$aA + bB \rightleftharpoons cC + \underline{d}D$ → No. of moles

$$K_C = \frac{[C]^c [D]^d}{[A]^a [B]^b} \quad \& \quad K_p = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$$

$\boxed{K_p = \text{Partial pressure at equilibrium for a gas}}$

or

$$K_C = \frac{(C_C)^c (C_D)^d}{(C_A)^a (C_B)^b}$$

K_C = Equilibrium constant in terms of concentration

K_p = Eq. constant in terms of partial pressure

"p" small p = represents the partial pressure of individual gas present at equilibrium state.

For an ideal gas $PV = nRT$ or $P = \frac{n}{V}RT$ where $\frac{n}{V} = C$

$n \rightarrow$ No. of moles

C (Concentration)

So, we can write ideal gas equation as.

$P = CRT$

$P_A = (C_A RT)^a$, $P_B = (C_B RT)^b$, $P_C = (C_C RT)^c$, $P_D = (C_D RT)^d$

$$K_p = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b} = \frac{(C_C RT)^c (C_D RT)^d}{(C_A RT)^a (C_B RT)^b}$$

So

$$K_p = \frac{(C_C)^c (C_D)^d (RT)^{c+d}}{(C_A)^a (C_B)^b (RT)^{a+b}}$$

P1

we know

$$K_c = \frac{(C_C)^c (C_D)^d}{(C_A)^a (C_B)^b}$$

No. of mols of product

" " " of reactants

n_p n_r

So $K_p = K_c \frac{(RT)^{c+d}}{(RT)^{a+b}}$ So $K_p = K_c (RT)^{(c+d) - (a+b)}$

$$\boxed{K_p = K_c (RT)^{\Delta n}}$$

Relation b/w Equilibrium Constant K_p & K_x

Relation b/w Equilibrium Constant K_p & K_x

$$aA + bB \rightleftharpoons cC + dD$$

$$K_p = \frac{(P_C)^c\,(P_D)^d}{(P_A)^a\,(P_B)^b} \quad \text{--- eq (1)}$$

Partial pressure (p) is a pressure of the individual gas in a gaseous mixture

$$K_x = \frac{(X_C)^c\,(X_D)^d}{(X_A)^a\,(X_B)^b} \quad \text{-- eq (2)}$$

Mole fraction (X) is equal to the no. of moles of one component divided by the total no. of moles of a solution

K_x = Eq. Constant in terms of mole fraction

Dalton's law : At ~~cont te~~ Constant temp

total pressure of a mixture of gases is equal to the sum of their partial pressure.

$$P_i = X_i P$$

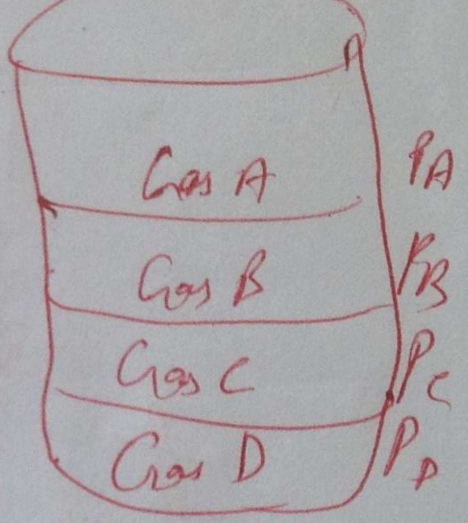
and

$$(P_A)^a = (X_A P)^a$$

$$(P_B)^b = (X_B P)^b$$

$$(P_C)^c = (X_C P)^c$$

$$(P_D)^d = (X_D P)^d$$



$$P = P_A + P_B + P_C + P_D$$

$$K_p = \frac{(X_C P)^c \, (X_D P)^d}{(X_A P)^a \, (X_B P)^b}$$

$$K_p = \boxed{\frac{(X_C)^c \, (X_D)^d}{(X_A)^a \, (X_B)^b}} \cdot \frac{(P)^{c+d}}{(P)^{a+b}} \text{ --- eq}$$

we know K_x

so $\boxed{K_p = K_x \cdot P^{\Delta n}}$

$\Delta n = n_p - n_r$

$\Delta n = (c+d) - (a+b)$

Calculate K_c & K_x for the reaction $N_2O_4 \rightleftharpoons 2NO_{2(g)}$ for which $K_p = 0.157$ atm at $25°C$ & 1 atm Pressure

Calculate K_c for the reaction $2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$ for which $K_p = 3.5 \times 10^{-23}$ atm at ~~20°~~ $27°C$.

Calculate K_c & K_x for the reaction $N_2O_4 \rightleftharpoons 2NO_2(g)$ for which

$K_p = 0.157$ atm at $25°C$ & 1 atm Pressure

Solution

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$, $\Delta n = 2-1 = 1$

$K_p = K_c (RT)^{\Delta n}$ or $K_c = \frac{K_p}{(RT)^{\Delta n}} = \frac{0.157 \text{ atm}}{0.08206 \text{ dm}^3 \text{ atm K}^{-1} \text{ mol}^{-1} \times 300 \text{K}}$

$= 6.38 \times 10^{-3} \text{ mol dm}^{-3}$

$K_x = K_p (P)^{-\Delta n} = (0.157 \text{ atm}) (1 \text{ atm})^{-1} = \underline{\underline{0.157}}$

The reaction $AB_2(g) \rightleftharpoons A(g) + 2B(g)$ is studied in a 10 lit flask. Initially there is 0.40 mole of AB_2. When after the introduction of the catalyst, at $27^\circ C$, equilibrium is reached, the pressure of the mixture is 1.2 atm. Calculate the equilibrium constant K_p.

Soln

$$AB_{2(g)} \rightleftharpoons A_{(g)} + 2B_{(g)}$$

No. of moles at equilibrium $(0.40-x)$ $\quad x \quad 2x$

Total No. of moles $n_{total} = 0.40 - \cancel{x} + \cancel{x} + 2x$ $\boxed{= 0.40 + 2x}$

Assuming that the equilibrium behaves ideally.

$$n_{total} = \frac{PV}{RT} = \frac{(1.20\ atm)\ (10\ dm^3)}{(0.08206\ dm^3\ atm\ K^{-1}\ mol^{-1})\ (300\ K)} = \underline{0.487}$$

Thus $0.40 + 2x = 0.487$ where $x = 0.0435$, $P = 1.2$ atm. (given)

$$P_A = \left(\frac{x}{0.40+2x}\right)P \ ; \ P_B = \left(\frac{2x}{0.40+2x}\right)P ; \ P_{AB_2} = \left(\frac{0.40-x}{0.40+2x}\right)P$$

$$K_P = \frac{P_A \times P_B^2}{P_{AB_2}} = \frac{(x)\ (2x)^2\ (1.20\ atm)^2}{(0.40-x)\ (0.40+2x)^2}$$

Using $x = 0.0435$ $\underline{K_P = 5.607 \times 10^{-3}\ atm^2}$

$$\frac{\left(\dfrac{x}{0.40+2x}\cdot \cancel{P}\right)\left(\dfrac{(2x)^2}{(0.40+2x)^2}\cdot P^2\right)}{\cancel{P}\;\dfrac{0.40-x}{0.40+2x}}$$

$$\frac{(x)\,(2x)^2\,(1.20)^2\,\cancel{(0.40+2x)}}{\cancel{(0.40+2x)}\,(0.40+2x)^2\,(0.40-x)}$$