Class: 9th

Subject: Chemistry

Chapter 6: Equilibria

Exercise MCQs:

1. What will happen if the rates of forward and reverse reactions are very high?

(a) The equilibrium point will reach very late.

(b) The equilibrium point will reach very soon. ✅

(c) The reaction will not attain the state of dynamic equilibrium.

(d) The reaction will be practically irreversible.

2. Predict which components of the atmosphere react in the presence of lightning.

(a) N_2 and H_2O

(b) O_2 and H_2O

(c) CO_2 and O_2

(d) N_2 and O_2 ✅

3. An inorganic chemist places one mole of PCl_5 in container A and one mole each of Cl_2 and PCl_3 in container B. Both containers are sealed and heated. What will be the composition at equilibrium?

(a) Both the containers will have the same composition of mixtures. ✅

(b) Container A will have more concentration of PCl_5 than B.

(c) Container A will have less concentration of PCl_5 than B.

(d) Both containers will have zero concentration of reactants.

4. CaO or lime is used extensively in steel, glass, and paper industries. It is produced by the decomposition of calcium carbonate ($CaCO_3$) in an endothermic reversible reaction. Choose the condition to produce the maximum amount of lime (CaO).

(a) Heating at high temperature in a closed vessel

(b) Heating at high temperature in an open vessel ✅

(c) Cooling it in a closed vessel

(d) Cooling it in an open vessel

5. What condition must be met for a reversible reaction to reach equilibrium?

(a) All the reactants should be converted into products.

(b) 50% of the reactants should be converted into products.

(c) The concentrations of all the reactants and the products should become constant. ✅

(d) One of the products should be removed from the reaction mixture.

6. Why does gas come out when a fizzy drink can is opened?

(a) Because the solubility of the gas increases

(b) Because the gas is insoluble in water

(c) Because the gas is dissolved under pressure

hence it comes out when pressure is decreased ✅

(d) Because the solubility of the gas decreases at high pressure

7. The following reaction is in equilibrium: $CaCO_3 \rightleftharpoons CaO + CO_2$. What happens if pressure is increased?

(a) The forward reaction will be favoured

(b) The backward reaction will be favoured ✅

(c) No effect on backward reaction

(d) No effect on forward or backward reaction

8. When a reaction will become a reversible one?

(a) If the activation energy of the forward reaction is comparable to that of backward reaction ✅

(b) If the activation energy of the forward reaction is higher than that of backward reaction

(c) If the activation energy of the forward reaction is lower than that of backward reaction

(d) If the enthalpy change of both the reactions is zero

9. Is reversible reactions useful for preparing compounds on large scale?

(a) No

(b) Yes

(c) They are useful only when equilibrium lies far to the right side ✅

(d) They are useful only when equilibrium lies far to the left side

10. What will happens to the concentration of the products if a reversible reaction at equilibrium is not disturbed?

(a) They will remain constant ✅

(b) They will keep on increasing

(c) They will keep on decreasing

(d) They will remain constant for some time and then start decreasing

Important MCQs:

1. Which reaction proceeds only in the forward direction and goes to completion?

(a) Reversible reaction

(b) Catalytic reaction

(c) Irreversible reaction ✅

(d) Physical change

2. Which of the following is a reversible reaction?

(a) $NaCl + AgNO_3 \Rightarrow AgCl + NaNO_3$

(b) $H_2 + Cl_2 \Rightarrow 2HCl$

(c) $CuSO_4 \cdot 5H_2O \rightleftharpoons CuSO_4 + 5H_2O$ ✅

(d) Burning of coal

3. What is the correct symbol used to represent a reversible reaction?

(a) $\Rightarrow$

(b) $\rightleftharpoons$ ✅

(c) =

4. In which condition does $CaCO_3 \Rightarrow CaO + CO_2$ become irreversible?

(a) In a closed container

(b) When CO_2 is added

(c) In an open container ✅

(d) At low temperature

5. What is the color of hydrated copper sulfate?

(a) White

(b) Pink

(c) Blue ✅

(d) Purple

6. What happens when anhydrous copper sulfate absorbs moisture?

(a) It turns pink

(b) It remains white

(c) It turns blue ✅

(d) It decomposes

7. Which color change is observed when cobalt chloride hexahydrate is heated?

(a) Blue to pink

(b) Pink to blue ✅

(c) White to green

(d) Purple to pink

8. What is formed first when anhydrous cobalt chloride absorbs less moisture?

(a) Monohydrate

(b) Hexahydrate

(c) Dihydrate ✅

(d) Tetrahydrate

9. What is the physical state of products in the reaction: $CaCO_3 \Rightarrow CaO + CO_2$?

(a) Solid and gas ✅

(b) Liquid and gas

(c) Solid and solid

(d) Gas and gas

10. In a reversible reaction, the reactants and products:

(a) Completely convert into one another

(b) Remain in equilibrium ✅

(c) Disappear fully

(d) Explode instantly

11. What is the condition for a chemical reaction to attain dynamic equilibrium?

(a) Products must be completely removed

(b) Rate of forward reaction equals rate of backward reaction ✅

(c) Reaction must stop

(d) Only products are present

12. What remains constant at the state of dynamic equilibrium?

(a) Reaction temperature

(b) Reaction pressure

(c) Concentrations of reactants and products ✅

(d) Rate of forward reaction only

13. Why is the equilibrium state called "dynamic"?

(a) Reactions stop at equilibrium

(b) Reactants disappear permanently

(c) Both forward and backward reactions continue ✅

(d) Only backward reaction occurs

14. Which factor does not affect dynamic equilibrium?

(a) Addition of catalyst

(b) Nature of reaction

(c) External magnetic field ✅

(d) Temperature of the system

15. What will happen if more nitrogen gas is added to a reaction at equilibrium:

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

(a) Reaction shifts backward

(b) Reaction remains unchanged

(c) Reaction shifts forward ✅

(d) Reaction stops

16. What happens when some ammonia is withdrawn from the equilibrium mixture of nitrogen and hydrogen?

(a) Backward reaction increases

(b) Forward reaction increases ✅

(c) Equilibrium is unaffected

(d) Reaction stops completely

17. What is the effect of increasing temperature on the exothermic reaction:

$N_2 + 3H_2 \rightleftharpoons 2NH_3$ ΔH = -92.4 kJ/mol?

(a) Shifts to product side

(b) Shifts to reactant side ✅

(c) No effect

(d) Reaction stops

18. What will be the effect of decreasing temperature on the formation of ammonia?

(a) Shifts equilibrium backward

(b) Shifts equilibrium forward ✅

(c) Slows down the reaction permanently

(d) Converts all ammonia to nitrogen

19. How can equilibrium be reached faster in the formation of ammonia?

(a) Increase pressure only

(b) Use excess hydrogen

(c) Add a catalyst ✅

(d) Remove all ammonia continuously

20. How long does it take for the reaction $2H_2O \rightleftharpoons 2H_2 + O_2$ to reach equilibrium?

(a) Several days

(b) 4–5 minutes

(c) 4–5 seconds ✅

(d) Instantaneously

21. What will happen to the equilibrium position of the reaction

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

if the pressure is increased?

(a) It will shift in backward direction

(b) It will shift in forward direction ✅

(c) It will not change

(d) Reaction will stop

22. Pressure affects the equilibrium of which type of reactions?

(a) Only exothermic reactions

(b) Reactions in solution only

(c) Gaseous reactions with unequal number of moles of reactants and products ✅

(d) Reactions with solid reactants

23. What is the role of a catalyst in a reversible reaction?

(a) Increases forward reaction only

(b) Increases backward reaction only

(c) Increases both forward and backward reactions

✅

(d) Changes the position of equilibrium

24. In the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, what happens if pressure is increased?

(a) Equilibrium shifts towards products

(b) Equilibrium remains unchanged

(c) Equilibrium shifts towards reactants ✅

(d) Reaction stops

25. In the reaction $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$, what will be the effect of increasing temperature (endothermic reaction)?

(a) Equilibrium shifts towards products ✅

(b) Equilibrium shifts towards reactants

(c) No effect

(d) Reaction becomes irreversible

Exercise Short Questions:

i. How is dynamic equilibrium different from static equilibrium?

