GASES

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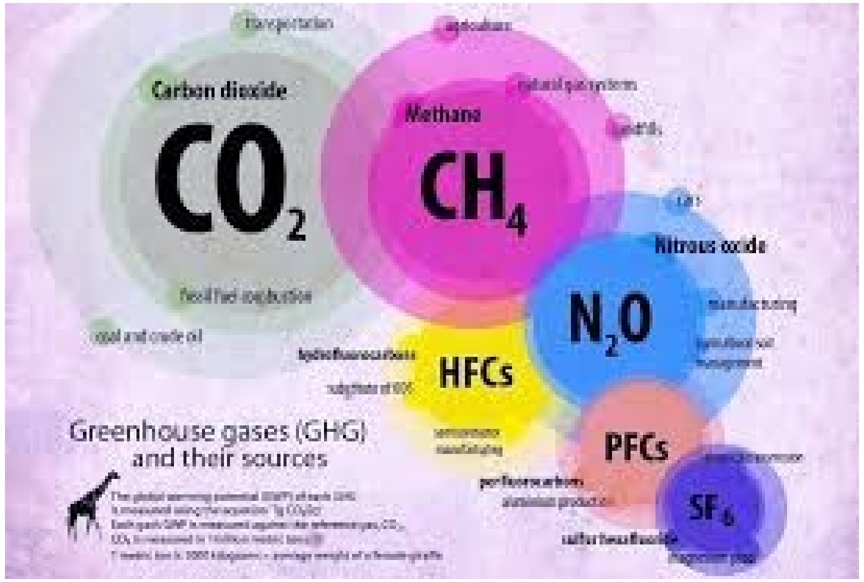


GASES

Gas is a state of matter that has no fixed shape and no fixed volume.

Gases have lower density than other states of matter, such as solids and liquids.

There is a great deal of empty space between particles, which have a lot of kinetic energy. They fill all available space.

They can be easily compressed.

Pure gases or their mixtures are homogeneous.

They diffuse without difficulty.

They exert pressure on walls of the container.

GAS LAWS

Boyle's Law

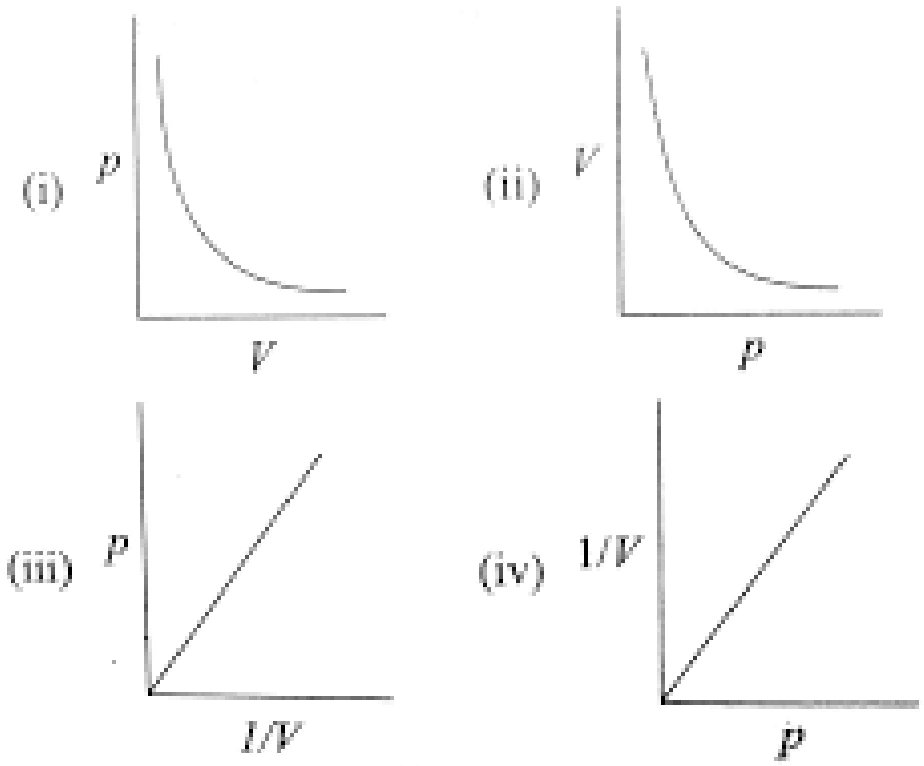
The volume of a given mass of a gas is inversely proportional to the pressure, at constant temperature.

