ULTIMATE KCET

CRASH COURSE 2026

Chemistry | Lecture - 01

Equilibrium

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Topics *to be covered*

1. Theory + PYQ.
2.
3.
4.

equilibrium:- the Condition at which rate of forward Reaction & Rate of backward Reactions are equal.

$$H_2O_{(l)} \underset{b}{\overset{f}{\rightleftharpoons}} H_2O_{(g)}$$

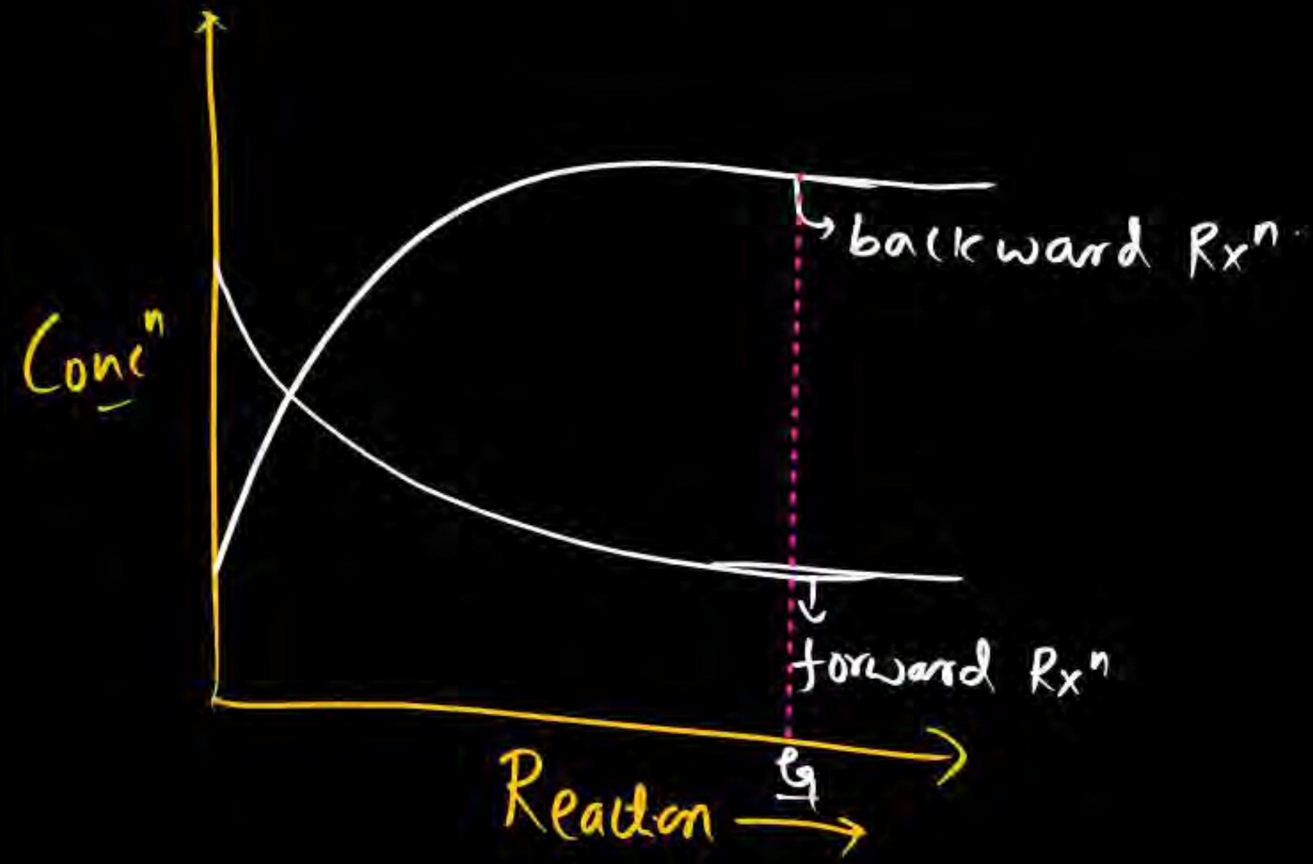
Types of equilibrium:-

(1) physical equilibrium

(02) chemical equilibrium.

