

Chem Chemical Equilibrium

Mithu
09/08/2021

Chemical Equilibrium:

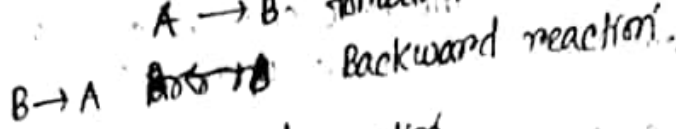
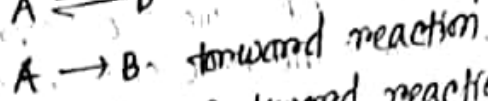
The chemical Equilibrium may be defined as the state of a reversible reaction when the two opposing reactions occur at the same time at a same rate and the concentration of reactants and products do not change with time.

Characteristics or condition of chemical equilibrium

- ① When a chemical Equilibrium is established in a closed vessel at constant temperature, concentration of the various species in the reaction mixture become constant.
- ② Equilibrium can not be attained in an open vessel.
- ③ When a catalyst is added to a system in equilibrium, it speeds up the rate of both the forward and the reverse reaction to an equal extent. Therefore a catalyst cannot change the equilibrium point except that it is achieved. It only enhance the rate of reaction.

you determine K_f, K_b by from equilibrium constant.

Let us consider a reaction,



rate of forward reaction,

$$r_f \propto C_A$$

$$r_f = k_f C_A$$

C_A = concentration of A

k_f = rate constant of forward reaction.

rate of backward reaction,

$$r_b \propto C_B$$

$$r_b = k_b C_B$$

C_B = concentration of B

k_b = rate constant of backward reaction.

At equilibrium, rate of forward reaction = rate of backward reaction.

$$r_f = r_b$$

$$k_f C_A = k_b C_B$$

$$\frac{k_f}{k_b} = \frac{C_B}{C_A}$$

$$K = \frac{C_B}{C_A}$$

where K is the equilibrium constant

(i) When equilibrium constant is represented by pressure then it is known as K_p .

$$K_p = \frac{P_B}{P_A}$$

(ii) When equilibrium constant is represented by concentration then it is known as K_c .

$$K_c = \frac{C_B}{C_A}$$

(iii) When equilibrium constant is represented by mole fraction then it is known as K_x .

$$K_x = \frac{X_B}{X_A}$$

Let us consider a reaction.



for forward reaction,

$$r_f \propto C_A^a C_B^b$$

$$r_f = K_f C_A^a C_B^b$$

for backward reaction,

$$r_b \propto C_M^m C_N^n$$

$$r_b = K_b C_M^m C_N^n$$

At equilibrium,

$$r_f = r_b$$

$$K_f \times C_A^a C_B^b = K_b \times C_M^m C_N^n$$

$$\frac{K_f}{K_b} = \frac{C_M^m \times C_N^n}{C_A^a \times C_B^b}$$

$$K_c = \frac{C_M^m \times C_N^n}{C_A^a \times C_B^b}$$

$$K_p = \frac{P_M^m \cdot P_N^n}{P_A^a \cdot P_B^b}$$

$$K_x = \frac{X_M^m \cdot X_N^n}{X_A^a \cdot X_B^b}$$

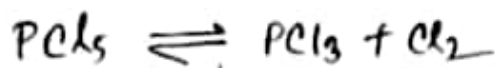
Determination of K_p, K_c, K_x from the equation, $N_2 + 3H_2 \rightleftharpoons 2NH_3$

$$K_p = \frac{P_{NH_3}^2}{P_{N_2} \times P_{H_2}^3}$$

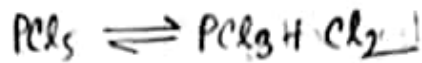
$$K_c = \frac{C_{NH_3}^2}{C_{N_2} \times C_{H_2}^3} = \frac{[NH_3]^2}{[N_2] [H_2]^3}$$

$$K_x = \frac{X_{NH_3}^2}{X_{N_2} \times X_{H_2}^3}$$

Calculation of K_p , K_c and K_x for a given reaction.



