

## Types of chemical Rxns



### Irreversible

1. The rxn which proceed in one direction (forward direction only)
2. Reactants are almost completely converted into products and Products do not react to form reactants again.
3. Do not attain equilibrium state
4. Such rxns are represented by single arrow



## Types of chemical Rxns



### Reversible

1. The rxn which proceed in both the direction under same experiment cond
2. Reactants form products and products also react to form reactants in backward direc<sup>n</sup>.
3. Attain equilibrium and never go for completion
4. Represented by double arrow.



## >> Nature of chemical Eq<sup>m</sup>



1. Eq<sup>m</sup> can be achieved from either direction.
2. Eq<sup>m</sup> is dynamic in nature
3. A catalyst can change the rate of rxn
4. Eq<sup>m</sup> can be observed by constancy of some observable prop like colour, pressure conc<sup>n</sup>, temp, etc
5. Eq<sup>m</sup> can be affected by changing factors like, P, T, Conc<sup>n</sup>, volume etc.

## Graphical analysis

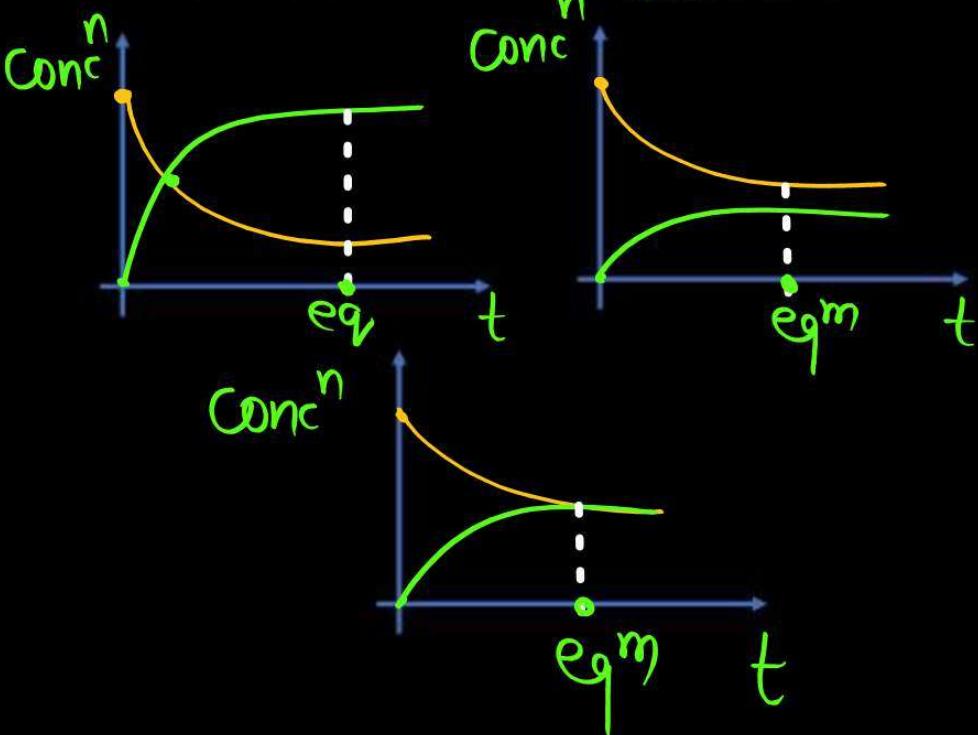
$\text{Conc}^n = \text{const}$



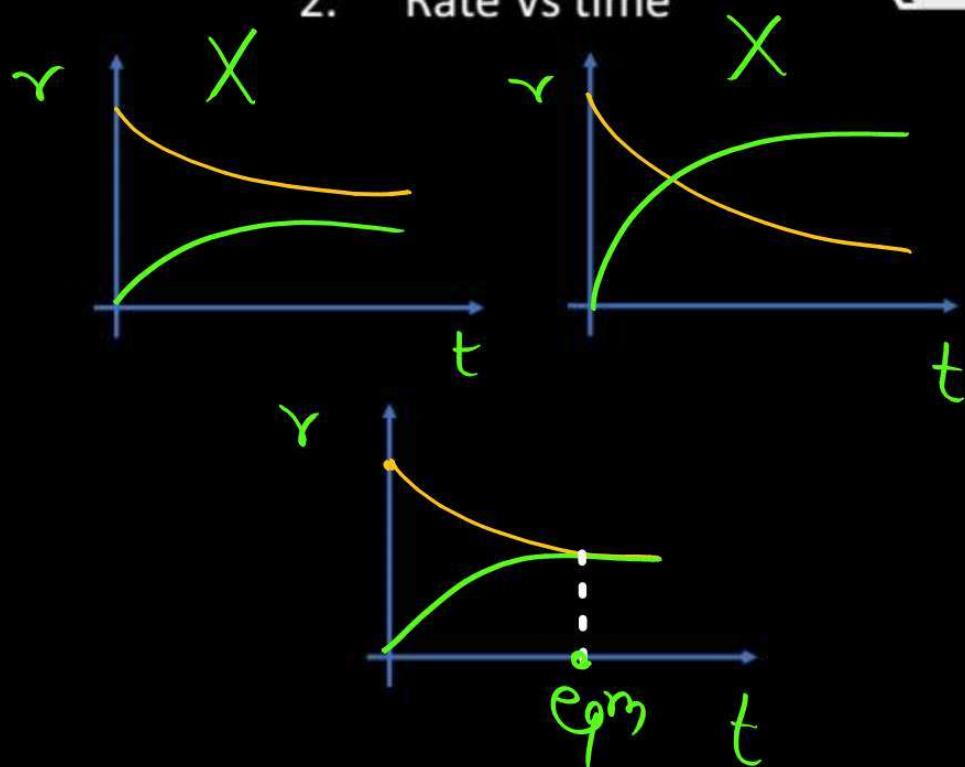
$$(\gamma_f = \gamma_b)$$



### 1. Conc<sup>n</sup> Vs time



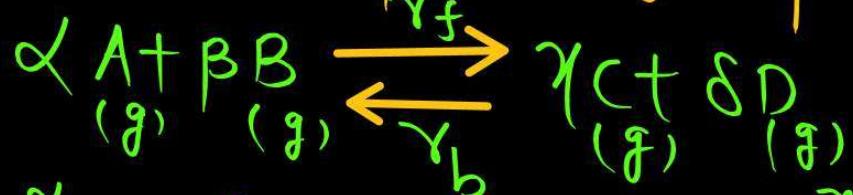
### 2. Rate Vs time



## Law of mass action



The R.O.R is directly propor. to the product of conc' of reactants to the power of respective stoichio coeff



$$\gamma_f \propto [A]^\alpha [B]^\beta$$

$$\gamma_b \propto [C]^\gamma [D]^\delta$$

$$\gamma_f = k_f [A]^\alpha [B]^\beta$$

$$\gamma_b = k_b [C]^\gamma [D]^\delta$$

$$At \text{ eqm} \quad \gamma_f = \gamma_b$$

$$k_f [A]^\alpha [B]^{\beta} = k_b [C]^\gamma [D]^{\delta}$$

$$\left\{ \frac{k_f}{k_b} \right\} = \frac{[C]^\gamma [D]^\delta}{[A]^\alpha [B]^\beta}$$

for solids

$$[J = 1]$$

$$k_c = \frac{[C]^\gamma [D]^\delta}{[A]^\alpha [B]^\beta}$$



Diff types of eq<sup>m</sup> const(K)



$$K_C = \frac{[C]^\gamma [D]^\delta}{[A]^\alpha [B]^\beta}$$

$$K_P = \frac{P_C^\gamma P_D^\delta}{P_A^\alpha P_B^\beta}$$

Relation b/w  $K_p$  and  $K_c$

$\Delta n_g = \text{no. of moles of gas products} - \text{no. of moles of gas reactant}$

