Class: 10th

Subject: Chemistry

Chapter 9: Chemical Equilibrium

Important MCQs:

1. Which statement best describes a reversible reaction?

(a) It occurs only in one direction

(b) It goes to completion

(c) Products do not convert back into reactants

(d) Products recombine to form reactants ✅

2. What happens at dynamic equilibrium?

(a) Only the forward reaction continues

(b) Only products are present

(c) Forward and reverse reactions occur at equal rate ✅

(d) Reaction stops completely

3. What does the equilibrium constant (K) represent?

(a) Speed of the reaction

(b) Ratio of product concentrations to reactant concentrations ✅

(c) Amount of catalyst

(d) Temperature of reaction

4. When does the equilibrium constant (K) have no units?

(a) When reaction is irreversible

(b) When moles of reactants and products are equal ✅

(c) When pressure is constant

(d) When a catalyst is used

5. A large value of equilibrium constant indicates:

(a) Reaction does not proceed

(b) Reaction goes almost to completion ✅

(c) No products are formed

(d) Only reverse reaction occurs

6. What does a small value of K mean for a reaction?

(a) Reaction is very fast

(b) Products dominate

(c) Very little product is formed ✅

(d) Reaction goes to completion

7. What can be predicted using the equilibrium constant?

(a) Catalyst efficiency

(b) Extent of reaction ✅

(c) Activation energy

(d) Reaction temperature

8. In a reaction with moderate value of K, the equilibrium mixture contains:

(a) Mostly reactants

(b) Mostly products

(c) Comparable amounts of reactants and products ✅

(d) Only intermediates

9. Which of the following symbols is used to represent a reversible reaction?

(a) →

(b) ↑

(c) ⇌ ✅

(d) ↓

10. In a reversible reaction, the products:

(a) Remain unchanged

(b) Escape into surroundings

(c) React again to form reactants ✅

(d) Form new elements

11. What is the colour of iodine vapours in the forward reaction?

(a) Colourless

(b) Purple ✅

(c) Yellow

(d) Blue

12. The reaction $H_2 + I_2 \rightleftharpoons 2HI$ is an example of:

(a) Irreversible reaction

(b) Static equilibrium

(c) Reversible reaction ✅

(d) Neutralization

13. At dynamic equilibrium rate of forward reaction is:

(a) Greater than reverse

(b) Less than reverse

(c) Equal to reverse ✅

(d) Zero

14. Which of the following is an example of an irreversible reaction?

(a) $CaCO_3 \rightleftharpoons CaO + CO_2$

(b) $H_2 + I_2 \rightleftharpoons 2HI$

(c) $2H_2 + O_2 \Rightarrow 2H_2O$ ✅

(d) $CO_2 + H_2O \rightleftharpoons H_2CO_3$

15. A forward reaction is a reaction in which:

(a) Products change into reactants

(b) Reactants form products ✅

(c) No change occurs

(d) Reactants evaporate

16. The reaction $CaCO_3 \rightleftharpoons CaO + CO_2$ in a closed flask represents:

(a) Static equilibrium

(b) Dynamic equilibrium ✅

(c) Open system

(d) Irreversible reaction

17. Dynamic equilibrium can only occur in:

(a) Open system

(b) Closed system ✅

(c) Half-filled flask

(d) Moving container

18. At the beginning of a reversible reaction, the

rate of forward reaction is:

(a) Very slow

(b) Zero

(c) Very fast ✅

(d) Equal to reverse

19. What remains constant at equilibrium?

(a) Reaction temperature

(b) Colour of reactants

(c) Concentration of all substances ✅

(d) Pressure only

20. The term "dynamic" in dynamic equilibrium means:

(a) Reaction is stopped

(b) Reaction is reversible

(c) Reaction continues in both directions ✅

(d) Energy is consumed

21. What happens to the reverse reaction as equilibrium is approached?

(a) It remains constant

(b) It slows down

(c) It increases gradually ✅

(d) It becomes zero

22. In static equilibrium, the chemical reaction:

(a) Continues slowly

(b) Proceeds forward

(c) Stops completely ✅

(d) Speeds up

23. Which of the following is not a characteristic of dynamic equilibrium?

(a) Reaction continues in both directions

(b) Occurs in a closed system

(c) Concentrations remain constant

(d) Reaction stops completely ✅

24. The Law of Mass Action was proposed by:

(a) Dalton and Rutherford

(b) Guldberg and Waage ✅

(c) Boyle and Charles

(d) Avogadro and Lavoisier

25. According to the Law of Mass Action, the rate of a reaction is directly proportional to:

(a) Volume of the flask

(b) Temperature only

(c) Product of active masses of reactants ✅

(d) Weight of products

26. Active mass is generally expressed as:

(a) Mole fraction

(b) Atomic number

(c) Molar concentration ✅

(d) Molecular mass

27. What is the unit of active mass?

(a) mol

(b) mol^{-1}

(c) $mol\ dm^{-3}$ ✅

(d) $g\ cm^{-3}$

28. The equilibrium constant (K_a) is defined as:

(a) Ratio of temperature to pressure

(b) Ratio of reactants to products

(c) Ratio of products to reactants ✅

(d) Sum of all concentrations

29. In the equilibrium expression, concentrations are raised to the power of:

(a) Atomic number

(b) Molar mass

(c) Coefficients from balanced equation ✅

(d) Volume in liters

30. What does the subscript 'c' in Kc stand for?

(a) Calorimeter

(b) Celsius

(c) Concentration ✅

(d) Catalyst

31. The units of Kc will be absent when:

(a) Temperature is zero

(b) Catalyst is used

(c) Number of moles on both sides are equal ✅

(d) Reaction is irreversible

32. What is the unit of concentration in Kc expression?

(a) mol g^{-1}

(b) mol dm^{-3} ✅

(c) g cm^{-3}

(d) mol s^{-1}

33. The numerical value of equilibrium constant Kc depends on:

(a) Volume

(b) Pressure

(c) Temperature ✅

(d) Initial concentration

34. If Qc < Kc, the reaction will proceed:

(a) In reverse direction

(b) Stop

(c) In forward direction ✅

(d) At constant rate

35. Qc is known as:

(a) Quick constant

(b) Quasi concentration

(c) Reaction quotient ✅

(d) Quality control

36. If Qc > Kc, then the reaction:

(a) Is at equilibrium

(b) Moves in reverse direction ✅

(c) Moves forward

(d) Stops completely

37. A large value of K indicates:

(a) No reaction

(b) Reaction is incomplete

(c) Reaction goes almost to completion ✅

(d) No products formed

38. A very small value of K means:

(a) Products dominate

(b) Reactants dominate ✅

(c) Equal quantities

(d) Temperature is high

39. If K has a moderate value, it shows:

(a) Only products are present

(b) Only reactants are present

(c) Comparable amounts of products and reactants ✅

(d) Reaction is stopped

40. The value of equilibrium constant for:

$2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$

at 1000 K is:

(a) 2.2×10^{-5}

(b) 3.0×10^{9}

(c) 2.2×10^{22} ✅

(d) 0.211

41. The value of K for the reaction:

$N_2O_4 \rightleftharpoons 2NO_2$ is 0.211. This means:

(a) Reaction goes to completion

(b) Reaction doesn't occur

(c) Reactants and products are almost equal ✅

(d) Reaction is irreversible

Exercise Short Questions:

1. What are irreversible reactions? Give a few characteristics of them?

Answer:

Irreversible reactions are those which proceed only in the forward direction and do not reverse to form reactants.

Characteristics:

- Products do not recombine to form reactants.
- Reaction goes to completion.
- Represented by a single arrow (⇒).

2. Define chemical equilibrium state.

Answer:

Chemical equilibrium is a state in a reversible reaction where the rate of the forward reaction equals the rate of the reverse reaction, and the concentrations of reactants and products remain constant.

3. Give the characteristics of reversible reaction.

Answer:

Reversible reactions:

- Occur in both forward and reverse directions.
- Do not go to completion.
- Reach a dynamic equilibrium.
- Represented by double arrows ($\rightleftharpoons$).

4. How is dynamic equilibrium established?

Answer:

Dynamic equilibrium is established when the rate of forward reaction becomes equal to the rate of reverse reaction, and both continue to occur simultaneously without any change in

concentrations of reactants and products.

