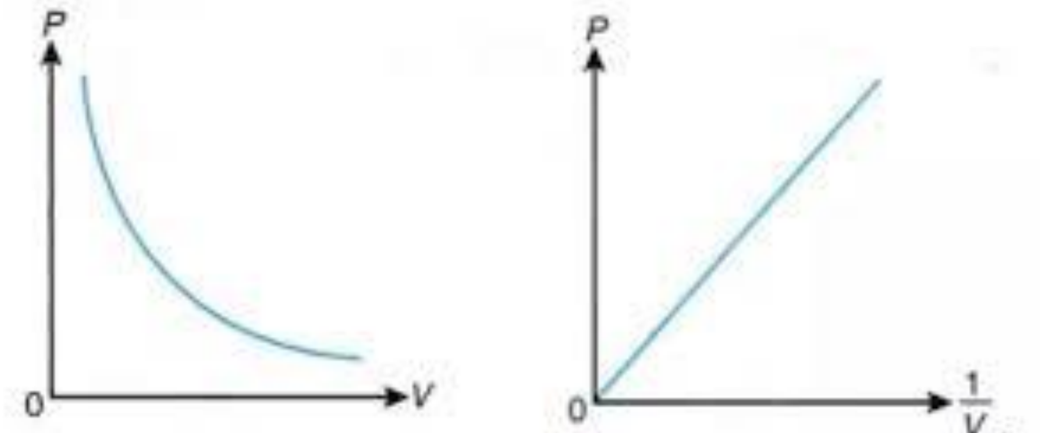
Gaseous behaviors and Gaseous Laws

Unlike Solid or liquids gases have variable volume and the volume of a gas is depending on the temprature,pressure and the no: of moles of the gas. As the volume of the gas is not fixed we learnt about the behavior of the gas by predicting how the volume would be changed along with the variation of the volume would be changed along with the variation of the other parameters of the gas.

- In order to do the calculation regarding the behavioral pattern of the gases these concepts have been forwarded as laws along with the mathematical equation.

1. Boyles Law : At constant temperatures for a fixed mass of gas the volume is inversely proportional to its pressure.

- $V = k\, 1/P$
- $PV = K$
- $P_1 v_1 = P_2 v_2$



(a) Graph of P against V (b) Graph of P against $\frac{1}{V}$

- 2 Charles Law : At constant pressure for a fixed mass of gas the volume is directly proportional to its temperature.

- $V = kT$ temprature graph pic
- $v/t = k$
- $V_1/T_1 = V_2/T_2$

- This Law was 1st forwarded by taking experimental values with regard to the behavior of real gases yet when the mathematical background of the equation is considered the straight line represent the behavior should start with the origin as shown in the graph above. At the origin when the temperature is zero the volume has to be zero but there is no meaning in that statement when we say a gas with zero volume .Intact with real gases is not possible to bring them down to the absolute zero temperature because of that they become liquid and become slid before they reach absolute zero.

- At the same time they realize this absolute zero is -273.15 C and it is not zero Celsius Therefore , the kelvin scale are Originated along with this finding thereby zero Celsius = 272.15 K
- Then the Scientist forwarded the ideal gas Concept to explain the behavior of gas mathematically as the real gases are deviating fro the gas laws beyond a certain range.In the case of nan Ideal Gas its volume becomes zero at zero Kelvin and the Ideal gas never become liquid or Solid. Thereby Ideal gases want have boiling points or melting points.