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

Case ④

$$\text{If } T = \frac{1}{R}$$

Case ① if  $\Delta n_g > 0$ ;  $K_p > K_c$

Case ② If  $\Delta n_g < 0$ ;  $K_p < K_c$

Case ③ if  $\Delta n_g = 0$ ;  $K_p = K_c$

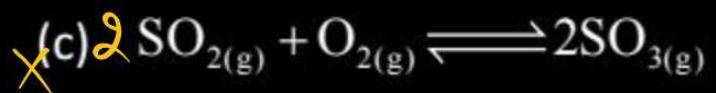
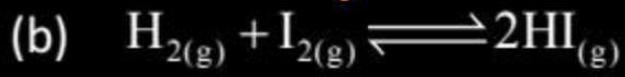
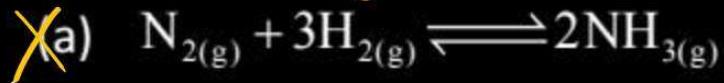
$$K_p = K_c$$



Q.  $K_p > K_c$  for

$$\Delta n_g = 2 - 4 = -2$$

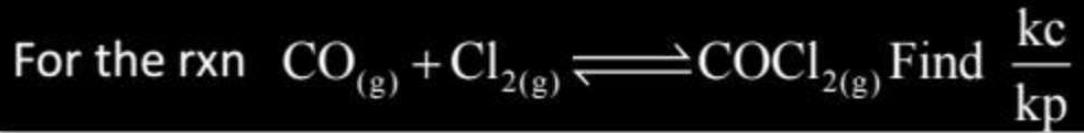
$$\Delta n_g = 2 - 2 = 0$$



$$\Delta n_g = 2 - 3 = -1$$

$$\Delta n_g = 2 - 1 = 1$$

Q.



$$\Delta n_g = 1 - 2 = -1$$

$$k_p = k_c (RT)^{-1}$$

$$\frac{k_c}{k_p} = RT$$



Q. Find  $T_{(k)}$  when  $\frac{K_P(\text{atm})}{K_c(M)} = 3$  for  $\text{SO}_2\text{Cl}_{2(g)} \rightleftharpoons \text{SO}_{2(g)} + \text{Cl}_{2(g)}$

$$K_P = K_c (RT)^{\Delta n_g} \quad \Delta n_g = 2 - 1 = 1$$

$$\frac{K_P}{K_c} = RT$$

$$\frac{3}{R} = T$$



Q.

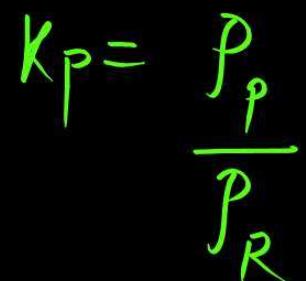
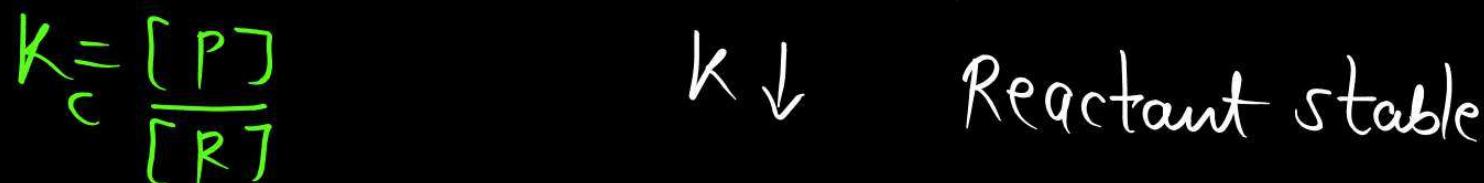
The KP for the rxn at  $191^{\circ}\text{C}$  is 1.24 find KC

$$K_p = K_c (RT)^{-\frac{1}{2}}$$
$$\Delta n_g = 1 - \frac{3}{2} = -\frac{1}{2}$$
$$1.24 = K_c \left( \frac{1}{12} \times (191 + 273) \right)^{-\frac{1}{2}}$$

## Application of K



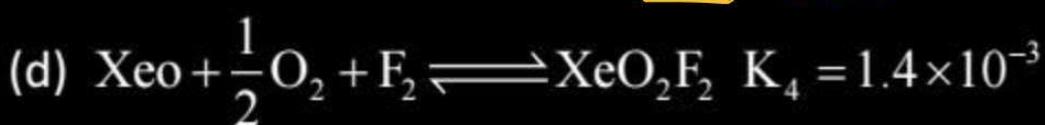
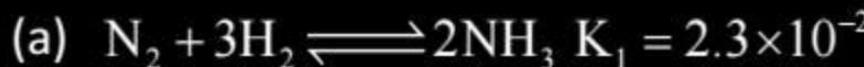
### ❖ Stability of Reactants and Products



**Q.**

In which rxn product is more stable

$\leftarrow \uparrow$



## Factors affecting K

① Temp

$$\log \frac{K_2}{K_1} = \frac{\Delta H}{2.3R} \left[ \frac{1}{T_1} - \frac{1}{T_2} \right]$$

$\Delta H = +ve$  Endothermic

$\Delta H = -ve$  Exothermic

$$\Delta H = J \quad R = 25/3$$

$$\Delta H = \text{Cal} \quad R = 2$$

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

$\downarrow \frac{1}{T^2}$



## Factors affecting K

② Stoichiometry of the Rxn



## Reaction Quotient ( $Q$ )



$$Q_c = \frac{[C]^\gamma [D]^\delta}{[A]^\alpha [B]^\beta} \quad [A], [B], [C], [D] \text{ not at eq^m}$$

Case ①  $Q_c = K_c \text{ Eq}^m$

Case ②  $Q_c > K_c$  Backward

Case ③  $Q_c < K_c$  Forward



Q.

$\text{NOBr}_{(g)} \rightleftharpoons \text{NO}_{(g)} + \frac{1}{2} \text{Br}_{2(g)}$   $K_P = 0.15$  atm if NOBr, NO and Br<sub>2</sub> are mixed having partial pressure 0.5 atm, 0.4 atm & 2 atm respectively. Predict the direction of eq<sup>m</sup> ?