The reaction occurs in a closed vessel which volume is V and a constant temperature T and pressure P



$$1 \quad 0 \quad 0 \quad t=0$$

$$1-\alpha \quad \alpha \quad \alpha \quad t=t$$

$$\text{Total moles} = 1-\alpha + \alpha + \alpha = 1+\alpha$$

$$\text{Now, } [PCl_5] = \frac{1-\alpha}{(1+\alpha)V}$$

$$[Cl_2] = \frac{\alpha}{V}$$

$$[PCl_3] = \frac{\alpha}{(1+\alpha)V}$$

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{\frac{\alpha}{V} \cdot \frac{\alpha}{V}}{\frac{1-\alpha}{V}} = \boxed{\frac{\alpha^2}{V(1-\alpha)}}$$

when; $1 \gg \alpha$

$$K_c = \frac{\alpha^2}{V}$$

$$\alpha^2 = K_c \cdot V$$

$$\alpha = \sqrt{K_c \cdot V}$$

$$\boxed{\alpha = \sqrt{K_c \cdot V}}$$

Partial pressure

$$P_{NO} = \frac{2(1-\alpha)}{3-\alpha} \cdot P$$

$$P_{Cl_2} = \frac{1-\alpha}{3-\alpha} \cdot P$$

$$P_{NOCl} = \frac{2\alpha}{3-\alpha} \cdot P$$

$$K_p = \frac{\left(\frac{2\alpha}{3-\alpha} P\right)^2}{\left(\frac{2(1-\alpha)}{3-\alpha} P\right)^2 \times \frac{1-\alpha}{3-\alpha} P}$$
$$= \frac{4\alpha^2 P^2}{(3-\alpha)^2} \times \frac{(3-\alpha)^3}{2(1-\alpha)^3 P^3}$$

$$= \frac{\alpha^2 (3-\alpha)}{(1-\alpha)^3 P}$$

$$\gg \alpha, \quad K_p = \frac{3\alpha^2}{P}$$

$$\alpha^2 = \frac{PK_p}{3}$$

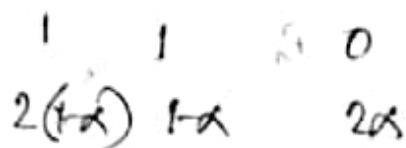
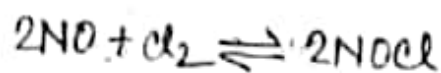
$$\alpha = \frac{1}{\sqrt{3}} \sqrt{P} \sqrt{K_p}$$

$$\boxed{\alpha \propto \sqrt{P}}$$

$$K_x = \frac{X_{CO} \cdot X_{Cl_2}}{X_{COCl_2}} = \frac{\frac{\alpha}{1+\alpha} \cdot \frac{\alpha}{1+\alpha}}{\frac{1-\alpha}{1+\alpha}}$$

$$\boxed{K_x = \frac{\alpha^2}{1-\alpha^2}}$$

Determination of K_c , K_p , K_x of the following reaction,



$$\text{Total moles} = 2 - 2\alpha + 1 - \alpha + 2\alpha = 3 - \alpha$$

$$K_c = \frac{\frac{2\alpha^2}{V}}{\left(\frac{2(1-\alpha)}{V}\right)^2 \frac{1-\alpha}{V}} = \frac{4\alpha^2}{V^2} \times \frac{V^3}{4(1-\alpha)^2} = \frac{\alpha^2 V}{(1-\alpha)^2}$$