- **Dynamic equilibrium** occurs when the forward and reverse reactions happen at the same rate, so the concentrations of reactants and products remain constant over time, but reactions continue to occur.
- **Static equilibrium** means no movement or reaction occurs; the system is completely at rest.

ii. How will the following reversible reaction be affected if its temperature is increased?

$2H_2O\ (l) \rightleftharpoons \text{Electricity}\ 2H_2(g) + O_2(g)$

This reaction is endothermic (requires energy input). Increasing temperature will shift the equilibrium towards the products (H_2 and O_2 gases), favoring the forward reaction and producing more gases.

iii. How can you get the maximum yield in a reversible reaction?

By changing reaction conditions (temperature, pressure, concentration) to favor the formation of products according to Le Chatelier's Principle. For example, lowering temperature for exothermic reactions or increasing pressure if fewer gas molecules are produced.

iv. How can you decrease the time to attain the position of equilibrium in a reversible reaction?

By adding a catalyst, which speeds up both forward and backward reactions without changing the equilibrium position, helping the system reach equilibrium faster.

v. What is the effect of increasing pressure on the following reaction at equilibrium?

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

Since 1 mole of reactants produces 2 moles of product gases, increasing pressure will shift the equilibrium towards the side with fewer moles to reduce pressure. Here, reactants side has fewer moles (2 moles) compared to products (2 moles), so increasing pressure has little or no effect on this

equilibrium.

Important Short Questions:

1. What is meant by an irreversible reaction? Give one example.

Answer:

An irreversible reaction is a chemical reaction that goes to completion and does not reverse back to form reactants. It proceeds only in the forward direction.

Example:

$NaCl(aq) + AgNO_3(aq) \Rightarrow AgCl(s) + NaNO_3(aq)$

2. Define a reversible reaction. Also give its symbol and one example.

Answer:

A reversible reaction is a chemical reaction in which the products can react to form the original reactants under the same conditions. It proceeds in both forward and backward directions.

Symbol: ⇌

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

3. Why does the decomposition of $CaCO_3$ go to completion in an open vessel?

Answer:

In an open vessel, the CO_2 gas produced escapes into the atmosphere. As a result, the backward reaction does not occur, and the reaction goes to completion.

Equation: $CaCO_3(s) \Rightarrow CaO(s) + CO_2(g)$

4. Write the chemical equation showing the reversible physical change of copper sulfate on heating and cooling.

Answer:

$CuSO_4 \cdot 5H_2O$ (blue) ⇌ $CuSO_4$ (white) + $5H_2O(g)$

When hydrated copper sulfate is heated, it becomes white (anhydrous), and when exposed to moisture again, it turns blue.

5. What happens when hydrated cobalt chloride is

heated and then exposed to moisture?

Answer:

When $CoCl_2 \cdot 6H_2O$ (pink) is heated, it loses water and becomes blue (anhydrous $CoCl_2$). When exposed to moisture, it first becomes purple (dihydrate) and then pink (hexahydrate) again.

Equation:

$$CoCl_2 \cdot 6H_2O \rightleftharpoons CoCl_2 + 6H_2O$$

6. What is dynamic equilibrium?

Dynamic equilibrium is a state in a reversible reaction where the forward and backward reactions occur at the same rate, so the concentrations of reactants and products remain constant.

7. What is the difference between reversible and irreversible reactions?

Reversible reactions proceed in both forward and backward directions, while irreversible reactions go only in the forward direction until reactants are fully converted to products.

8. Why do concentrations remain constant at equilibrium?

Because the rate of the forward reaction equals the rate of the backward reaction, resulting in no net change in concentrations.

9. Give an example of a reversible physical change.

Heating hydrated copper sulphate (blue) turns it into anhydrous copper sulphate (white), which reverts back to blue when it absorbs water.

10. How is equilibrium achieved in the synthesis of ammonia?

At high temperature and pressure with a catalyst, ammonia forms and decomposes simultaneously until their rates are equal, reaching equilibrium.

11. What happens when more reactant gas is added to a reversible reaction at equilibrium?

When more reactant gas is added, its concentration increases and disturbs the equilibrium. To restore equilibrium, the reaction shifts forward to produce more products until a new equilibrium is

established.