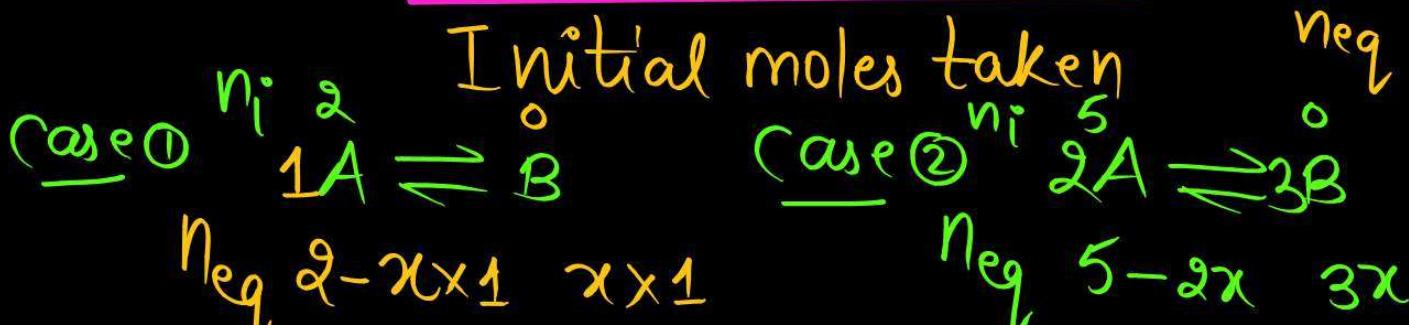
$$\begin{aligned} Q_P &= \frac{P_{\text{NO}} \times P_{\text{Br}_2}^{1/2}}{P_{\text{NOBr}}} \\ &= \frac{0.4 \times 2^{1/2}}{0.5} \end{aligned}$$

$$Q_P > K_P$$

B.W.R

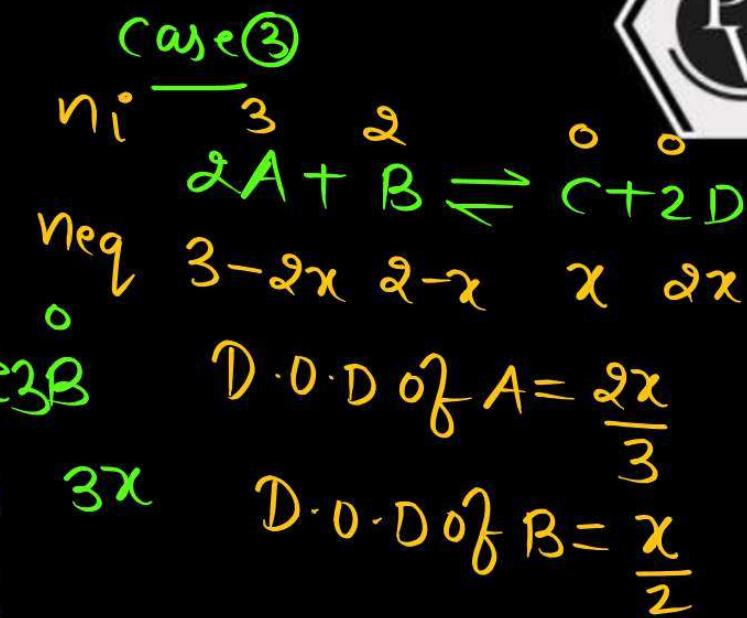
## Degree of dissociation

$$\text{D.O.D} = \frac{\text{No. of moles dissociated}}{\text{Initial moles taken}}$$



