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GUIDED EXPLANATION

AQA GCSE Chemistry | Spec Ref: 4.6.2

HIGHER TIER

Reversible Reactions and Dynamic Equilibrium

Key Learning Objectives

1. Explain what a reversible reaction is and the symbol used to represent it
2. Describe how energy changes in reversible reactions
3. Explain what dynamic equilibrium is in a closed system
4. Predict the effect of changing concentration on equilibrium (HT ONLY)
5. Predict the effect of changing temperature on equilibrium (HT ONLY)
6. Predict the effect of changing pressure on equilibrium (HT ONLY)
7. Apply Le Chatelier's Principle to reversible reactions (HT ONLY)

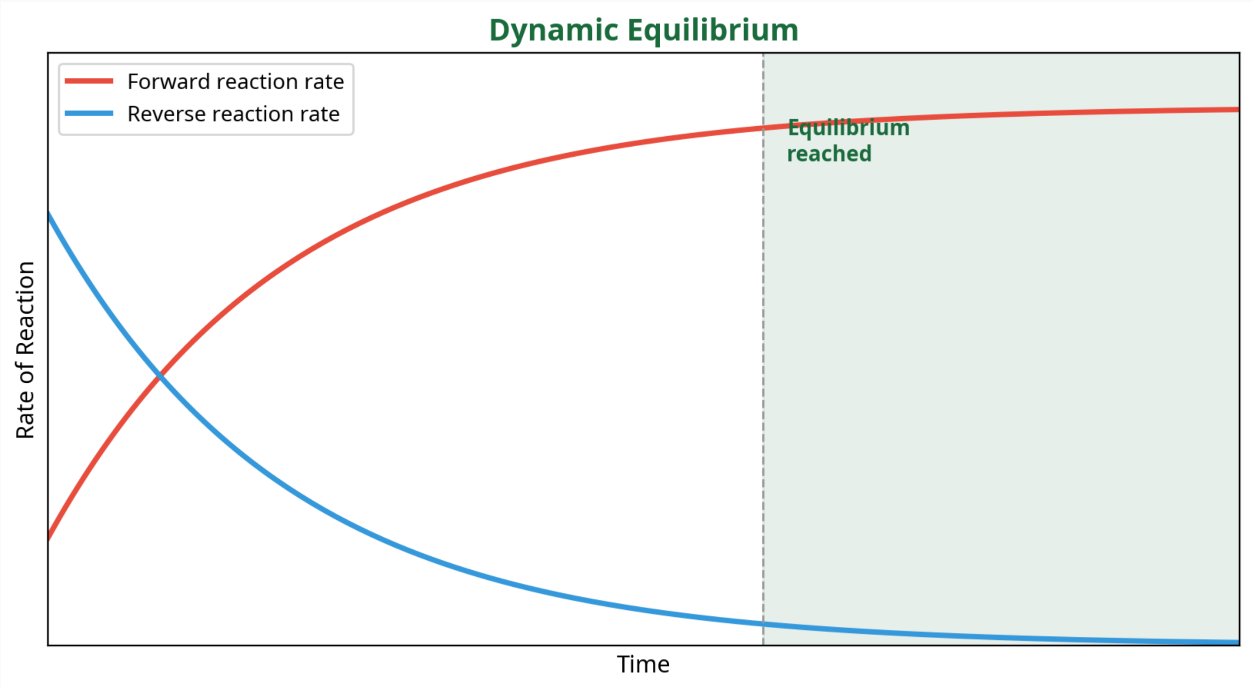
Reversible Reactions and Dynamic Equilibrium

1. Reversible Reactions

In some chemical reactions, the products of the reaction can react to produce the original reactants. These are called **reversible reactions**. The direction of reversible reactions can be changed by changing the conditions.

Reversible Reaction Symbol

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



For example, ammonium chloride decomposes when heated, but the products recombine when cooled:

Example

ammonium chloride ⇌ ammonia + hydrogen chloride

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

2. Energy Changes and Reversible 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 each case.

For example, the hydration of anhydrous copper(II) sulfate is exothermic, while the dehydration of hydrated copper(II) sulfate is endothermic:

Energy Change Example

hydrated copper(II) sulfate (blue) ⇌ anhydrous copper(II) sulfate (white) + water
Forward reaction: Endothermic (heat required)
Reverse reaction: Exothermic (heat released)

3. Dynamic Equilibrium

Key Definition: Dynamic Equilibrium

When a reversible reaction occurs in a **closed system** (where no reactants or products can escape), equilibrium is reached when the forward and reverse reactions occur at exactly the **same rate**.

At dynamic equilibrium, the concentrations of reactants and products remain constant, even though both reactions are still happening.

4. Le Chatelier's Principle HT

Key Definition: Le Chatelier's Principle

If a system is at equilibrium and a change is made to any of the conditions, then the system responds to counteract the change.

This principle can be used to predict the effects of changing concentration, temperature, and pressure on a system at equilibrium.

5. The Effect of Changing Concentration HT

If the concentration of one of the reactants or products is changed, the system is no longer at equilibrium and the concentrations of all the substances will change until equilibrium is reached again.

- If the concentration of a **reactant is increased**, more products will be formed until equilibrium is reached again (equilibrium shifts to the right).
- If the concentration of a **product is decreased**, more reactants will react until equilibrium is reached again (equilibrium shifts to the right).

6. The Effect of Temperature Changes HT

If the temperature of a system at equilibrium is changed:

- If the temperature is **increased**: the equilibrium shifts in the direction of the **endothermic** reaction to reduce the temperature. The yield of products from the endothermic reaction increases.

- If the temperature is **decreased**: the equilibrium shifts in the direction of the **exothermic** reaction to increase the temperature. The yield of products from the exothermic reaction increases.

7. The Effect of Pressure Changes HT

In reactions involving gases, changing the pressure affects the equilibrium position. The effect depends on the number of molecules (moles) of gas on each side of the balanced equation:

- If pressure is **increased**: the equilibrium shifts to the side with the **smaller number of molecules** of gas to reduce the pressure.
- If pressure is **decreased**: the equilibrium shifts to the side with the **larger number of molecules** of gas to increase the pressure.
- If both sides have the same number of molecules of gas, changing the pressure has no effect on the equilibrium position.

Worked Examples

Worked Example: Predicting the Effect of Temperature

Problem: For the reaction $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, the forward reaction is exothermic. Explain what happens to the yield of ammonia if the temperature is increased.

Solution:
Step 1: Identify the nature of the reactions. Forward is exothermic, so reverse is endothermic.
Step 2: Apply Le Chatelier's Principle. An increase in temperature favours the endothermic reaction to counteract the change.
Step 3: State the effect. The equilibrium shifts to the left, so the yield of ammonia decreases.

Worked Example: Predicting the Effect of Pressure

Problem: For the reaction $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, explain what happens to the yield of sulfur trioxide if the pressure is increased.

Solution:
Step 1: Count gas molecules on each side. Left side = 2 + 1 = 3 molecules. Right side = 2 molecules.
Step 2: Apply Le Chatelier's Principle. An increase in pressure favours the side with fewer gas molecules.
Step 3: State the effect. The equilibrium shifts to the right (fewer molecules), so the yield of sulfur trioxide increases.

Common Mistakes

Common Mistake

Thinking that reactions stop at dynamic equilibrium. They don't! The forward and reverse reactions are still happening, just at the same rate.

Common Mistake

Confusing the effects of temperature and pressure. Remember: Temperature relates to exothermic/endothermic, while pressure relates to the number of gas molecules.

Common Mistake

Forgetting that a closed system is required for equilibrium to be established. If gases can escape, the reaction will just go to completion.