

Boyle's law:-

At constant temperature pressure of a fixed amount of gas is inversely proportional to its volume.

$P \propto \frac{1}{V}$ When T and n is constant
~~If a gas~~ $P = \frac{K}{V}$ or, $PV = K$ (constant)

If a gas has volume V_1 at pressure P_1

then, $P_1 V_1 = K$ (constant)

and volume V_2 at pressure P_2

then, $P_2 V_2 = K$ (constant)

$\therefore P_1 V_1 = P_2 V_2$ ————— (1)

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

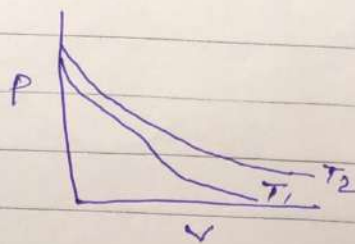
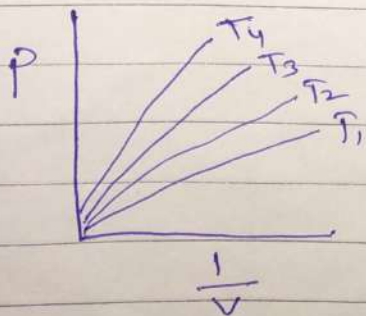
Relation between pressure and density of a gas.

We know that, $d = \frac{m}{V}$ or, $V = \frac{m}{d}$

$V_1 = \frac{m}{d_1}$ and $V_2 = \frac{m}{d_2}$

put the value of V_1 and V_2 in equation (1)

$P_1 \frac{m}{d_1} = P_2 \frac{m}{d_2}$ or $\frac{P_1}{d_1} = \frac{P_2}{d_2}$



Charles's law: —

At constant pressure the volume of a fixed amount of a gas is directly proportional to ~~the~~ its temperature.

$V \propto T$ When p and n is constant.

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

Similarly,

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

So, $\boxed{\frac{V_1}{T_1} = \frac{V_2}{T_2}} \quad \text{--- (1)}$

Relation between density and temperature of a gas —

$$V_1 = \frac{m}{d_1} \quad \text{or} \quad V_2 = \frac{m}{d_2} \quad (\text{Earlier discuss})$$

$$\frac{\frac{m}{d_1}}{T_1} = \frac{\frac{m}{d_2}}{T_2} \quad , \quad \frac{1}{d_1 T_1} = \frac{1}{d_2 T_2} \quad \text{or,} \quad \boxed{d_1 T_1 = d_2 T_2}$$

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Equilibrium constant of Reversible reaction:-

Let us consider a general reversible reaction -



At equilibrium the active mass of A, B, C and D are represented by [A], [B], [C] and [D] respectively. Here a, b, c, and d are stoichiometric coefficient of A, B, C and D.

rate of forward reaction $\propto [A]^a [B]^b$

rate of backward reaction $\propto [C]^c [D]^d$

or, rate of forward reaction = $K_f [A]^a [B]^b$

rate of backward reaction = $K_b [C]^c [D]^d$

K_f and K_b are called velocity constant for forward and backward reaction.

At equilibrium -

rate of forward reaction = rate of backward reaction

$$K_f [A]^a [B]^b = K_b [C]^c [D]^d$$

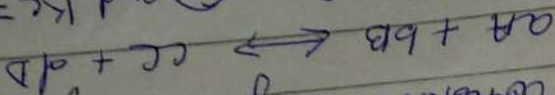
$$\text{or } \frac{[C]^c [D]^d}{[A]^a [B]^b} = \frac{K_f}{K_b} = K_c$$

K_c is called equilibrium constant. K_f and K_b are constant at constant temperature.

Therefore, $K_c = \frac{K_f}{K_b}$ is also constant at constant temperature.

Relation between K_p and K_c .
In gaseous system, the equilibrium constant may be expressed in terms of partial pressure K_p .

Let us consider a general gaseous reaction



$$-P \times P_D \quad \text{① and } K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

For, ideal gas equation,

$$pV = nRT$$

$$\text{or } p = \frac{n}{V}RT \text{ or } p = cRT$$

where c is concentration in terms of molarity

$$P_A = [A]RT, P_B = [B]RT, P_C = [C]RT \text{ and } P_D = [D]RT$$

put the value of these partial pressure in eq (1)

$$K_P = \frac{[C]^c [D]^d [RT]^d}{[A]^a [B]^b [RT]^b}$$

$$= \frac{[C]^c [D]^d}{[A]^a [B]^b} \frac{[RT]^{c+d}}{[RT]^{a+b}}$$

$$K_P = K_C \frac{[RT]^{c+d}}{[RT]^{a+b}}$$

$$K_P = K_C (RT)^{\Delta n}$$

where Δn is number of moles of gaseous products and reactants

if $\Delta n = 0$ then $K_P = K_C$

$\Delta n = +ve$ then $K_P > K_C$

$\Delta n = -ve$ then $K_P < K_C$