The Avogadro's Concept for gases

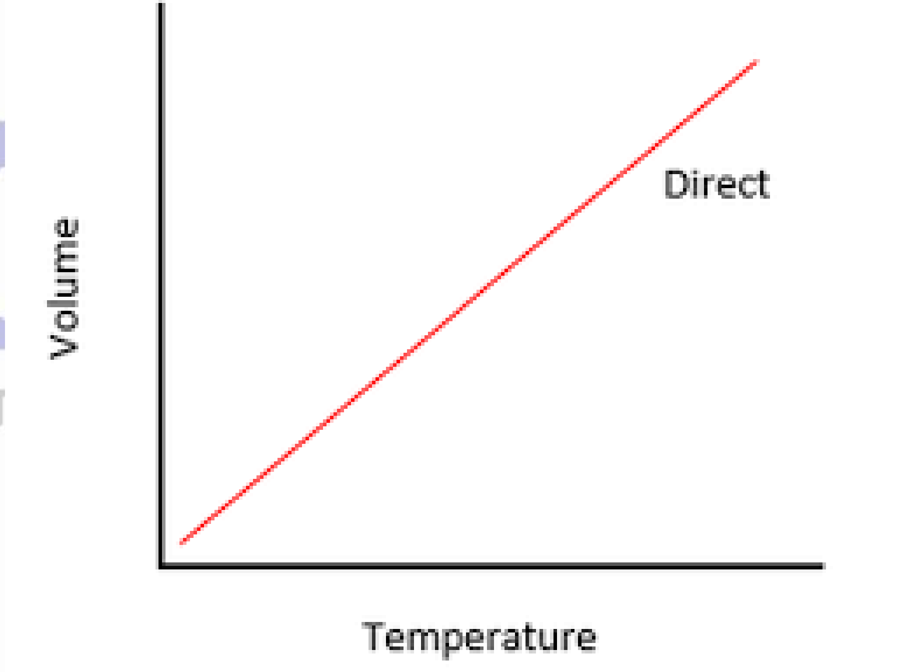
- At the same temperature and the pressure the volume of the different gases when there taken in equal , no: of molecules will also be equal.
- In other words when we take equal volumes of different gases at the same temperature and pressure there will be equal no: of moles as well.

- $n = N/N_A$

N = No of Molecules
N_A = Avogadro's Constant

- $V/n = K$

- **$V_1/n_1 = V_2/n_2$**



Ideal gas Constant

- PV = nRT

P = Pressure of the gas

V = volume of the gas

n = no: of moles of the gas

R = Universal gas Constant

T = Absolute Temperature

- The constant ‘R’ doesn’t depend on the Identity of the gas or the Conditions at which the gas is kept thereby it is called the universal gas constant.

- The real gases deviate from the ideal gas behavior most of the time thereby to discuss the magnitude of the deviation we use a parameter called the compressibility factor(Z).For the Ideal gases (Z) is always equal to 1 as there PV produc t is always equal to there nRT product.

Equations of Ideal gases

- Combined gas Equation
- $P_1V_1/T_1 = P_2 V_2/T_2$

- $PV = m/M_w RT$

$PM_w = \rho RT$

$PV = NRT$

- $P_1V_1/n_1T_1 = P_2 V_2/n_2 T_2$

Dalton's Law of Partial Pressure

- As we work with cases we might work with mixtures of gases as well in a mixture of gases partial pressures talk about individual pressure components in parted by individual gases Dalton in his law addressed about the Total Pressure of the mixture.
- Law : The Total Pressure of a mixture of gases at given conditions equal the total sum of the partial pressures of the constituent gases.

Definition of Partial Pressures

- Partial Pressure is defined as the pressure exerted by a certain gaseous component in a mixture on the walls of a vessels in which the gaseous mixture is mixed when the other components have been removed from the mixture leaving out the particular gas of concerned.

Pressure of a Gas

- The pressure of a gas is the force per unit area of the walls of the container in which the gas is stored caused by the gas molecules when they collided with the walls of the container.
- Therefore, the pressure of the gas id directly proportional to the no: of collision per unit Area of the wall.

Equation of the Dalton's law of Partial Pressure

- The volume of a gas is always the volume of the container in which it is stored therefore the volume of individual gases in a mixture of gases present in a vessels will be having equal volume.

- $P_B = X_B \, P_T$

Ideal Gas Behavior

- In fact the ideal gas concept came into play long after most of the above laws were forwarded but finally when scientist analyzed those primary laws with help of the Ideal gas equation and the molecular kinetic equation which explains the ideal behavior all the premitive3 laws are also valid for the ideal gases we need to assume the Ideal gases behavior for the real gases when we do calculation.

The Molecules Kinetic Equations

- For the gases as there very light in weight there potential energies are not significant but the kinetic energies based on this concept Scientist established the ideal gas concept defining the ideal gas Concepts as follows

1. They do not have interaction (Neither attraction nor repulsions)
2. Ideal gas molecules show random novements in other movements of 1 molecule is not effected by the other one and vice versa
3. They have a point like molecules volumes.
4. Ideal gas molecules show perfectly In-elastic Collisions.

- The perfect In-elastic Collision are the Collision having total Kinetic energetics of the 2 molecules colliding to be equal to the total Kinetic energy after the collision.

- $V_1^2 + v_2^2 = V_3^2 + V_4^2$

- Perfectly elastic collision is when molecules collides and bounces off without losing their kinetic energy it is in fact the kinetic energy conversation.
- In this moment of conversation is not given a significant as the travel direction of different molecules are different in a sample of gas having lot of gas particles.

