ROYAL SOCIETY OF CHEMISTRY

UNIVERSITY OF BIRMINGHAM

Topic 6 – Rate & Extent of Chemical Change

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Topic 6 – The Rate and Extent of Chemical Change

Sub Topics

- Rates of Reaction
- Factor Affecting Rates of Reaction
- Measuring Rates of Reaction
- Rate Experiments
- Finding Reaction Rates from Graphs
- Reversible Reactions
- Le Chatelier's Principle

Reversible Reactions

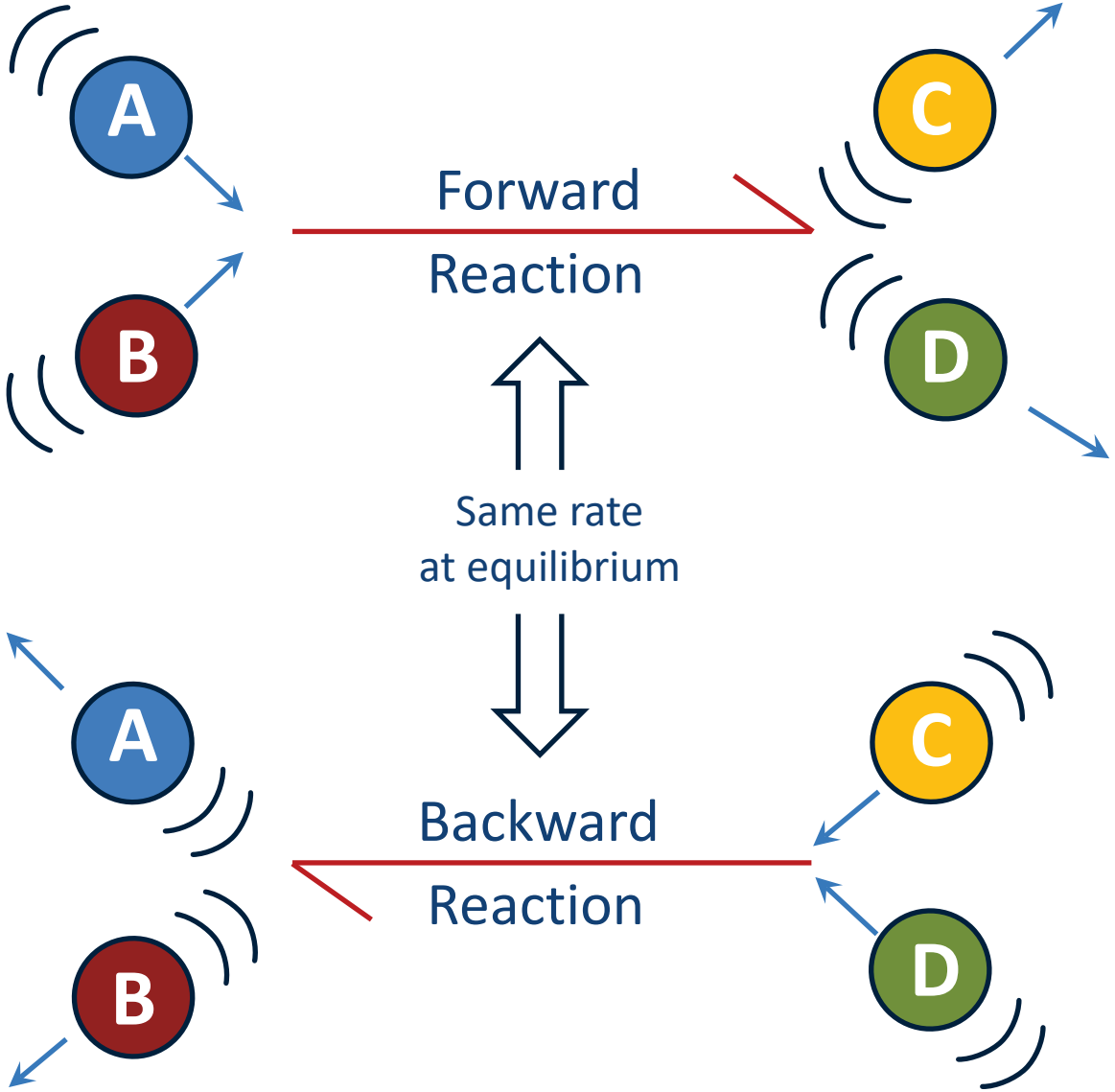
Reversible Reactions Will Reach Equilibrium

In a Reversible Reaction - products (**C** and **D**) can react to form the reactants (**A** and **B**) again:

1. As the reactants react, their concentrations fall – so the forward reaction will slow down. But as more and more products are made and their concentrations rise – the backward reaction will speed up.
2. After a while the forward reaction will be going at exactly the same rate as the backward one The system is at equilibrium.
3. At equilibrium, both reactions are still occurring, but there is no overall effect (it is a dynamic equilibrium). This means that the concentrations of reactants and products have reached a balance and will not change.
4. Equilibrium is only reached if the reversible reaction takes place in a 'closed system'. In a closed system, none of the reactants or products can escape and nothing else can enter.