$\gg \alpha$,

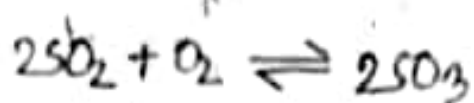
$$K_c = \alpha^2 V$$

$$\alpha^2 = \frac{1}{V} \cdot K_c$$

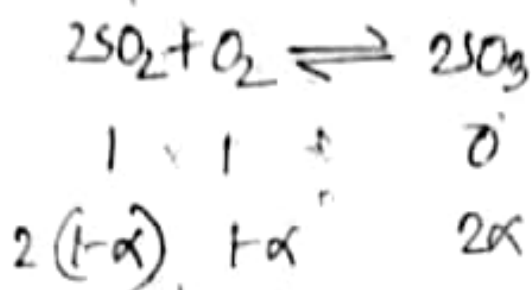
$$\alpha = \frac{1}{\sqrt{V}} \cdot \sqrt{K_c}$$

$$\boxed{\alpha \propto \frac{1}{\sqrt{V}}}$$

Determination of K_p, K_c, K_x of the following reaction,



The reaction is carried out in a closed vessel which volume is V in a closed vessel in a constant temperature T and pressure P .



Total moles = $2 - 2\alpha + 1 - \alpha + 2\alpha = 3 - \alpha$

$$[SO_2] = \frac{2(1-\alpha)}{V}, \quad [O_2] = \frac{1-\alpha}{V}, \quad [SO_3] = \frac{2\alpha}{V}$$

$$\begin{aligned}
 K_c &= \frac{\left(\frac{2\alpha}{V}\right)^2}{\left\{\frac{2(1-\alpha)}{V}\right\}^2 \times \frac{1-\alpha}{V}} = \frac{4\alpha^2}{V^2} \times \frac{V^2 \cdot V}{4(1-\alpha)^3} \\
 &= \frac{\alpha^2 V}{(1-\alpha)^3}
 \end{aligned}$$

$\alpha \gg \alpha^2$,

$$K_c = \alpha^2 V$$

$$\alpha^2 = \frac{K_c}{V}$$

$$\left| \alpha \propto \frac{1}{\sqrt{V}} \right|$$

Partial pressure

$$P_{SO_2} = \frac{2(1-\alpha)}{3-\alpha} \times P$$

$$P_{O_2} = \frac{1-\alpha}{3-\alpha} \times P$$

$$P_{SO_3} = \frac{2\alpha}{3-\alpha} \times P$$

$$K_p = \frac{\left\{ \frac{2\alpha}{3-\alpha} \cdot P \right\}^2}{\left\{ \frac{2(1-\alpha)}{3-\alpha} \cdot P \right\}^2 \times \left\{ \frac{1-\alpha}{3-\alpha} \cdot P \right\}}$$

$$= \frac{4\alpha^2 P^2}{(3-\alpha)^2} \times \frac{(3-\alpha)^2 \cdot (3-\alpha)}{4(1-\alpha)^2 P^2 (1-\alpha) \cdot P}$$

$$= \frac{4\alpha^2 P^2}{(3-\alpha)^2} \times \frac{(3-\alpha)^3}{4P^3 (1-\alpha)^3}$$

$$= \boxed{\frac{\alpha^2 (3-\alpha)}{P (1-\alpha)^3}}$$

when $1 \gg \alpha$,

$$K_p = \frac{3\alpha^2}{P}$$

$$\alpha^2 = \frac{P}{3} K_p$$

$$\alpha = \frac{1}{\sqrt{3}} \sqrt{P K_p}$$

$$\boxed{\alpha \propto \sqrt{P}}$$

$$K_p = \frac{P_{N_2O_4}}{P_{NO_2}} = \frac{\frac{\alpha}{2-\alpha} \cdot P}{\left\{ \frac{2(1-\alpha)}{2-\alpha} P \right\}^2}$$

$$= \frac{\alpha P}{2-\alpha} \times \frac{(2-\alpha)^2}{4(1-\alpha)^2 P^2}$$

$$= \boxed{\frac{\alpha(2-\alpha)}{4(1-\alpha)^2 P}}$$

When $1 \gg \alpha$, then

$$K_p = \frac{2\alpha}{4P}$$

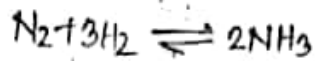
$$K_p = \frac{\alpha}{2P}$$

$$\alpha = 2PK_p$$

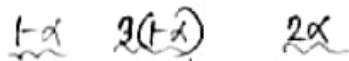
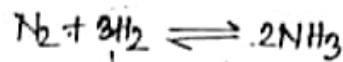
$$\boxed{\alpha \propto P}$$