Important terms

1. Perfectly elastic collision(molecules Bounce off after the collision with zero loss of kinetic energy).
2. Elastic Collision (which is not perfectly elastic) molecules bounces off after the collision yet with a certain loss of Kinetic energy.
3. Non – elastic collision(when molecules collides they react and stay together without bouncing off)

- The above mentioned characteristics at the beginning described the ideal characteristic or the characteristic of the ideal gas there by these characteristic describe the nature of the ideal gas.
- If a gas is equal to pv = nRT or the molecular kinetic equation them those gases are set to be gases are said to be having ideal gas behavior even the can show the ideal gas behavior or sometimes the atoms to the ideal gas behavior but they will never become ideal in nature as attraction forces are found to be there between gas molecules even can let them approach the ideal characteristics but we cannot move them reach those

- Under the following Condition real gases approach ideal characteristics and get themselves very much closer to those 4 characteristics.

1. Under very low pressure approaching zero.
2. Under very high temperature.
3. Under very low pressure the volume will be large there by the gas molecules will lie far apart from one another so that their repulsive are zero , attractions are minimum and movements are negligible affected by the movements of the others as the volume is large compared to the molecular volume become negligible and in high temperatures mean kinetic energies becomes negligible as they collide fast they bounce off fast so these we get the minimum chances to get attracted it high temperature.

Molecular Kinetic Equation

- For the gas molecules what's more important is not the potential energy but the kinetic energy. The kinetic energy is given by KE =1/2 mv^2 . In a sample of gas there will be lot of sample of gas molecules for an example:
  - 1 mole of 'Ar' gas will be having 6.022 x 10^{23} atoms of 'Ar' under the same temperature then all the atoms want be having the same speed or velocity there direction may different as well as the speeds.

- For the Calculations we need a mean value to represent a sample therefore , if we try to add up all the Velocities and we divide it by to Calculate the mean velocity value is going to have lot of errors as their will be can collations of (+) or (-) with the (+) values when we adopt therefore a mean velocity calculation or squared mean velocity calculation shouldn't be applied.
- Instead of Calculating the mean velocity we calculate the squared velocity 1st then the sign could be eliminated which comes along with the directions .Afterwards, we get the means of the squared velocity which is written as C^{2}.