* equilibrium attains at closed container
* at equilibrium Rate of forward Reaction & Rate of backward reaction equal.

$$R \rightleftharpoons P$$



Chemical equilibrium:- the equilibrium Reaction which has change in chemical composition from Reactant to product.

eg:- $N_2 + 3H_2 \rightleftharpoons 2NH_3$

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

$$R_f = K_f [A]^a [B]^b$$

$$R_b = K_b [C]^c [D]^d$$

$$\frac{R_f}{R_b} = \frac{K_f [A]^a [B]^b}{K_b [C]^c [D]^d} = 1 = \frac{K_f [A]^a [B]^b}{K_b [C]^c [D]^d}$$

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

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

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

$$K_p = \frac{P_C^c \times P_D^d}{P_A^a \times P_B^b}$$

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

$$\Delta n = n_p - n_R$$

Reaction Quotient (Q_c) :-

$$aA + bB \longrightarrow cC + dD$$

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

Case i) $Q_c = K_c$

Reaction at equilibrium.

Case ii $Q_c > K_c$

* Reaction shift to backward direction

Case iii $Q_c < K_c$

* Reaction Shift to forward direction

* Predicting Extent of Reaction :-

Case i) $K_c > 10^3$ Reaction at almost completion stage [P > R]

Case ii) $K_c < 10^{-3}$ Reaction at starting phase [R > P]

Case iii) $10^3 > K < 10^{-3}$ in this Equilibrium Reaction appreciable amount of product & Reactant are there.

Types of Chemical Equilibrium:-

01. Homogeneous Equilibrium:-

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

02. Heterogeneous Equilibrium:-

$$CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$$

Le Chatelier's principle:- The equilibrium Reaction nullify's External disturbance in a such a way that it adjust it self.

* **effect of Concⁿ:-** $R \rightleftharpoons P$

  * if Concⁿ of Reactant increases Reaction shift to forward direction
  * if Concⁿ of Product increases Reaction shift to backward direction.

* effect of pressure :-

$$A + B \rightleftharpoons C \quad \Delta n_g < 0$$

* if pressure increases the reaction shift to forward direction.
* if pressure decreases the reaction shift to backward direction.

$$A \rightleftharpoons B + C \quad \Delta n_g > 0$$

* if pressure increases the reaction shift to backward direction.
* if pressure decreases the reaction shift to forward direction.

* Effect of volume :- $A + B \rightleftharpoons C \quad \Delta n_g < 0$

* if volume increases the reaction shift to backward direction.
* if volume decreases the Reaction shift to forward direction

$$A \rightleftharpoons B + C \quad \Delta n_g > 0$$

* if volume increases The Reaction shift to fordward direction
* if volume decreases The Reaction shift to backward direction.

* Effect of addⁿ of Inert gas:-

01. at constant volume :- no change in equilibrium.

02. at constant pressure :- $A \rightleftharpoons B + C \quad \Delta n_g > 0$

* The Reaction shift to forward direction.

$A + B \rightleftharpoons C \quad \Delta n_g < 0$

* The Reaction shift to backward direction.

* Effect of Catalyst :-

$$A \rightleftharpoons B$$

* Catalyst doesnot disturb equilibrium it alters Activation Energy

* Effect of Temp:- $T_1 = K_1$ $T_2 = K_2$ $R \rightleftharpoons P$

$$\log \frac{K_2}{K_1} = \frac{\Delta H}{2.303R} \left\{ \frac{1}{T_1} - \frac{1}{T_2} \right\}.$$

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

$$K_{c_1} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$2N_2 + 6H_2 \longrightarrow 4NH_3$$

$$K_{c_2} = \frac{[NH_3]^4}{[N_2]^2[H_2]^6}$$

$$K_{c_2} = (K_{c_1})^2$$

0.5 mole

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

* Relation b/w Gibbs Energy & equilibrium:-

$$\Delta G = \Delta G^\circ + 2.303\ RT \log Q$$

$\Delta G = 0$ at equilibrium $Q = K$

$$\Delta G^\circ = -2.303\ RT \log K$$

$\Delta G^\circ = -ve \Rightarrow$ Spontaneous

$\Delta G^\circ = +ve \Rightarrow$ Non-Spontaneous

Question

Which of the following statements is/are true about equilibrium?