$$K_x = \frac{\frac{\alpha}{2-\alpha}}{\left\{ \frac{2(1-\alpha)}{2-\alpha} \right\}^2} = \boxed{\frac{\alpha(2-\alpha)}{4(1-\alpha)^2}}$$

Determination of K_c, K_p, K_x of the following reaction.



The reaction is occur in a closed vessel which volume is V in a constant temperature T and pressure P .



$$\text{Total mole} = 1-\alpha + 3-3\alpha + 2\alpha = 4-2\alpha = 2(2-\alpha)$$

$$[\text{N}_2] = \frac{1-\alpha}{V}, \quad [\text{H}_2] = \frac{3(1-\alpha)}{V}, \quad [\text{NH}_3] = \frac{2\alpha}{V}$$

$$\begin{aligned} K_c &= \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} = \frac{\left(\frac{2\alpha}{V}\right)^2}{\frac{1-\alpha}{V} \times \left(\frac{3(1-\alpha)}{V}\right)^3} \\ &= \frac{\frac{4\alpha^2}{V^2}}{\frac{1-\alpha}{V} \times \frac{27(1-\alpha)^3}{V^3}} \\ &= \frac{4\alpha^2}{V^2} \times \frac{V^4}{27(1-\alpha)^4} \end{aligned}$$

$$K_c = \frac{4\alpha^2 V^2}{27(1-\alpha)^4}$$

Relation between K_p, K_c, K_x

Show that, $K_p = K_c (RT)^{\Delta n} = K_x P^{\Delta n}$

Let us consider a reaction



The reaction is occurred in a closed vessel which volume is V and a temperature T and pressure P

$$\text{Now, } K_p = \frac{P_M^m P_N^n}{P_A^a P_B^b} \quad \text{--- (1)}$$

We know that, $PV = nRT$

$$P = \frac{n}{V} RT$$

$$P = CRT \quad \left[\because C = \frac{n}{V} \right]$$

$$P_A = C_A RT, \quad P_B = C_B RT, \quad P_M = C_M RT, \quad P_N = C_N RT$$

Now from equation (1)

$$K_p = \frac{(C_M RT)^m (C_N RT)^n}{(C_A RT)^a (C_B RT)^b}$$

$$= \frac{C_M^m \times C_N^n}{C_A^a \times C_B^b} \times \frac{(RT)^{m+n}}{(RT)^{a+b}}$$

$$= K_c \times (RT)^{(m+n) - (a+b)}$$

when $\gg \alpha$ then, $K_c = \frac{4\alpha^2 V^2}{27}$

$$\alpha^2 = 27 K_c \times \frac{1}{4} \times \frac{1}{V^2}$$

$$\alpha = \frac{\sqrt{27}}{2} \times \frac{1}{V} \times \sqrt{K_c}$$

$$\boxed{\alpha \propto \frac{1}{V}}$$

Partial pressure,

$$P_{N_2} = \frac{1-\alpha}{2(2-\alpha)} \cdot P$$

$$P_{H_2} = \frac{3(1-\alpha)}{2(2-\alpha)} P$$

$$P_{NH_3} = \frac{2\alpha}{2(2-\alpha)} P$$

$$K_p = \frac{P_{NH_3}^2}{P_{N_2} \times P_{H_2}^3}$$

$$= \frac{\left\{ \frac{2\alpha}{2(2-\alpha)} P \right\}^2}{\left\{ \frac{1-\alpha}{2(2-\alpha)} P \right\} \times \left\{ \frac{3(1-\alpha)}{2(2-\alpha)} P \right\}^3}$$