1. Velocity => C
2. Mean velocity => c^{-} **X**
3. Squared mean Velocity => $(C^{-})^{2}$ **X**

Equations : **$PV = 2/3\ \overline{KE}N$**

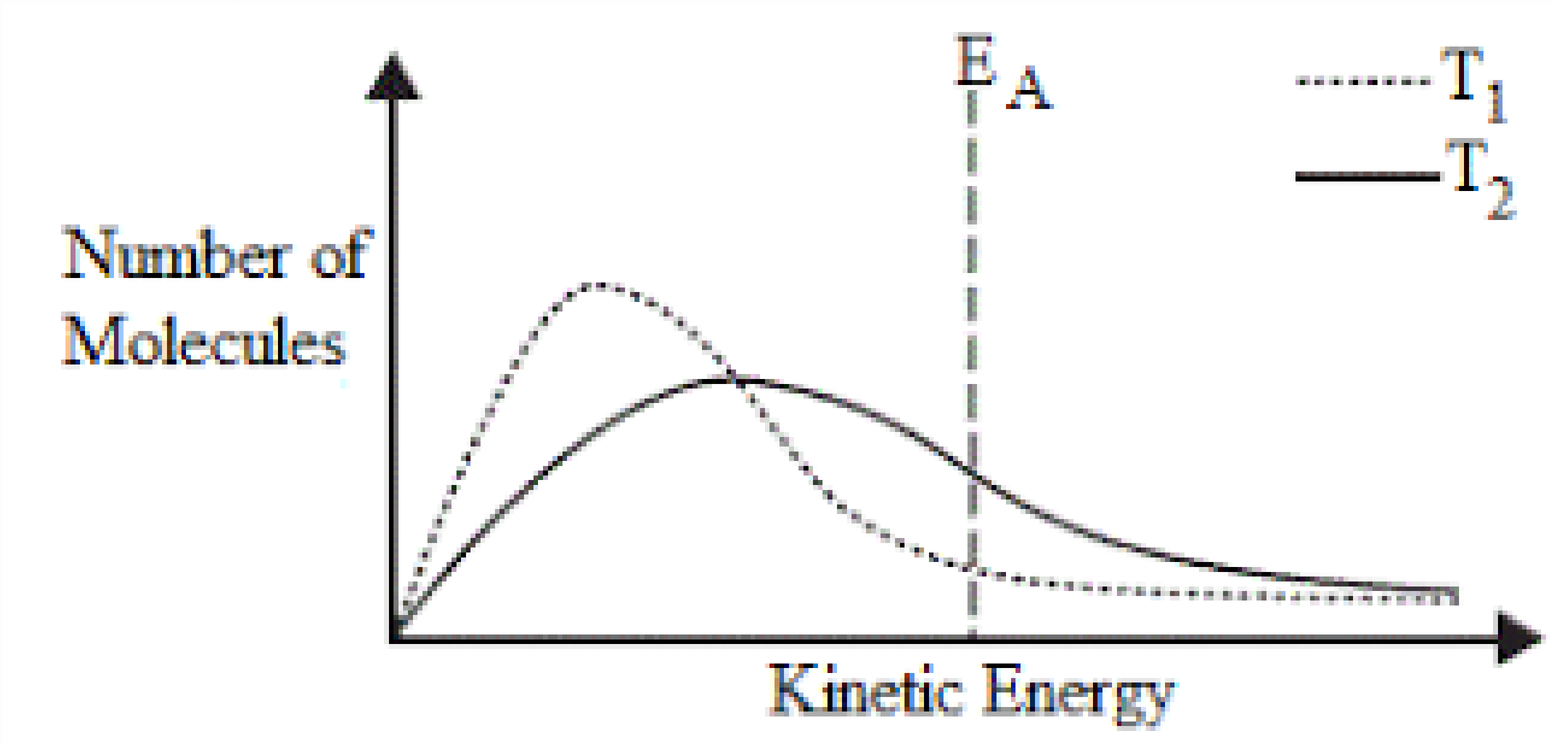
$\overline{KE} = 3RT/\ 2N_A$

$\overline{KE}$ is directly proportional to T

- **$\overline{C^2} = 3RT/M_W$**

- According to the 2nd Derivation we can see that $KE = 3RT/2N_A$ in this equation the $M_{W(\text{Molar}}$ $\text{Mass}_{)}$ of the gas is independent of the identity of the gas and it depends only on the absolute temperature.
- The mean square velocity $\overline{C^2}$ and the root mean square velocity depend on the identity of the gas as the M_W of the gas is found in the equation.

Boltzmann Curve of gases



- In a Sample of gas all the molecules want be having the same KE or the same there will be a distribution of KE s in a bell shape curve as the mean KE is directly proportional to T it gets increased with increasing temperature .Therefore, the spread of energies will be broaden.
- The area covered by the curved represents the total no: of molecules thereby when the spread broaden the peak drops.

