Reversible Reactions and Equilibrium

GCSE Chemistry

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Reversible Reactions

In some chemical reactions, the products can react to form the original reactants.

Representation:

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

Key Point: The direction of reversible reactions can be changed

by altering the conditions (e.g., temperature or pressure).

Energy Changes in Reversible Reactions

Exothermic and Endothermic Reactions:

- If a reversible reaction is **exothermic** in one direction, it is **endothermic** in the opposite direction.
- The same amount of energy is transferred in both directions.

Example:

$$\mathrm{A} + \mathrm{B} \rightleftharpoons \mathrm{C} + \mathrm{D} \quad (\Delta H = \pm x\,\mathrm{kJ})$$

Endothermic and Exothermic Reactions

Endothermic Reactions:

- Absorb energy from the surroundings.
- Result in a temperature **decrease** in the surroundings.
- Example: Photosynthesis or dissolving ammonium nitrate in water.

Exothermic Reactions:

- Release energy to the surroundings.
- Result in a temperature **increase** in the surroundings.
- Example: Combustion or neutralisation reactions.

Key Point: In reversible reactions, if one direction is endothermic, the other is exothermic.

Equilibrium

Dynamic Equilibrium:

- Achieved in a **closed system** where no reactants or products can escape.
- At equilibrium, the forward and reverse reactions occur at the **same rate**.

Key Concept: At equilibrium, the concentrations of reactants and products remain constant, but the reactions continue to occur.

Le Chatelier's Principle

When a system at equilibrium is disturbed:

- The system responds to **counteract the change**.
- The equilibrium position shifts to minimise the disturbance.

Key Idea: The effects of changing conditions (e.g., concentration, temperature, pressure) can be predicted using **Le Chatelier's Principle**.

Effect of Changing Concentration (HT)

Key Points:

- Increasing the concentration of a reactant shifts the equilibrium towards the **products**.
- Decreasing the concentration of a product shifts the equilibrium towards the **reactants**.
- The system adjusts until equilibrium is restored.

Example:

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

Increasing **A** or **B** leads to more **C** and **D**.

Effect of Changing Temperature (HT)

Key Points:

- **For Endothermic Reactions:**
  - Increasing temperature shifts equilibrium towards the **products**.
  - Decreasing temperature shifts equilibrium towards the **reactants**.
- **For Exothermic Reactions:**
  - Increasing temperature shifts equilibrium towards the **reactants**.
  - Decreasing temperature shifts equilibrium towards the **products**.

Effect of Changing Pressure (HT)

For gaseous reactions at equilibrium:

- Increasing pressure shifts equilibrium towards the side with **fewer molecules**.
- Decreasing pressure shifts equilibrium towards the side with **more molecules**.

Example:

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

- Increasing pressure favours **ammonia (NH_3)** formation (fewer molecules).

Practice Problems

1. What happens to the equilibrium position when:

- The concentration of a reactant is increased?
- The temperature is decreased for an exothermic reaction?

2. Predict the effect of increasing pressure on the following reaction:

$$\mathrm{A}(g) + 2\mathrm{B}(g) \rightleftharpoons 3\mathrm{C}(g)$$

3. Explain Le Chatelier's Principle in your own words.

Answers to Practice Questions

1. **What happens to the equilibrium position when:**
   - **The concentration of a reactant is increased?**
     The equilibrium shifts towards the **products** to reduce the concentration of the reactant.
   - **The temperature is decreased for an exothermic reaction?**
     The equilibrium shifts towards the **products**, as the system releases more heat to counteract the decrease in temperature.

2. **Predict the effect of increasing pressure on the reaction:**

$$A(g) + 2B(g) \rightleftharpoons 3C(g)$$

Increasing pressure shifts the equilibrium towards the side with **fewer molecules** of gas. In this case, towards **A and B**. **3.**

Explain Le Chatelier's Principle:
If a system at equilibrium is disturbed by changing the conditions, the equilibrium shifts to **counteract the change**.