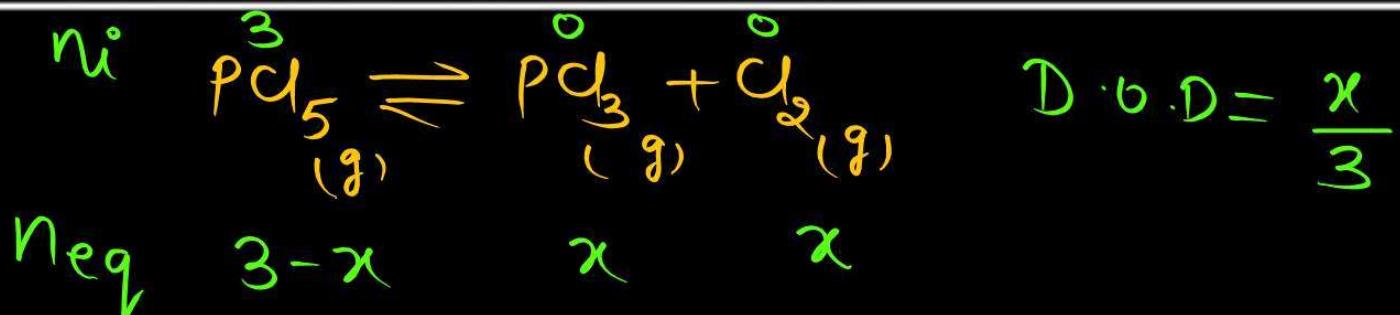
$$\text{D.O.D} = \frac{x}{2}$$

$$\text{D.O.D} = \frac{2x}{5}$$

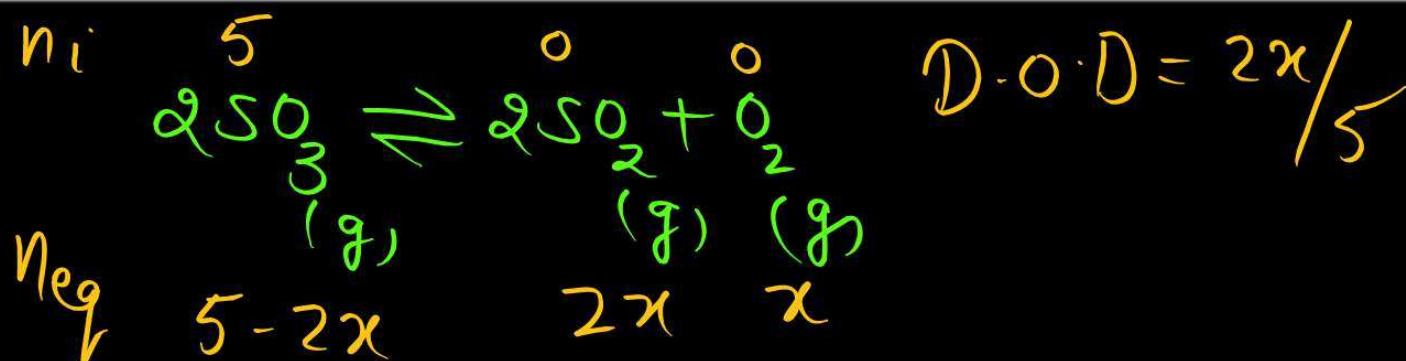




Q. If 3 moles of  $\text{PCl}_5$  is dissociated acc<sup>n</sup> to the Rxn



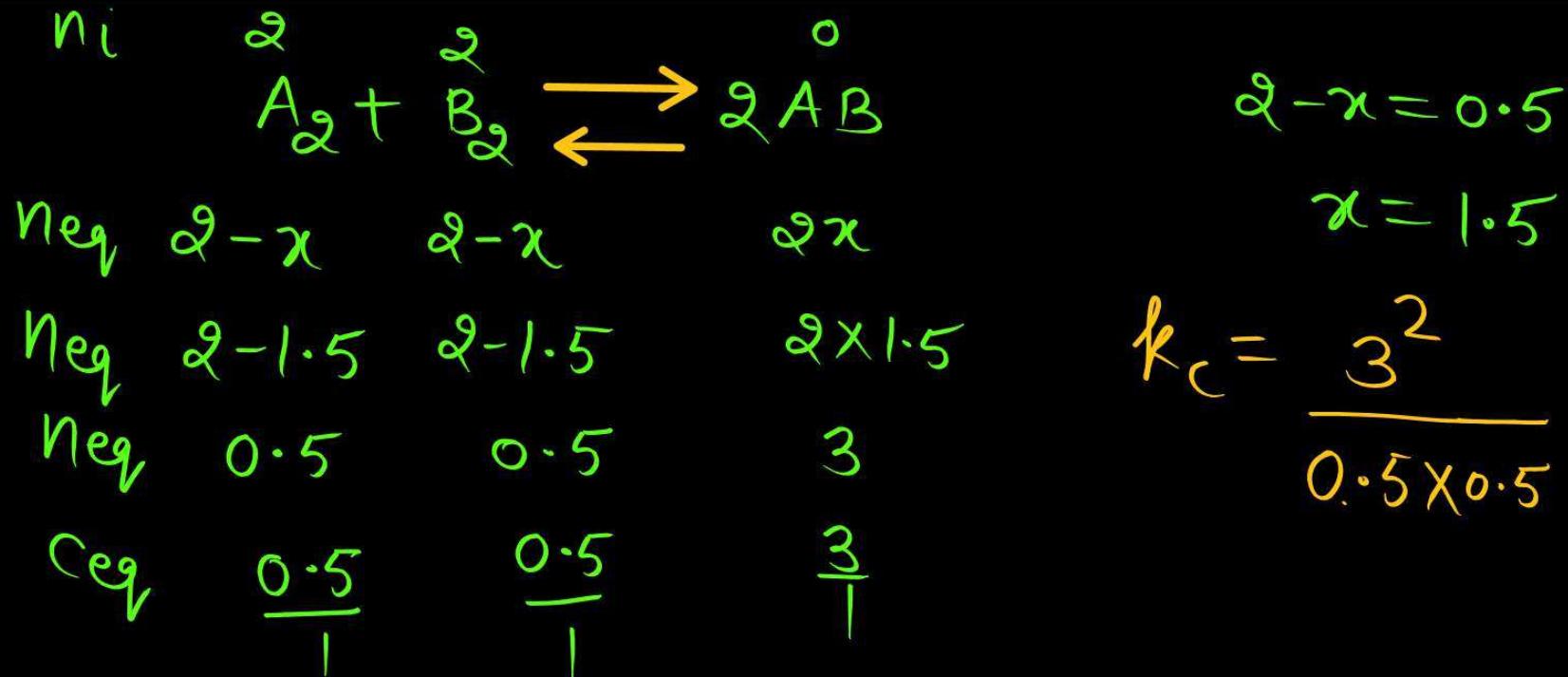
Q. If 5 moles of  $\text{SO}_3$  is dissociated acc<sup>n</sup> to the rxn





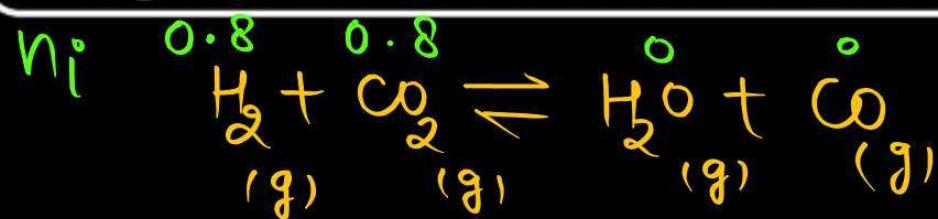
Q.

2 moles of  $A_2$  & 2 moles of  $B_2$  are mixed in a flask of volume 1L if at eq<sup>m</sup> 0.5 moles of  $A_2$  are obtained find  $K_c$  ?





Q.  $\Delta n_g = 0$   
 $H_{2(g)} + CO_{2(g)} \rightleftharpoons H_2O_{(g)} + CO_{(g)}$   $K_c = 4$  initially 0.8 mole of  $H_2$  and 0.8 mole  
of  $CO_2$  are injected in 5L flask find eq<sup>m</sup> conc<sup>n</sup> of  $CO_{(g)}$  1.6/3



If  $\Delta n_g = 0$

$$K_c = \frac{x^2}{(0.8-x)^2}$$

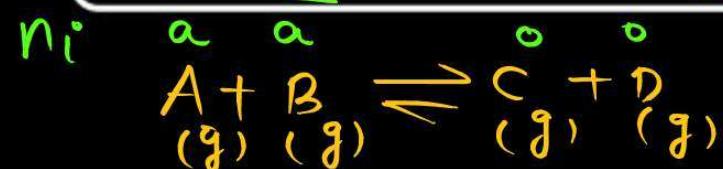
$$\frac{x}{0.8-x} = \frac{x}{0.8-x}$$
$$1.6 - 2x = x$$

$$3x = 1.6$$

$$4 = \left( \frac{x}{0.8-x} \right)^2$$



Q.  $A + B \rightleftharpoons C + D$ , initially A and B are taken in equal amount but at eq<sup>m</sup> conc<sup>n</sup> of D will be twice that of A then find eq<sup>m</sup> const?