12. How does removing some product affect the equilibrium state?

Removing some product decreases its concentration, disturbing the equilibrium. The reaction shifts forward to produce more product and restore equilibrium at a new concentration level.

13. Explain the effect of increasing temperature on an exothermic reversible reaction.

Increasing temperature adds heat to the system, which shifts the equilibrium towards the reactants (backward direction) to absorb the excess heat, thus decreasing product formation.

14. When does changing pressure affect the equilibrium of a gaseous reaction?

Pressure changes affect equilibrium only if the number of moles of gaseous reactants differs from the number of moles of gaseous products. The reaction shifts toward the side with fewer gas moles when pressure increases.

15. How does a catalyst influence the rate and equilibrium of a reversible reaction?

A catalyst speeds up both forward and backward reactions equally, decreasing the time to reach equilibrium, but it does not change the position of the equilibrium.

Important Long Questions:

Q1: Differentiate between reversible and irreversible reactions with suitable examples.

(Explain with chemical equations like NaCl + $AgNO_3$ and $N_2 + 3H_2 \rightleftharpoons 2NH_3$)

Answer:

Chemical reactions are broadly categorized into irreversible and reversible reactions based on the direction in which they proceed and whether the products can be converted back into reactants.

1. Irreversible Reactions:

An irreversible reaction is a chemical reaction in which the reactants are completely converted into products, and the products do not react back to form the reactants under the same conditions. These reactions occur only in the forward direction and go to completion.

Example:

When aqueous solutions of sodium chloride (NaCl) and silver nitrate ($AgNO_3$) are mixed, they react to form a white precipitate of silver chloride (AgCl) and sodium nitrate ($NaNO_3$).

Chemical Equation:

$NaCl\ (aq) + AgNO_3\ (aq) \Rightarrow AgCl\ (s) + NaNO_3\ (aq)$

In this reaction, the silver chloride formed as a solid (precipitate) does not change back into the original reactants. Hence, it is an irreversible reaction.

2. Reversible Reactions:

A reversible reaction is a chemical reaction in which the products can react among themselves to reform the reactants under the same conditions.

These reactions occur in both forward and backward directions simultaneously. After some time, a state of dynamic equilibrium is achieved where the rate of the forward reaction becomes equal to the rate of the backward reaction.

Example:

When nitrogen gas (N_2) reacts with hydrogen gas (H_2) under high temperature and pressure in the presence of an iron catalyst, it forms ammonia (NH_3). The ammonia formed also decomposes back into nitrogen and hydrogen.

Chemical Equation:

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

(Conditions: 400°C, 200 atm, Iron catalyst)

In this reaction, both the reactants and products are present at all times, and the reaction continues in both directions, making it reversible.

Q2: Define dynamic equilibrium. How is it established in a reversible reaction?

(Explain with a suitable example like the decomposition of water or synthesis of ammonia.)

Answer:

Definition:

Dynamic equilibrium is a state in a reversible reaction where the rate of the forward reaction becomes equal to the rate of the backward (reverse) reaction.

Key Features:

- At dynamic equilibrium, both reactions continue to occur.
- However, there is no observable change in the concentration of reactants and products.
- The system appears static, but the reactions are continuously happening at the molecular level.
- How it is established:
- When a reversible reaction starts, initially only

the forward reaction takes place.

- As products are formed, they begin to react among themselves to form reactants again — this is the backward reaction.
- Eventually, both the forward and backward reactions balance out in terms of their rates.
- This balance is what creates a state of dynamic equilibrium.

Example: Synthesis of Ammonia (Haber Process)

- **Reaction**: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
- In a closed container, nitrogen and hydrogen gases react to form ammonia.
- As the ammonia concentration increases, it begins to decompose back into nitrogen and hydrogen.
- After a certain time, the rate at which ammonia is formed equals the rate at which it decomposes.
- This is when dynamic equilibrium is achieved.

Q3: Differentiate between static equilibrium and dynamic equilibrium.

Answer:

Static Equilibrium:

- It is a state where all changes have stopped, and no movement or reaction occurs anymore.
- There is no ongoing reaction in either direction.
- It usually applies to physical systems like a book lying on a table or a balanced beam, where forces are equal and nothing is moving.
- **Example**: A stationary object at rest on a surface — no forces are causing motion.