$$= \frac{4\alpha^2 P^2}{4(2-\alpha)^2 \times \frac{(1-\alpha)P}{2(2-\alpha)} \times \frac{27(1-\alpha)^3 P^3}{8(2-\alpha)^3}}$$

$$= \frac{4\alpha^2 P^2}{4(2-\alpha)^2}$$

$$\frac{(1-\alpha)P}{2(2-\alpha)} \times \frac{27(1-\alpha)^3 P^3}{8(2-\alpha)^3}$$

$$K_p = K_c \times (RT)^{\Delta n} \quad [\text{where, } \Delta n = (m+n) - (a+b)]$$

Again, we know that,

Partial pressure = mole fraction \times total pressure

$$P_A = X_A \cdot P$$

$$P_B = X_B \cdot P$$

$$P_M = X_M \cdot P$$

$$P_N = X_N \cdot P$$

Now we can write from equation ①

$$K_p = \frac{(X_M \cdot P)^m (X_N \cdot P)^n}{(X_A \cdot P)^a (X_B \cdot P)^b}$$

$$= \frac{X_M^m \cdot X_N^n}{X_A^a \cdot X_B^b} \times \frac{P^{m+n}}{P^{a+b}}$$

$$= K_x \times P^{(m+n) - (a+b)}$$

$$= K_x \cdot P^{\Delta n}$$

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

$$K_x = \frac{X_{NO}^2}{X_{NO} X_{O_2}}$$

$$\left(\frac{2x}{3-x}\right)^2 \div \left(\frac{2(1-x)}{3-x}\right) \left(\frac{1-x}{3-x}\right)$$

$$= \frac{4x^2}{(3-x)^2} \times \frac{(3-x)^3}{4(1-x)^3}$$

become

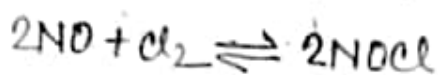
$$\boxed{\frac{x^2(3-x)}{(1-x)^3}}$$

बिका: 7/19

$$K_x = \frac{X_{CO} \cdot X_{Cl_2}}{X_{COCl_2}} = \frac{\frac{\alpha}{1+\alpha} \cdot \frac{\alpha}{1+\alpha}}{\frac{1-\alpha}{1+\alpha}}$$

$$\boxed{K_x = \frac{\alpha^2}{1-\alpha^2}}$$

Determination of K_c , K_p , K_x of the following reaction,



$$1 \quad 1 \quad 0$$

$$2(1-\alpha) \quad 1-\alpha \quad 2\alpha$$

$$\text{Total moles} = 2 - 2\alpha + 1 - \alpha + 2\alpha = 3 - \alpha$$

$$K_c = \frac{\left(\frac{2\alpha}{V}\right)^2}{\left(\frac{2(1-\alpha)}{V}\right)^2 \cdot \frac{1-\alpha}{V}} = \frac{4\alpha^2}{V^2} \times \frac{V^3}{4(1-\alpha)^2}$$

$$= \frac{\alpha^2 V}{(1-\alpha)^2}$$

$\gg \alpha$,

$$K_c = \alpha^2 V$$

$$\alpha^2 = \frac{1}{V} \cdot K_c$$

$$\alpha = \frac{1}{\sqrt{V}} \cdot \sqrt{K_c}$$

$$\boxed{\alpha \propto \frac{1}{\sqrt{V}}}$$

$$= \frac{4\alpha^2 P^2}{4(2-\alpha)^2} \times \frac{16(2-\alpha)^4}{27P^4(1-\alpha)^4}$$

$$K_p = \boxed{\frac{16\alpha^2(2-\alpha)^2}{27P^2(1-\alpha)^4}}$$

$$\gg \alpha, \quad K_p = \frac{16\alpha^2 \cdot 2^2}{27P^2}$$

$$\alpha^2 = \frac{27P^2 K_p}{64}$$

$$\alpha = \frac{\sqrt{27}}{8} P \sqrt{K_p}$$

$$\boxed{\alpha \propto P}$$

$$K_x = \frac{\left(\frac{2\alpha}{2(2-\alpha)}\right)^2}{\left(\frac{1-\alpha}{2(2-\alpha)}\right) \left(\frac{3(1-\alpha)}{2(2-\alpha)}\right)^3}$$