$n_{eq}$   $a-x$   $a-x$   $x$   $x$

$n_{eq}$   $\frac{a-2x}{3}$   $\frac{a-2x}{3}$   $\frac{2x}{3}$   $\frac{2x}{3}$

$\gamma_3$   $\frac{a}{3}$   $\frac{2x}{3}$   $\frac{2x}{3}$

$$K = \frac{\left(\frac{2x}{3}\right)^2}{\left(\frac{a}{3}\right)^2}$$

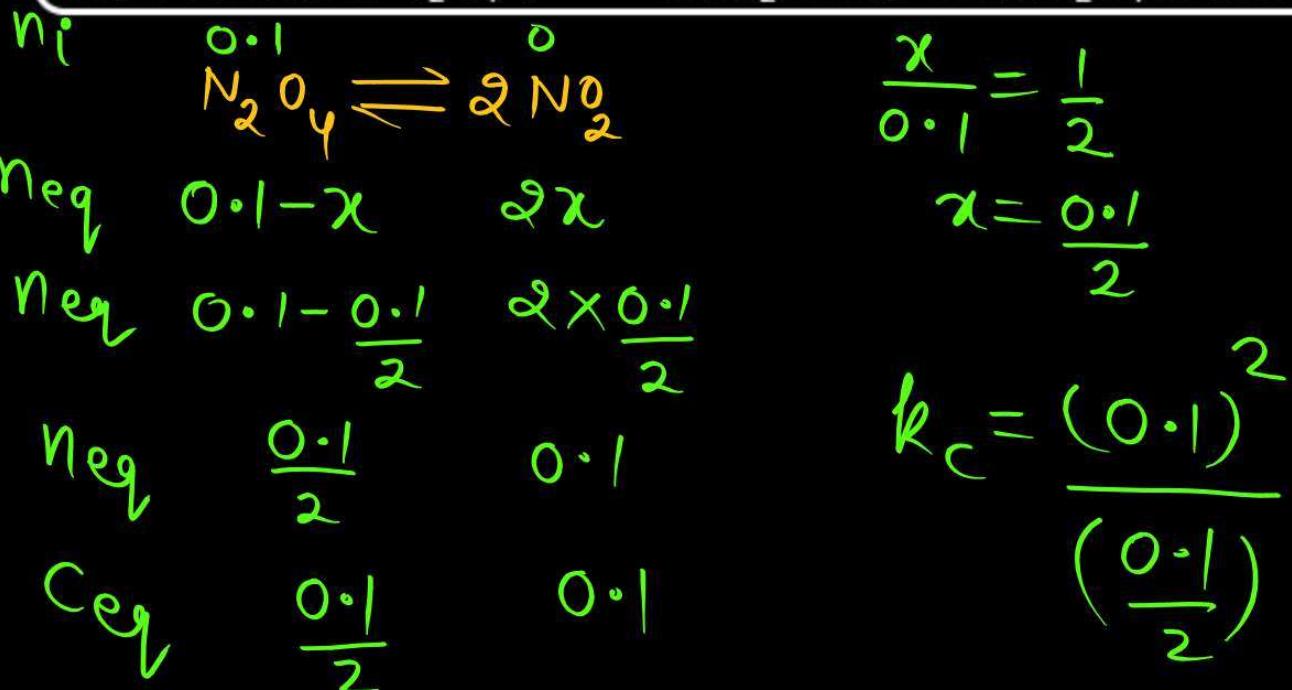
$$x = 2(a-x)$$

$$x = 2a - 2x$$
$$3x = 2a$$

$$x = \frac{2a}{3}$$



Q. 9.2 grams of  $\text{N}_2\text{O}_4$  is taken in a closed 1 L vessel and heated till the following eq<sup>m</sup> is reached  $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$  at eq<sup>m</sup> 50%  $\text{N}_2\text{O}_4$  is dissociated find  $k_c$ ?



## Le chatelier's principle

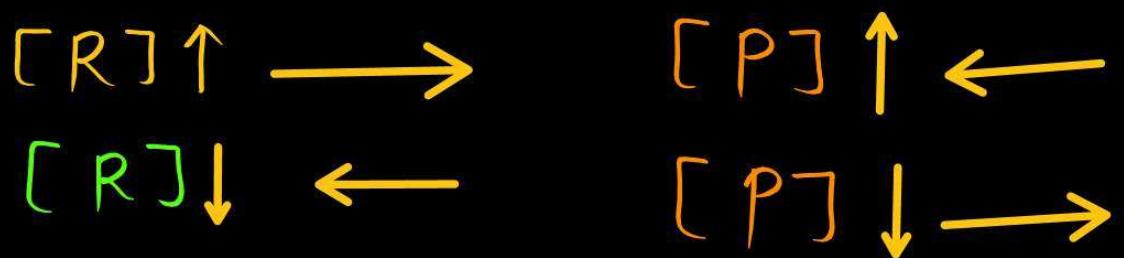


If a chemical reaction is at equilibrium and experiences a change in pressure, temperature, or concentration of products or reactants, the equilibrium shifts in the opposite direction to offset the change.

## Le chatelier's principle



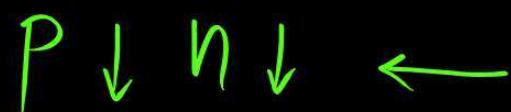
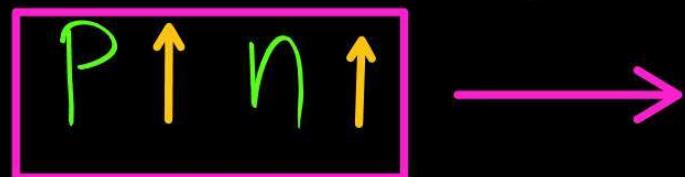
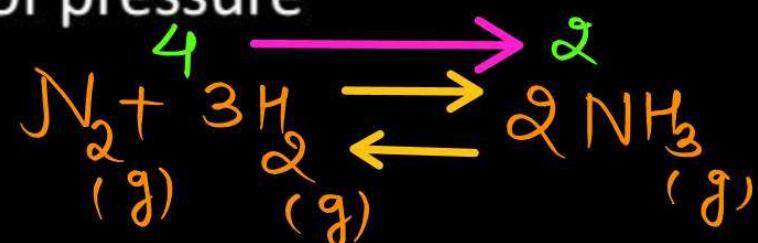
### Effect of Concentration



## Le chatelier's principle



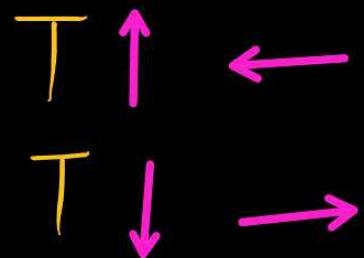
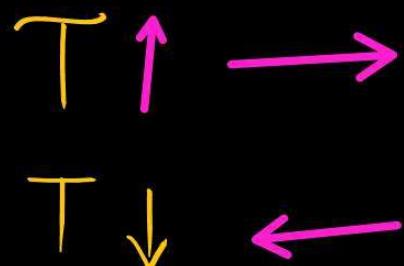
Effect of pressure



