

Topic 7 Equilibrium (SL)

Syllabus:

7.1 Equilibrium

A state of equilibrium is reached in a closed system when the rates of the forward and backward reactions are equal.

The equilibrium law describes how the equilibrium constant (K_c) can be determined for a particular chemical reaction.

The magnitude of the equilibrium constant indicates the extent of a reaction at equilibrium and its temperature dependent.

Calculate the reaction quotient (Q) which is the equilibrium expression with non-equilibrium concentrations.

- Equilibrium is reached when the rates of the forward and backward reactions are equal for a reversible reaction in a closed system.
- Characteristics of equilibrium
 1. It is for reversible reaction only.
 2. It occurs in a closed system.
 3. Dynamic equilibrium: forward reaction rate = backward reaction rate
 4. The concentrations of reactants and products are constant.
 5. Reactants keep reacting to attain product side and products keep reacting to attain reactant side.
- **Physical system**

Physical system is the system involving physical change, like phase change.

$$\text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{H}_2\text{O}(\text{g})$$
$$\text{NaCl}(\text{s}) \rightleftharpoons \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$$
- **Chemical system**

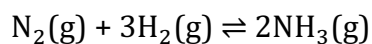
Chemical system is the system involving chemical change.

$$2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$$

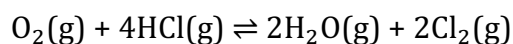
➤ **Equilibrium Law**

➤ The law of chemical equilibrium states that at a given temperature the ratio of the concentration of products to the concentration of reactants is a constant, which is called equilibrium constant (**K_c**).

➤ For example,



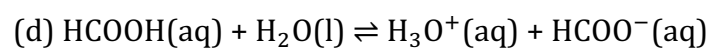
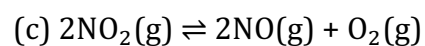
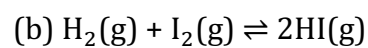
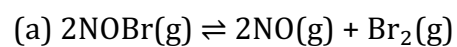
$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \quad \text{Unit: } \frac{(\text{mol dm}^{-3})^2}{(\text{mol dm}^{-3})(\text{mol dm}^{-3})^3} = \frac{1}{(\text{mol dm}^{-3})^2} = \text{mol}^{-2} \text{ dm}^6$$



$$K_c = \frac{[\text{H}_2\text{O}]^2[\text{Cl}_2]^2}{[\text{O}_2][\text{HCl}]^4} \quad \text{Unit: } \frac{(\text{mol dm}^{-3})^2(\text{mol dm}^{-3})^2}{(\text{mol dm}^{-3})(\text{mol dm}^{-3})^4} = \frac{1}{\text{mol dm}^{-3}} = \text{mol}^{-1} \text{ dm}^3$$

Exercise

1. Write the the equilibrium constant expression, K_c , for the following reaction and state the unit.

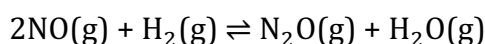


MCQ

- Which statement about chemical equilibrium implies they are dynamic?
 - The position of equilibrium constantly changes.
 - The rates of forward and backward reactions change.
 - The reactants and products continue to react.
 - The concentrations of the reactants and products continue to change.

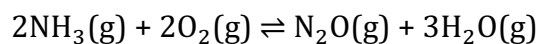
- Which are characteristics of a dynamic equilibrium?
 - Amounts of products and reactants are constant.
 - Amounts of products and reactants are equal.
 - The rate of the forward reaction is equal to the rate of the backward reaction.
 - I and II only
 - I and III only
 - II and III only
 - I, II and III

- What is the equilibrium constant expression, K_c , for this reaction?



- $K_c = \frac{[\text{N}_2\text{O}] + [\text{H}_2\text{O}]}{2[\text{NO}] + [\text{H}_2]}$
- $K_c = \frac{[\text{NO}]^2[\text{H}_2]}{[\text{N}_2\text{O}][\text{H}_2\text{O}]}$
- $K_c = \frac{2[\text{NO}] + [\text{H}_2]}{[\text{N}_2\text{O}] + [\text{H}_2\text{O}]}$
- $K_c = \frac{[\text{N}_2\text{O}][\text{H}_2\text{O}]}{[\text{NO}]^2[\text{H}_2]}$

4. What is the equilibrium constant expression, K_c , for the following reaction?



A. $\frac{3[\text{H}_2\text{O}][\text{N}_2\text{O}]}{2[\text{NH}_3]2[\text{O}_2]}$

B. $\frac{[\text{NH}_3]^2[\text{O}_2]^2}{[\text{N}_2\text{O}][\text{H}_2\text{O}]^3}$

C. $\frac{2[\text{NH}_3]2[\text{O}_2]}{3[\text{H}_2\text{O}][\text{N}_2\text{O}]}$

D. $\frac{[\text{N}_2\text{O}][\text{H}_2\text{O}]^3}{[\text{NH}_3]^2[\text{O}_2]^2}$