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

or $PV=k$ where P is the pressure and V, the volume of the gas and k is a constant.

Boyle's Law is also stated as

$$P_1V_1 = P_2V_2$$



Graph of Boyle's Law

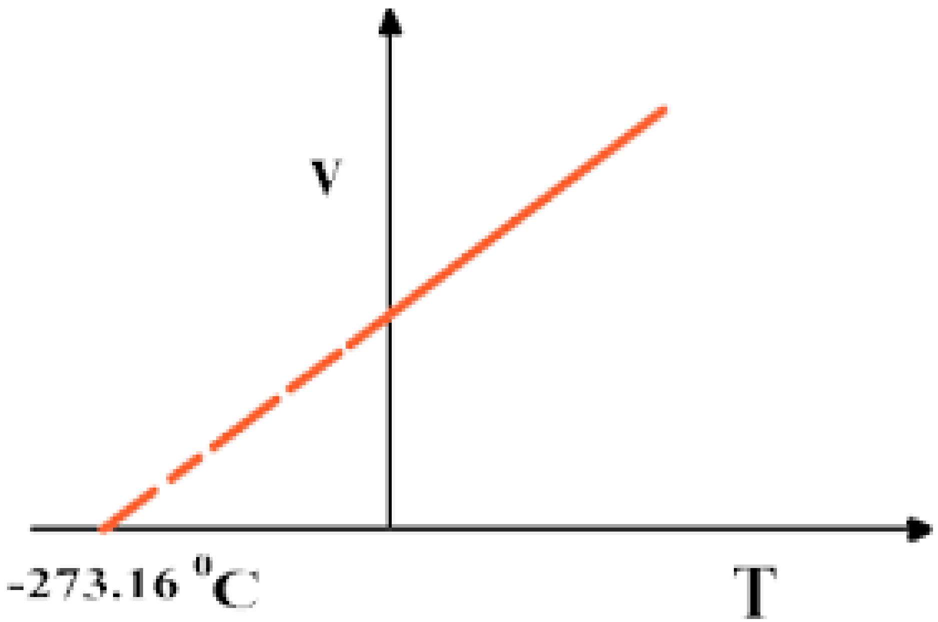
Charles' Law

At constant pressure, the volume of a given mass of a gas varies directly as temperature.

$$V \alpha T$$

$$\text{or, } \frac{V}{T} = k$$

$$\text{or, } \frac{V_1}{T_1} = \frac{V_2}{T_2}$$



Gay Lussac's Law

Volume remaining constant, the pressure of a gas is directly proportional to its temperature.

$$P \alpha \, T$$

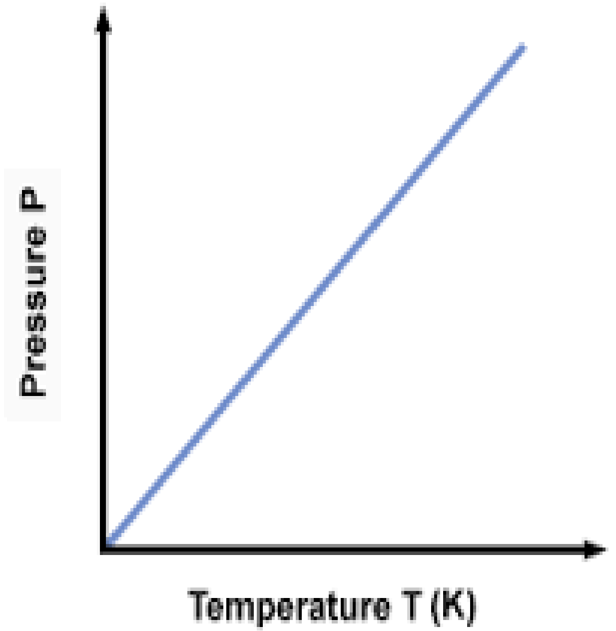
$$\text{or, } \frac{P}{T} = k$$

$$\text{or, } \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Avogadro's Law