## Le chatelier's principle



Effect of Temperature



## Le chatelier's principle

Effect of catalyst

Does not affect the eq<sup>n</sup>

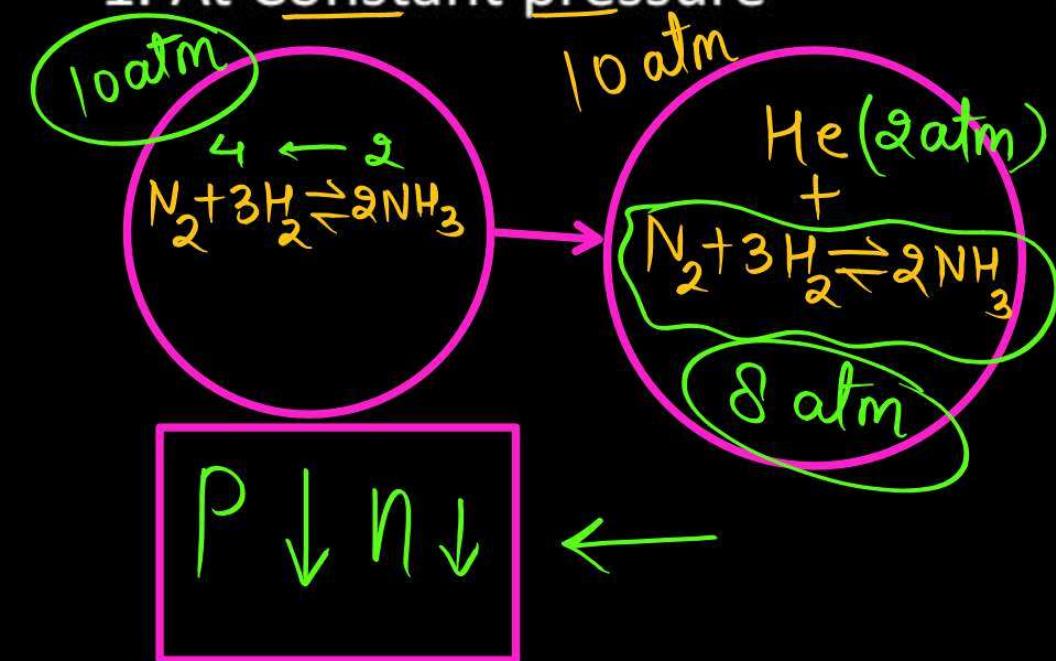


## Le chatelier's principle



Effect of inert gas

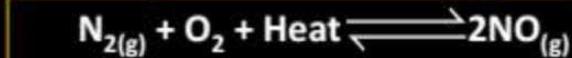
1. At Constant pressure



2. At constant Volume

① Does not affect  
the eqm.

## Le chatelier's principle



$P \downarrow n \downarrow$  does not affect



$T \downarrow \leftarrow$   
inert gas at const

press  
 $P \downarrow n \downarrow$   
 $\downarrow$   
 Rxn mix



+ Heat  
 by Adding catalyst  
 NO effect



» Relation b/w D.O.D & V. D

$$A_n \geq nA$$

$$\alpha = \frac{D - d}{d(n-1)}$$

$n \neq 1$

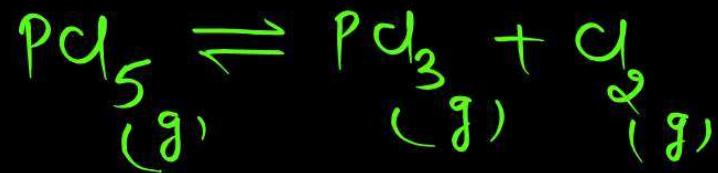
$D = V \cdot D$  of Reactant

$d = V \cdot D$  of equi mix

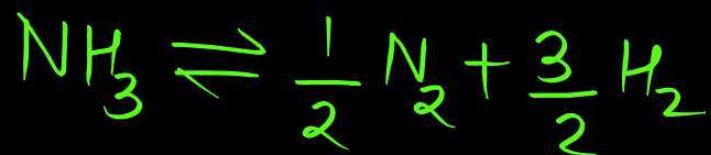
$\alpha = D \cdot O \cdot D$



## Significance of n



$$n = 1 + 1 = 2$$



$$n = \frac{1}{2} + \frac{3}{2} = 2$$



Q.

A is 90% converted into B acc<sup>n</sup> to the rxn  $A_{(g)} \rightleftharpoons 3B_{(g)}$ . Find value of  $\frac{D}{d}$ ?

$$\alpha = \frac{D-d}{d(n-1)}$$

$$0.9 = \frac{D-d}{d(3-1)}$$

$$1.8 = \frac{D-d}{d}$$

$$n = 3$$

$$1.8 = \frac{D}{d} - 1$$

$$2.8 = \frac{D}{d}$$

>>

omg

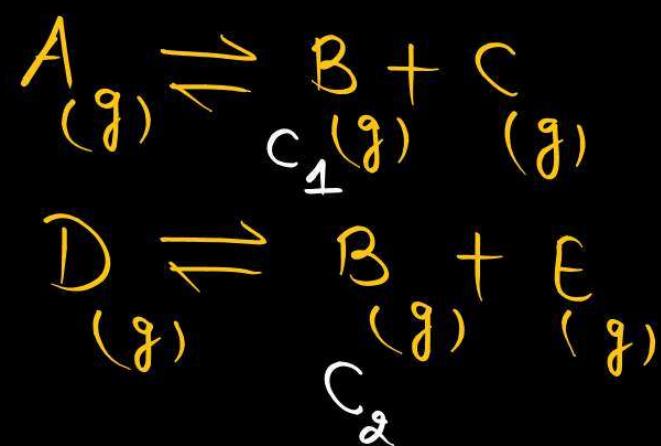


1.  $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)} \Delta H = -ve$
2.  $2SO_{2(g)} + O_2 \rightleftharpoons 2SO_{4(g)} \Delta H = -ve$
3.  $N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)} \Delta H = +ve$
4. Decomposition rxn  $\Delta H = +ve$
5. Combustion rxn  $\Delta H = -ve$

## Simultaneous Equilibrium



- If in any container there are two or more eq<sup>m</sup> existing simultaneously involving one or more than one common species. Then in both/all the eq<sup>m</sup> the conc<sup>n</sup> of common species is the total conc<sup>n</sup> of that species due to all the eq<sup>m</sup>.



Total conc<sup>n</sup> of B

$$= C_1 + C_2$$

Relation b/w standard gibbs free energy change and K



$$\Delta G = \Delta G^\circ + RT \ln Q$$

At eq<sup>m</sup>  $\Delta G = 0$   $Q = K$

$$\Delta G^\circ_J = -RT \ln K$$

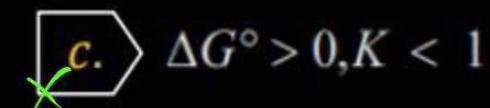
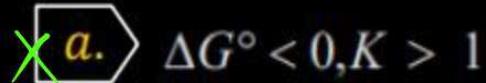
$\Delta G^\circ_{\text{cal}}$

$$R = \frac{25}{3}$$
$$R = 2$$

$$T = k$$

Q.

The incorrect match in the following is (2019 Main, 12 April II)



$$\Delta G^\circ = -RT \ln K$$

$$\Delta G^\circ = 0, K = 1$$

$$\Delta G^\circ < 0, K > 1$$

$$\Delta G^\circ > 0, K < 1$$

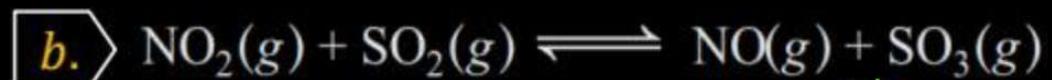
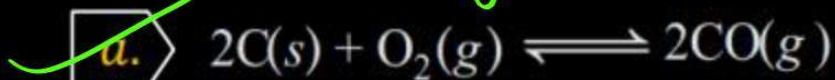


Q.