5. Why at equilibrium state reaction does not stop?

Answer:

Because both forward and reverse reactions continue to occur at the same rate, the reaction does not stop—it appears static but is actually dynamic.

6. Why is equilibrium state attainable from either way?

Answer:

A reversible reaction can reach the same equilibrium state whether it starts from reactants or products, because both directions lead to the same balance of concentrations.

7. What is relationship between active mass and rate of reaction?

Answer:

According to the Law of Mass Action, the rate of a reaction is directly proportional to the active mass (concentration) of the reactants. Higher active

mass = faster rate.

8. Derive equilibrium constant expression for the synthesis of ammonia from nitrogen and hydrogen.

For the reaction:

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

The equilibrium constant expression is:

$Kc = [NH_3]^2 / ([N_2][H_2]^3)$

9. Write the equilibrium constant expression for the following reactions:

Answer:

i. $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

✅ $Kc = [HI]^2 / ([H_2] \times [I_2])$

ii. $CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$

✅ $Kc = ([CH_4] \times [H_2O]) / ([CO] \times [H_2]^3)$

10. How direction of a reaction can be predicted?

Answer:

The direction of a chemical reaction can be predicted by comparing the reaction quotient (Qc) with the equilibrium constant (Kc):

- If Qc < Kc ⇒ reaction proceeds forward.
- If Qc > Kc ⇒ reaction proceeds in reverse.
- If Qc = Kc ⇒ reaction is at equilibrium.

11. How can you know that a reaction has achieved an equilibrium state?

Answer:

- A reaction is said to be in equilibrium when:
- The concentrations of reactants and products remain constant over time.
- The rate of forward and reverse reactions becomes equal.
- There is no observable change in the system.

12. What are the characteristics of a reaction that establishes equilibrium state at once?

Answer:

Characteristics of such reactions:

- Both forward and reverse reactions are fast.
- Equilibrium is established quickly.

- Concentrations of reactants and products become constant in a short time.
- Such reactions are usually gaseous or in solution phase.

13. If reaction quotient Qc of a reaction is more than Kc, what will be the direction of the reaction?

Answer:

If Qc > Kc, it means there are more products than needed at equilibrium.

👉 Therefore, the reaction will proceed in the reverse direction to form more reactants until equilibrium is achieved.

14. An industry was established based upon a reversible reaction. It failed to achieve products on commercial level. Can you point out the basic reasons of its failure being a chemist?

Possible reasons for failure:

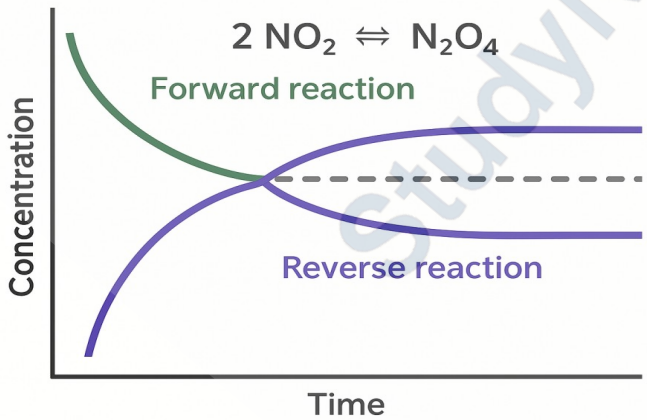
- Low value of equilibrium constant, so little product is formed.
- Improper temperature or pressure conditions

not favorable for product formation.

- Failure to remove products from system, causing reverse reaction.
- Lack of effective catalyst.
- Insufficient time given for the reaction to reach equilibrium.
- Poor design of industrial process ignoring equilibrium conditions.

Exercise Long Questions:

🌟 **Q1: Describe a reversible reaction with the help of an example and graph.**



Answer:

Reversible reaction is a chemical reaction in which the products can react again to form the original reactants. These reactions do not go to completion and reach a dynamic equilibrium where the forward and reverse reactions occur at equal rates.

❖ Definition:

A reversible reaction is a chemical reaction that can proceed in both forward and reverse directions under the same conditions.