$$\boxed{\frac{16\alpha^2(2-\alpha)^2}{27(1-\alpha)^4}}$$

$$\gg \alpha, \quad K_x = \frac{16\alpha^2 \cdot 4}{27}$$

$$\alpha^2 = \frac{27}{64} K_x$$

$$\alpha = \frac{27}{8} \sqrt{K_x}$$

Partial pressure, $P_{NO} = \frac{2(1-\alpha)}{3-\alpha} \cdot P$

$$P_{Cl_2} = \frac{1-\alpha}{3-\alpha} \cdot P$$

$$P_{NOCl} = \frac{2\alpha}{3-\alpha} \cdot P$$

$$K_p = \frac{\left(\frac{2\alpha}{3-\alpha} P\right)^2}{\left(\frac{2(1-\alpha)}{3-\alpha} P\right)^2 \times \frac{1-\alpha}{3-\alpha} P}$$
$$= \frac{4\alpha^2 P^2}{(3-\alpha)^2} \times \frac{(3-\alpha)^3}{2(1-\alpha)^3 P^3}$$

$$= \frac{\alpha^2 (3-\alpha)}{(1-\alpha)^3 P}$$

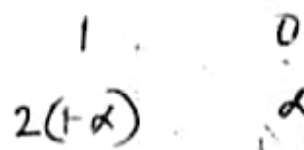
$$\gg \alpha, \quad K_p = \frac{3\alpha^2}{P}$$

$$\alpha^2 = \frac{PK_p}{3}$$

$$\alpha = \frac{1}{\sqrt{3}} \sqrt{P} \sqrt{K_p}$$

$$\boxed{\alpha \propto \sqrt{P}}$$

Determination of K_c , K_p , K_x of the following reaction.



$$\text{Total moles} = 2 - 2\alpha + \alpha = 2 - \alpha$$

$$[\text{NO}_2] = \frac{2(1-\alpha)}{V}, \quad [\text{N}_2\text{O}_4] = \frac{\alpha}{V}$$

$$K_c = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2} = \frac{\frac{\alpha}{V}}{\left[\frac{2(1-\alpha)}{V}\right]^2} = \frac{\alpha}{V} \times \frac{V^2}{4(1-\alpha)^2} = \boxed{\frac{\alpha V}{4(1-\alpha)^2}}$$

$\gg \alpha$,

$$K_c = \frac{\alpha V}{4}$$

$$\alpha = \frac{4K_c}{V}$$

$$\boxed{\alpha = \frac{4K_c}{V}}$$

Partial pressure, $P_{\text{NO}_2} = \frac{2(1-\alpha)}{2-\alpha} \cdot P$

$$P_{\text{N}_2\text{O}_4} = \frac{\alpha}{2-\alpha} \cdot P$$

$$\Rightarrow \alpha, \quad K_c = \frac{\alpha^{\nu}}{V}$$

$$\alpha^{\nu} = V K_c$$

$$\alpha = \sqrt{V K_c}$$

$$\boxed{\alpha \propto \sqrt{V}}$$

Partial pressure, $P_{\text{COCl}_2} = \frac{1-\alpha}{1+\alpha} P$

$$P_{\text{CO}} = \frac{\alpha}{1+\alpha} P$$

$$P_{\text{Cl}_2} = \frac{\alpha}{1+\alpha} P$$

$$K_p = \frac{\frac{\alpha}{1+\alpha} P \times \frac{\alpha}{1+\alpha} P}{\frac{1-\alpha}{1+\alpha} P}$$