Dynamic Equilibrium:

- It is a state in a reversible chemical reaction where both the forward and backward reactions are still occurring but at the same rate.
- Although the reaction continues, the concentrations of reactants and products remain constant.

- It gives the appearance that nothing is happening, but in reality, there is continuous molecular activity.
- **Example**:
- In the reaction: $2H_2O(l) \rightleftharpoons 2H_2(g) + O_2(g)$,
- if carried out in a closed system with electric current, water decomposes into hydrogen and oxygen gases, and these gases recombine to form water.
- Over time, both reactions occur at equal rates — this is dynamic equilibrium.

3. Constructed Response Questions:

i. Why are some reactions irreversible while others are reversible?

- In irreversible reactions, products do not easily convert back into reactants.

- These reactions often go to completion, using up all reactants.
- In reversible reactions, both forward and backward reactions occur.
- Dynamic equilibrium can be established in reversible reactions.
- It depends on reaction conditions, energy changes, and product stability.

ii. Why are combustion reactions generally irreversible?

- Combustion reactions release large amounts of heat and light.
- Products like CO_2 and H_2O are stable and do not revert to reactants.

- The energy released is not easily reabsorbed to reverse the reaction.
- Oxygen and fuel cannot easily reform from the products.

iii. Can you make an irreversible reaction reversible and vice versa?

- Irreversible reactions usually cannot be made reversible due to product stability.
- Reversible reactions can be made irreversible by:
- Removing products from the system.
- Changing conditions (temperature, pressure).

- Some special setups (like electrolysis) can reverse certain reactions.

iv. How do you know if a reaction is reversible or irreversible?

- Reversible if it can proceed in both directions under same conditions.
- A dynamic equilibrium is formed where forward = backward rate.
- Irreversible if products do not revert to reactants.
- Look for energy release, product stability, and system closure.

v. Do the phase changes in water (solid to liquid, vapour) reversible or irreversible?

- Reversible, because:
- No chemical change, only physical change.
- Can freeze, melt, evaporate, or condense easily.
- Controlled by temperature and pressure changes.
- Water can return to any phase repeatedly without changing its chemical identity.

4. Descriptive Questions:

i. How can you drive the reversible reaction at equilibrium:

(a) In the forward direction

- Add more reactants to increase their concentration.
- Remove products as they are formed.
- Decrease temperature if the forward reaction is exothermic.
- Increase pressure if the forward reaction forms fewer gas molecules.

(b) In the backward direction

- Add more products to shift equilibrium backward.
- Remove reactants as they are formed.
- Increase temperature if the backward reaction is endothermic.

- Decrease pressure if the backward reaction forms more gas molecules.

ii. Explain how the rates of forward and backward reactions change when the system approaches equilibrium:

- Initially, forward reaction rate is high due to more reactants.
- As products form, the forward rate slows down.
- Backward reaction rate increases as product concentration increases.
- Eventually, both rates become equal — this is called dynamic equilibrium.
- At equilibrium, reactions still occur but net

concentrations remain constant.

iii. Describe the effect of a catalyst on the reversible reaction:

- A catalyst speeds up both forward and backward reactions equally.
- It reduces the time required to attain equilibrium.
- However, it does not affect the position of equilibrium.
- Catalyst simply helps in reaching equilibrium faster, without changing the amounts of products or reactants.

iv. How can a reversible reaction be forced to go to completion?

- Remove one of the products continuously, so the backward reaction cannot proceed.
- Use excess of reactants to shift the equilibrium far to the right.
- Change temperature or pressure to favor the forward direction completely.
- Use selective catalysts or absorbents that trap the product permanently.

v. How does change in temperature affect the reaction at equilibrium?

- If the forward reaction is exothermic, increasing temperature shifts equilibrium backward.
- If the forward reaction is endothermic,

increasing temperature shifts equilibrium forward.

- Lowering temperature favors the exothermic direction.
- So, temperature change can alter product yield and equilibrium position.

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.

Author: Muhammad Asghar

Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

Copyright & Usage Policy