- **General form:**

$A + B \rightleftharpoons C + D$

- **Example:**

Formation of ammonia gas from nitrogen and **hydrogen is a classic example:**

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

In the forward direction: ammonia is formed.

In the reverse direction: ammonia breaks back into nitrogen and hydrogen gases.

🌟 **Q2: Write down the macroscopic characteristics of dynamic equilibrium.**

❖ **Definition:**

Dynamic equilibrium is the condition in a reversible reaction where both forward and reverse reactions continue to occur at the same rate, resulting in no observable change in the system.

🔹 **Macroscopic Characteristics:**

1. Constant Concentrations:

- The concentrations of reactants and products remain unchanged over time.
- They are not necessarily equal but stay constant.

2. Equal Rates:

- The rate of forward reaction equals the rate of reverse reaction.

3. No Observable Change:

- The system appears static, but both reactions are still happening at the molecular level.

4. Closed System Required:

- Dynamic equilibrium occurs only in a closed system (no matter enters or leaves).

5. Can be Reached from Either Side:

- Whether the reaction starts with reactants or products, the system reaches the same equilibrium state.

6. Temperature & Pressure Influence:

- Changes in temperature or pressure can shift the position of equilibrium, but equilibrium can still be re-established.

🌟 Q3: State the Law of Mass Action and derive the expression for equilibrium constant for a general reaction.

$$aA + bBB \rightleftharpoons cC + dD$$

$$[A] \xrightarrow[R_1]{R_2} [B] \qquad c\,[C] \xrightarrow{R_2} [D]$$

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

Law of Mass Action:

The Law of Mass Action states that:

"The rate of a chemical reaction is directly proportional to the product of the molar concentrations of the reacting substances, each raised to the power equal to their respective coefficients in the balanced chemical equation."

General Reaction:

Consider the reversible reaction:

$aA + bB \rightleftharpoons cC + dD$

A and B = Reactants

C and D = Products

a, b, c, d = Stoichiometric coefficients

According to Law of Mass Action:

✅ Rate of Forward Reaction:

$Rf \propto [A]^a \times [B]^b$

$\Rightarrow Rf = kf \times [A]^a \times [B]^b$

Where kf = rate constant of forward reaction

✅ Rate of Reverse Reaction:

Rr ∝ [C]^c × [D]^d

⇒ Rr = kr × [C]^c × [D]^d

Where kr = rate constant of reverse reaction

🔹 At Equilibrium:

At dynamic equilibrium:
Rf = Rr
So,
kf × [A]^a × [B]^b = kr × [C]^c × [D]^d

Divide both sides by kr × [A]^a × [B]^b:

$$\frac{[C]^c \tilde{A}‖[D]^d}{[A]^a \tilde{A}‖[B]^b} = \frac{kf}{kr}$$

Let:

$$K_c = \frac{kf}{kr}$$

Then:

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

✅ Equilibrium Constant Expression:

For a general reversible reaction:

aA + bB ⇌ cC + dD

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

🌟**Q4: What is the importance of equilibrium constant?**

Answer:

Equilibrium constant (Kc) is very important in chemistry because it helps us understand and predict the extent of a chemical reaction, and how changes in conditions affect the equilibrium.

🔹 **Importance of Equilibrium Constant (Kc):**

1. Extent of Reaction:

- A large Kc (Kc >> 1) means more products are formed ⇒ reaction nearly goes to completion.
- A small Kc (Kc << 1) means reactants are favored ⇒ very little product is formed.

2. Predicts Direction of Reaction:

- By comparing Qc (reaction quotient) with Kc,

we can tell whether the reaction will go forward or backward to reach equilibrium.

3. Industrial Use:

- In industries like Haber Process, Kc helps in deciding optimal conditions (pressure, temperature) to maximize product yield.

4. Designing Chemical Reactions:

- Chemists use Kc to manipulate conditions for better efficiency in labs and factories.

5. Understanding Dynamic Equilibrium:

- It confirms that concentrations remain constant at equilibrium but reactions are still happening.

6. Helps in Calculations:

- We can use Kc to calculate unknown concentrations of reactants/products at equilibrium.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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