(a) Equilibrium is possible only in a closed system of at a given temperature

(b) All the measurable properties of the system remain constant at equilibrium

(c) Equilibrium constant for the reverse reaction is the inverse of the equilibrium constant for the reaction in the forward direction. (KCET 2025)

A. Only b

B. Only c

C. a, b, and c

D. Only a

Question

According to Le Chatelier's principle, in the reaction $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$, the formation of methane is favoured by

(a) Increasing the concentration of **CO**

(b) Increasing the concentration of H_2O

(c) Decreasing the concentration of CH_4

(d) Decreasing the concentration of H_2.

(KCET 2025)

A. a and c

B. b and d

C. a and d

D. a and b

Question

The equilibrium constant at 298K for the 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 $\text{mol}L^{-1}$) will be (KCET 2025)

(A) 0.182

(B) 1.818 ✓

(C) 1.182

(D) 0.818

$$A + B \rightleftharpoons C + D$$

Initial: $1 \quad 1 \quad 1 \quad 1$

Eq: $1-x \quad 1-x \quad 1+x \quad 1+x$

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

$$\frac{1+x}{1-x} = 10$$

$$\Rightarrow 1+x = 10-10x$$

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

$$D = 1+x = 1+\frac{9}{11} = \frac{11+9}{11} = \frac{20}{11}$$

Question

At 500 K, for a reversible reaction $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$ in a closed container, $K_C = 2 \times 10^{-5}$. In the presence of catalyst, the equilibrium is attaining 10 times faster. The equilibrium constant K_C in the presence of catalyst at the same temperature is

(KCET 2023)

A. 2×10^{-4}

B. 2×10^{-6}

C. 2×10^{-10}

D. 2×10^{-5}

Question

1 mole of HI is heated in a closed container of capacity of 2L. At equilibrium half a mole of HI is dissociated. The equilibrium constant of the reaction is (KCET 2022)

(A) 0.5

(B) 0.25

(C) 0.35

(D) 1

$$2HI \rightleftharpoons H_2 + I_2$$

$t=0$: 1, 0, 0

$t=eq$: 0.5, 0.25, 0.25

$$K_c = \frac{\left(\frac{0.25}{2}\right)\left(\frac{0.25}{2}\right)}{\left(\frac{0.5}{2}\right)^2} = \frac{(0.25)^2}{(0.5)^2} = \frac{\frac{1}{16}}{\frac{1}{4}} = \frac{1}{4} = 0.25$$

Question

For the reaction,

$A(g) + B(g) \rightleftharpoons C(g) + D(g); \Delta H = Q$ kJ

The equilibrium constant cannot be disturbed by (KCET 2021)

$\Delta n_g = 0$

(A) Addition of A

(B) Addition of D

(C) Increasing of pressure

(D) Increasing of temperature

Question

The relationship between K_p and K_c is $K_p = K_c(RT)^{\Delta n}$. What would be the value of Δn for the reaction $NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$? (KCET 2018)

$\Delta n = P - R$
$= 2 - 0$
$= 2$

A. 1

B. 0.5

C. 1.5

D. 2

$\Delta n_g = n_p - n_R$.

Question

The reaction quotient 'Q' is useful inpredicting the direction of the reaction. Which of the following is incorrect? (KCET 2017)

A If $Q_c < K_c$, the forward reaction is favoured

B If $Q_c > K_c$, the reverse reaction is favoured

C If $Q_c > K_c$, the forward reaction is favoured

D If $Q_c = K_c$, no reaction occur

Question

The equilibrium constant for the reaction $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ is 4×10^{-4} at 2000 K. In presence of a catalyst the equilibrium is attained ten times faster. Therefore the equilibrium constant in presence of catalyst 2000 K is (KCET 2017)

(A) 4×10^{-3}

(B) 4×10^{-2}

(C) 40×10^{-4}

(D) 4×10^{-4}

Summary

Theory + PYQ

Homework

DPP + Examplar problem

Thank You