In which one of the following equilibria,  $K_p \neq K_c$ ?

(2019 Main, 12 April II)

$$\Delta n_g = 2 - 1 = 1$$



$$\Delta n_g = 0$$



$$\Delta n_g = 0$$

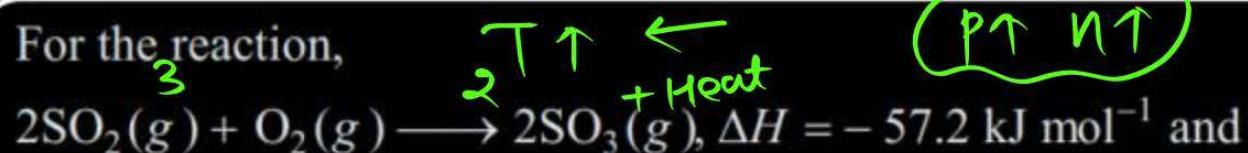
$$K_p \neq K_c$$

$$\Delta n_g = 0$$



Q.

For the reaction,



$K_c = 1.7 \times 10^{16}$ . Which of the following statement is incorrect? (2019 Main, 10 April II)

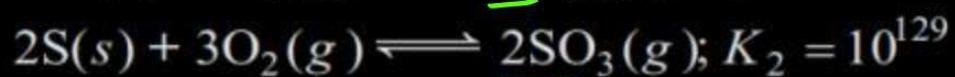
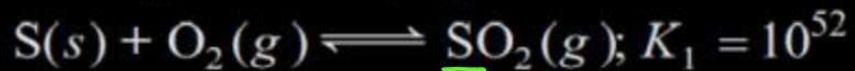
(P↑ N↑)

- a. The equilibrium constant decreases as the temperature increases
- b. The addition of inert gas at constant volume will not affect the equilibrium constant
- c. The equilibrium will shift in forward direction as the pressure increases
- d. The equilibrium constant is large suggestive of reaction going to completion and so no catalyst is required

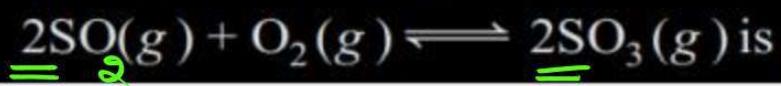


Q.

For the following reactions, equilibrium constants are given :



The equilibrium constant for the reaction,



(2019 Main, 12 Jan I)

a.  $10^{25}$

b.  $10^{77}$

c.  $10^{154}$

d.  $10^{181}$

$$K_3 = \left( \frac{1}{K_1} \right)^2 \times K_2$$

$$= \frac{10^{129}}{10^{104}} = 10^{25}$$

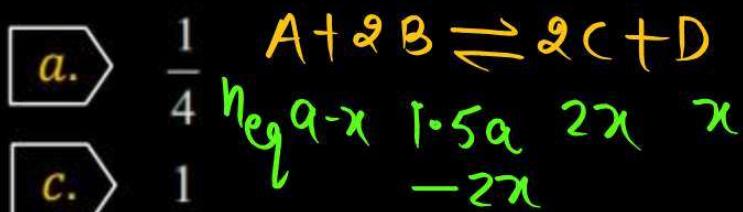
Q.

$\Delta H^\circ = 0$

In a chemical reaction,  $A + 2B \xrightleftharpoons{K} 2C + D$ , the initial concentration of  $B$  was 1.5 times of the concentration of  $A$ , but the equilibrium concentrations of  $A$  and  $B$  were found to be equal. The equilibrium constant ( $K$ ) for the aforesaid chemical reaction is

$$\text{Initial: } A \ a \quad B \ 1.5a \quad C \ 0 \quad D \ 0$$

(2019 Main, 12 Jan I)



b. 16       $K_c = \frac{(2x)^2 \times x}{(a-x)(1.5a-2x)^2}$

c. 1       $a-x = 1.5a-2x$

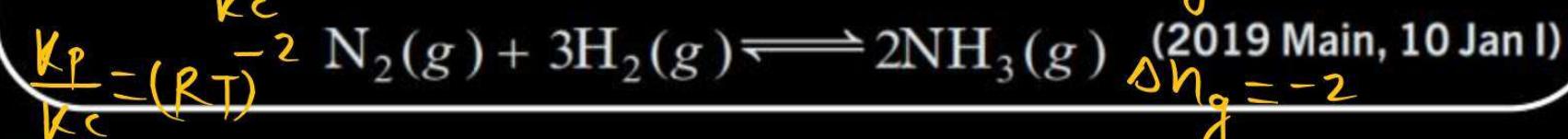
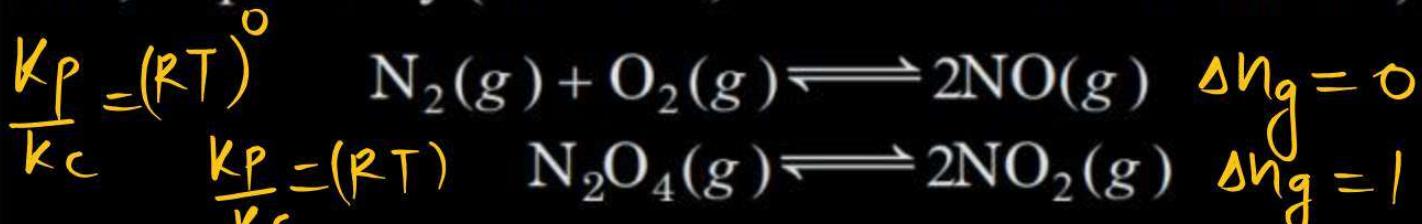
$x = 0.5a$

$K_c =$

Q.

The values of  $\frac{K_p}{K_c}$  for the following reactions at 300 K

are, respectively (At 300 K,  $RT = 24.62 \text{ dm}^3 \text{ atm mol}^{-1}$ )

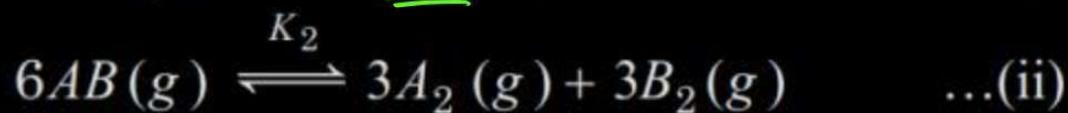
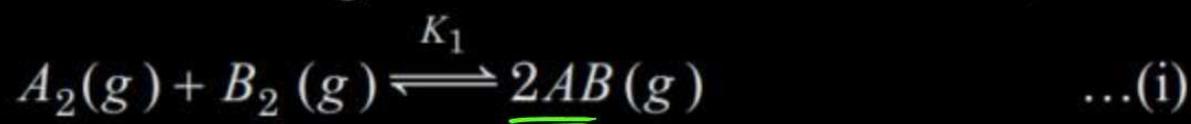


- a.  $1, 24.62 \text{ dm}^3 \text{ atm mol}^{-1}, 606.0 \text{ dm}^6 \text{ atm}^2 \text{ mol}^{-2}$
- b.  $1, 24.62 \text{ dm}^3 \text{ atm mol}^{-1}, 1.65 \times 10^{-3} \text{ dm}^{-6} \text{ atm}^{-2} \text{ mol}^2$
- c.  $24.62 \text{ dm}^3 \text{ atm mol}^{-1}, 606.0 \text{ dm}^6 \text{ atm}^{-2} \text{ mol}^2,$   
 $1.65 \times 10^{-3} \text{ dm}^{-6} \text{ atm}^{-2} \text{ mol}^2$
- d.  $1, 4.1 \times 10^{-2} \text{ dm}^{-3} \text{ atm}^{-1} \text{ mol}, 606 \text{ dm}^6 \text{ atm}^2 \text{ mol}^{-2}$



Q.