Equal volumes of all gases contain equal number of molecules under similar conditions of temperature and pressure.

$$V \alpha \, n$$



Gay Lussac's Law

Combined Gas Law

The above gas laws may be combined to give a general equation, called the *Equation of state*. This may be done as follows:

$V \alpha \frac{1}{P}$ if T is kept constant

$V \alpha T$ if P is kept constant

$V \alpha n$ if T and P are kept constant

Combining the three we get

$$V \alpha \frac{1}{P} X\ T\ X\ n$$

$$V = R\ X \frac{1}{P} X\ T\ X\ n$$

$PV = nRT$ where R is a constant of proportionality and is known as the *Universal Gas constant*

- **So we can conclude:**

- Four variable that are dependent on each other define the physical behavior of ideal gases
  - Volume, pressure, temperature, moles

- Boyle’s law → as volume increases, pressure decreases

- Charles’s law → as temperature increases, volume increases

- Avogadro’s law → as quantity of moles increases, volume increases

- The ideal gas law incorporates the individual gas laws into one equation
  - R is the universal gas constant

NUMERICAL VALUES OF GAS CONSTANT

The Gas constant R in the equation PV=nRT has the dimensions of energy per Kelvin per mole as shown:

$$R = \frac{PV}{nT} = \frac{\text{PressureXVolume}}{\text{MolesXTemperature(K)}}$$

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{\text{Force}}{\text{Length}^2}$$

$$\text{Volume} = \text{Length}^3$$

$$R = \frac{PV}{nT} = \frac{\frac{\text{Force}}{\text{Length}^2} \text{xLength}^3}{\text{MolesXTemperature(K)}}$$

$$R = \frac{PV}{nT} = \frac{\text{ForceX Length}}{\text{MolesXTemperature(K)}}$$

$$\mathbf{R} = \frac{\mathbf{PV}}{\mathbf{nT}} = \frac{\mathbf{Energy}}{\mathbf{MolesXTemperature(K)}}$$

NUMERICAL VALUES OF GAS CONSTANT

The numerical values of R in different units are the following:

$R = 0.082 L\ atm\ K^{-1}\ mole^{-1}$

$R = 8.314 Joules\ K^{-1}\ mole^{-1}$

$R = 8.314 X 10^{7} ergs\ K^{-1}\ mole^{-1}$

$R = 1.987 calories\ K^{-1}\ mole^{-1}$

GRAHAM'S LAW OF DIFFUSION

Different gases diffuse at different rates through a tube of narrow opening, depending on their densities or molecular weights.

Graham's Law of diffusion states that ***at constant temperature and pressure, the rates of diffusion of various gases are inversely proportional to the square roots of their densities or molecular weights.*** Mathematically,

$$\mathbf{r}\ \alpha \sqrt{1/d}\ \alpha \sqrt{1/M}$$

If there are two gases with diffusion rates $r_1$and r_2 and molecular weights M_1 and M_2 then

$$^{r1}/_{r2}=\sqrt{d_2/d_1}=\sqrt{M_2/M_1}$$

DALTON'S LAW OF PARTIAL PRESSURES

When two or more gases which do not interact chemically, are allowed to mix together in a vessel, the pressure of the mixture is given by Dalton's Law of partial pressure.

This law states that ***when two or more gases are kept in a closed space, the total pressure exerted by the mixture is equal to the sum of the partial pressures of the individual gases. In other words,***

$$P=P_1+P_2+P_3 \ ....$$

Where P is the total pressure exerted by the mixture and P_1 ,P_2,P_3 ....
Are the partial pressure of the various gases present in the mixture.