$$= \frac{\alpha^2 P^2}{(1+\alpha)^2} \times \frac{1+\alpha}{P(1-\alpha)}$$

$$= \frac{\alpha^2 P}{1-\alpha^2}$$

$$\Rightarrow \alpha, \quad K_p = \alpha^2 P$$

$$\alpha^2 = \frac{1}{P} K_p$$

$$\boxed{\alpha \propto \frac{1}{\sqrt{P}}}$$

Partial pressure

$$P_{\text{O}_2} = \frac{1-\alpha}{2-\alpha} \cdot P$$

$$P_{\text{CO}_2} = \frac{1-\alpha}{2-\alpha} \cdot P$$

$$P_{\text{CO}} = \frac{\alpha}{2-\alpha} \cdot P$$

$$K_p = \frac{P_{\text{CO}_2}}{P_{\text{O}_2} \times P_{\text{CO}}} = \frac{\frac{\alpha}{2-\alpha} \cdot P}{\frac{1-\alpha}{2-\alpha} \cdot P \times \frac{1-\alpha}{2-\alpha} \cdot P}$$

$$= \frac{\alpha P}{2-\alpha} \times \frac{(2-\alpha)^2}{(1-\alpha)^2 P^2}$$

$$= \boxed{\frac{\alpha(2-\alpha)}{P(1-\alpha)^2}}$$

when, $1 \gg \alpha$,

$$K_p \approx \frac{\alpha \cdot 2}{P}$$

$$\alpha = \frac{1}{2} K_p \times P$$

$$\boxed{\alpha \propto P}$$

$$K_x = \frac{\alpha}{2-\alpha} = \frac{\frac{1-\alpha}{2-\alpha} \times \frac{1-\alpha}{2-\alpha}}{\frac{1-\alpha}{2-\alpha} \times \frac{1-\alpha}{2-\alpha}} = \boxed{\frac{\alpha(2-\alpha)}{(1-\alpha)^2}}$$

$1 \gg \alpha$,

$$\boxed{K_x = 2\alpha}$$

Partial pressure $P_{\text{PCl}_5} = \frac{1-\alpha}{1+\alpha} \cdot P$ [mole fraction \times total pressure]

$$P_{\text{PCl}_3} = \frac{\alpha}{1+\alpha} P$$

$$P_{\text{Cl}_2} = \frac{\alpha}{1+\alpha} \cdot P$$

$$K_p = \frac{P_{\text{PCl}_3} \times P_{\text{Cl}_2}}{P_{\text{PCl}_5}} = \frac{\frac{\alpha}{1+\alpha} \cdot P \times \frac{\alpha}{1+\alpha} \cdot P}{\frac{1-\alpha}{1+\alpha} \cdot P}$$

$$= \frac{\alpha^2}{(1+\alpha)^2} P^2 \times \frac{1+\alpha}{(1-\alpha)P}$$

$$\boxed{K_p = \frac{\alpha^2 P}{(1+\alpha)(1-\alpha)}} = \boxed{\frac{\alpha^2 P}{1-\alpha^2}}$$

$\gg \alpha$, then,

$$K_p = \alpha^2 P$$

$$\alpha^2 = K_p \times \frac{1}{P}$$

$$\alpha = \sqrt{K_p} \times \frac{1}{\sqrt{P}}$$

$$\boxed{\alpha \propto \frac{1}{\sqrt{P}}} \quad \checkmark$$

mole fraction, $X_{\text{PCl}_5} = \frac{1-\alpha}{1+\alpha}$, $X_{\text{PCl}_3} = \frac{\alpha}{1+\alpha}$, $X_{\text{Cl}_2} = \frac{\alpha}{1+\alpha}$

$$\textcircled{K_x} = \frac{X_{\text{PCl}_3} \times X_{\text{Cl}_2}}{X_{\text{PCl}_5}} = \frac{\frac{\alpha}{1+\alpha} \cdot \frac{\alpha}{1+\alpha}}{\frac{1-\alpha}{1+\alpha}} = \boxed{\frac{\alpha^2}{1-\alpha^2}}$$