Consider the following reversible chemical reactions,



The relation between  $K_1$  and  $K_2$  is

(2019 Main, 9 Jan II)

a.  $K_2 = K_1^3$

c.  $K_2 = K_1^{-3}$

b.  $K_1 K_2 = 3$

d.  $K_1 K_2 = \frac{1}{3}$



Q.

An aqueous solution contains 0.10 M H<sub>2</sub>S and 0.20 M HCl. If the equilibrium constants for the formation of HS<sup>-</sup> from H<sub>2</sub>S is  $1.0 \times 10^{-7}$  and that of S<sup>2-</sup> from HS<sup>-</sup> ions is  $1.2 \times 10^{-13}$  then the concentration of S<sup>2-</sup> ions in aqueous solution is :

(2018 Main)

a.  $5 \times 10^{-8}$

b.  $3 \times 10^{-20}$

c.  $6 \times 10^{-21}$

d.  $5 \times 10^{-19}$





$$K_3 = \frac{[H^+]^2 [S^{2-}]}{[H_2S]}$$

$$1.2 \times 10^{-20} = \frac{(0.2)^2 \times [S^{2-}]}{0.1}$$

$$[S^{2-}] = \frac{1.2 \times 10^{-20} \times 0.1}{0.2 \times 0.2}$$



Q.

The equilibrium constant at 298 K for a reaction,  $A + B \rightleftharpoons C + D$  is 100. If the initial concentrations of all the four species were 1 M each, then equilibrium concentration of  $D$  (in mol L<sup>-1</sup>) will be (2016 Main)

a. 0.818



c. 1.182

$$\Delta n_g = 0 \quad K_c = \frac{(1+x)^2}{(1-x)^2}$$

$$100 = \left( \frac{1+x}{1-x} \right)^2$$

b. 1.818

$$[D] = 1+x$$

d. 0.182

$$= 1 + \frac{9}{11}$$

$$100 = \frac{1+x}{1-x}$$

$$10 - 10x = 1 + x$$

$$x = \frac{9}{11}$$

$$= \frac{20}{11}$$

Q.

The standard Gibbs energy change at 300 K for the reaction,  $2A \rightleftharpoons B + C$  is 2494.2 J. At a given time, the composition of the reaction mixture is  $[A] = \frac{1}{2}$ ,  $[B] = 2$  and  $[C] = \frac{1}{2}$ . The reaction proceeds in the

( $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$ ,  $e = 2.718$ )

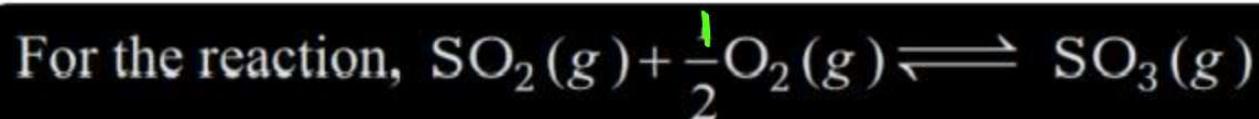
$$\Delta G > 0$$

(2015, Main)

- a. forward direction because  $Q > K_c$        b. reverse direction because  $Q > K_c$
- c. forward direction because  $Q < K_c$        d. reverse direction because  $Q < K_c$



Q.



if  $K_p = K_C (RT)^x$  where, the symbols have usual meaning,  
then the value of  $x$  is (assuming ideality) (2014 Main)

a. -1

c.  $\frac{1}{2}$

$$\begin{aligned} \Delta n &= 1 - \frac{3}{2} \\ &= -\frac{1}{2} \end{aligned}$$

b.  $-\frac{1}{2}$

d. 1



Q.



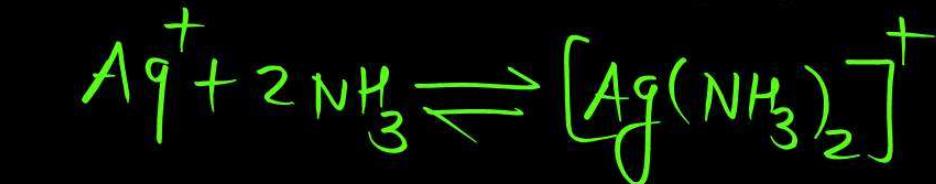
then the formation constant of  $[\text{Ag}(\text{NH}_3)_2]^+$  is (2006, 3M)

a.  $6.08 \times 10^{-6}$

b.  $6.08 \times 10^6$

c.  $6.08 \times 10^{-9}$

d. None of these



$$K_3 = K_1 K_2 = 3.5 \times 10^{-3} \times 1.7 \times 10^{-3}$$



Q.

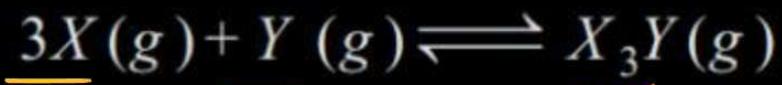
At constant temperature, the equilibrium constant ( $K_p$ ) for the decomposition reaction,  $\text{N}_2\text{O}_4 \rightleftharpoons 2\text{NO}_2$ , is expressed by  $K_p = \frac{4x^2 p}{(1-x^2)}$ , where,  $p$  = pressure,  $x$  = extent of decomposition. Which one of the following statement is true? (2001, 1M)

- a.  $K_p$  increases with increase of  $p$
- b.  $K_p$  increases with increase of  $x$
- c.  $K_p$  increases with decrease of  $x$
- d.  $K_p$  remains constant with change in  $p$  and  $x$



Q.

For the chemical reaction,  $\Delta n_g = -3$



the amount of  $\underline{X_3}Y$  at equilibrium is affected by (1999, 2M)

- a. temperature and pressure
- b. temperature only
- c. pressure only
- d. temperature, pressure and catalyst



Q.



the equilibrium constant  $K_p$  changes with (1981, 1M)

- a. total pressure
- b. catalyst
- c. the amount of  $H_2$  and  $I_2$  present
- d. temperature