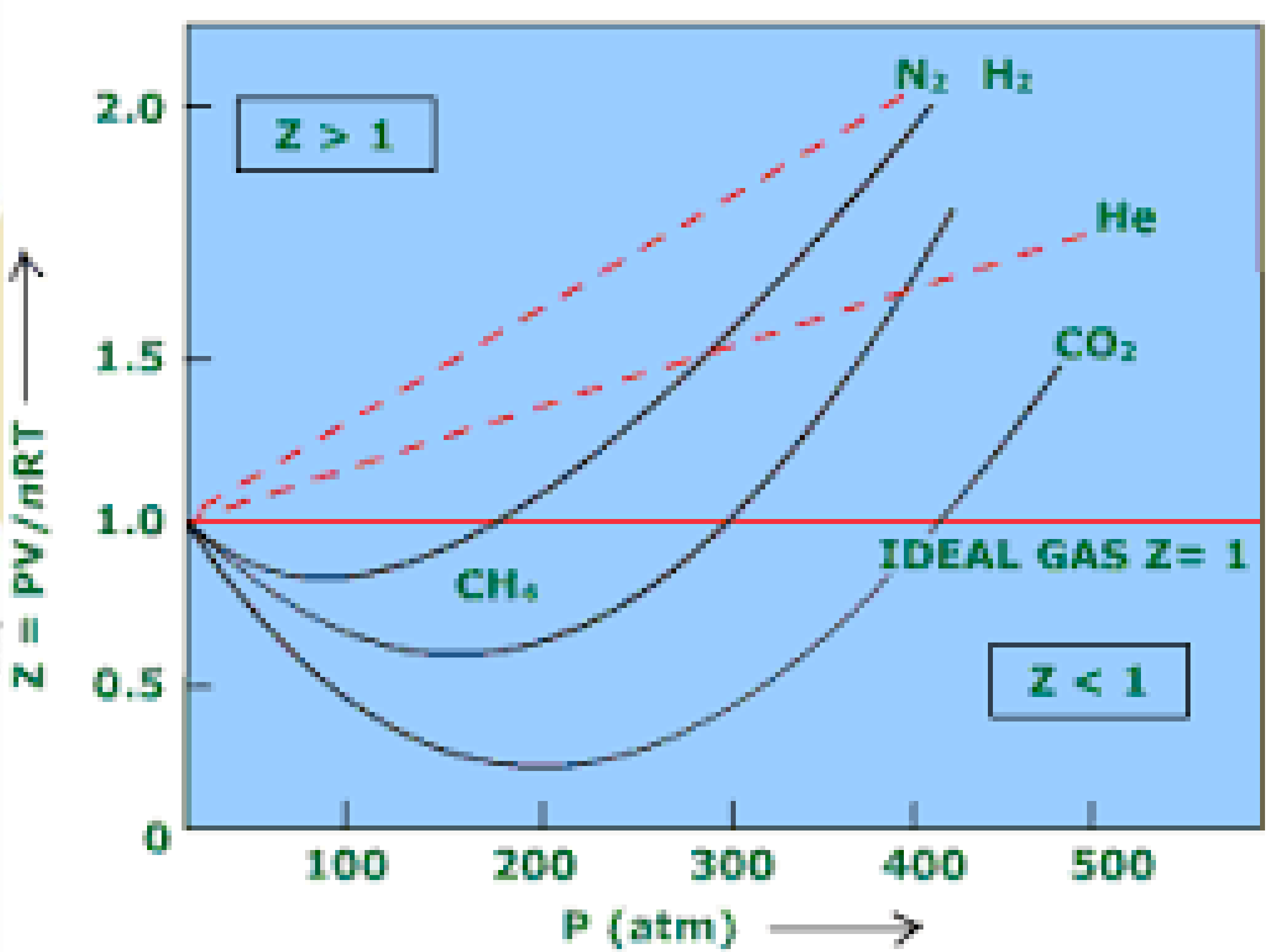
- These Curves must start from the origin describing that the no: of molecules having Zero K.E(Kinetic energy) is zero and they all ends with a tapering tail describing that there will be very low no: of molecules with high K.Es will maintaining the peak near the mean K.E .The end of the tapering tail should not touch the x axis describing that there are some no: of molecules present in the sample having the highest K.E.

Extent of the deviation of real gases from the ideal gas behaviors

- The compressibility factor of gases is compared to understand the extent of the deviation of real gases from the ideal gas behaviors.Ideal gas behaviors is little different from the ideal gas nature or the ideal gas characteristics because of that the ideal ideal gas nature or characteristics cannot be 100% approach by real gases yet under certain condition real gases can approach 100% ideal behaviors.

- Ideal behaviour is always expressed in terms of mathematical relationships such pv =nRT , $PV = 1/3mR\ \overline{C^2}$, $C^2 = 3RT/ M_{W.}$

- Compressibility factor(Z) is used to the Comparison as follows :
- $Z = PV/nRT$



Z > 1
N₂ H₂
He
CO₂
CH₄
IDEAL GAS Z= 1
Z < 1
2.0
1.5
1.0
0.5
0
100
200
300
400
500
Z = PV/nRT
P (atm)

- At standard room temperature which is 25°C almost all the gases deviate greatly from the ideal gas behavior as shown above there by the assumptions we make in the calculations of there behavior using gas laws are all vital huge assumptions.

- If we Compare the Compressibility factor of a particular real gas vs the pressure under several different different temperatures. There variation can be shown by a graphical represent as follows. Here , T1,T2,T3,T4 represent denotes the boil temperature of the gas . In other words the ‘PV’ product of the gas will remain constant in the law pressure region yet having abroad pressure range and its behavior within this range is ideal. But the gas doesn’t passes the characteristics of ideal gases but the behavior of it is ideal .

- Under Boils temperature the real gases behaves ideadly.Though, there characteristics are not even closer to the ideal characteristics. Infact,the attraction forces for as to keep them in a behavior .Distributed by PV = nRT.
- ‘He(Helium)’ gases boil temperature is less than the room temperature while the CO2 has boils temperature is greater than the room temperature. The above description Confirms that any real gas could show ideal behavior even though there characteristics are moving near the ideal characteristics.