Reversible Reactions

Reversible Reactions Will Reach Equilibrium



Reversible Reactions

The Position of Equilibrium Can be on the Right or the Left

1. When a reaction reaches equilibrium, it doesn't mean amounts of reactants and products are equal
2. If equilibrium lies to the right, concentration of products is greater than that of reactants
3. If equilibrium lies to the left, concentration of reactants is greater than that of products
4. The position of equilibrium depends on the following conditions (as well as the reaction)

1. The temperature
2. The pressure (only affects equilibria involving gases)
3. The concentration of the reactants and products

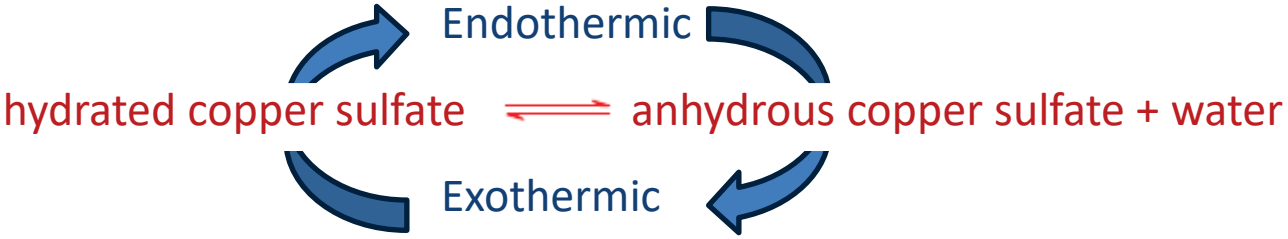
ammonium chloride $\rightleftharpoons$ ammonia + hydrogen chloride

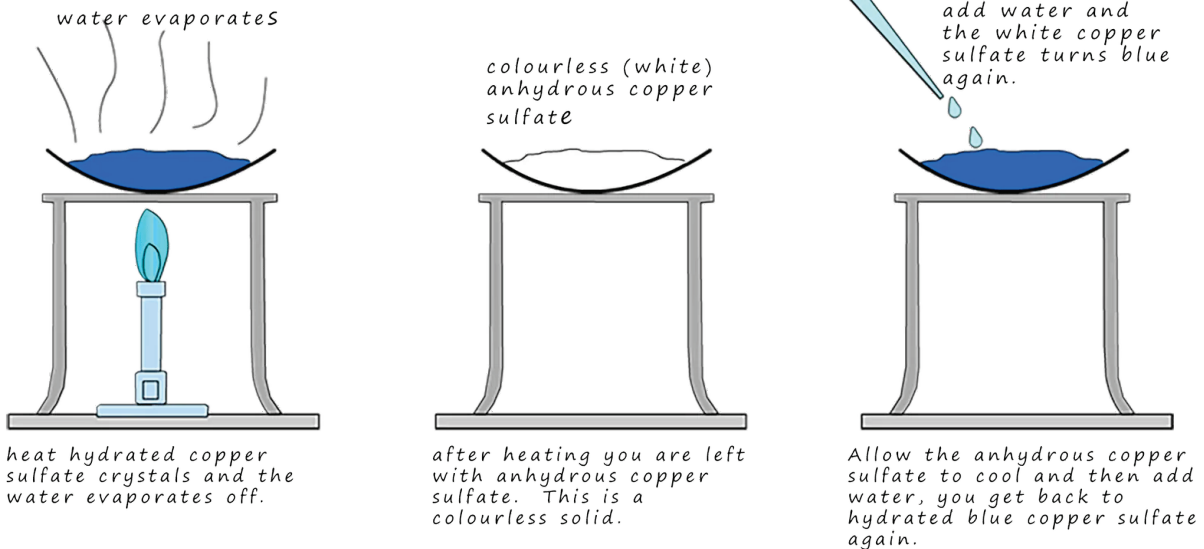
Heating this reaction moves the equilibrium to the right (more ammonia and hydrogen chloride) and cooling it moves it to the left (more ammonium chloride)

Reversible Reactions

Reversible Reactions Can Be Endothermic and Exothermic

1. In reversible reactions, if the reaction is endothermic in one direction, it will be exothermic in the other.
2. The energy transferred from the surroundings by the endothermic reaction is equal to the energy transferred to the surroundings during the exothermic reaction.
3. E.g. the thermal decomposition of hydrated copper sulfate:





Le Chatelier's Principle

Reversible Reactions Try to Counteract Changes…

1. Le Chatelier's Principle is the idea that if you change the conditions of a reversible reaction at equilibrium, the system will try to counteract that change
2. It can be used to predict the effect of any changes you make on a reaction system

Such as:

- Temperature
- Pressure
- Concentration

Le Chatelier's Principle

Reversible Reactions: Effect of **Temperature**

1. All reactions are exothermic in one direction and endothermic in the other
2. If Temperature decreases, equilibrium moves in the exothermic direction to produce more heat
   i.e. get more products for the exothermic reaction and fewer for the endothermic
3. Raising the Temperature will move the equilibrium in the endothermic direction to try and decrease it
   i.e. get more products for the endothermic reaction and fewer for the exothermic

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Here, the forward reaction is exothermic:

A decrease in Temperature will move equilibrium to the right hand side

Producing more NH_3 product

Le Chatelier's Principle

Reversible Reactions: Effect of **Pressure**

1. Changing Pressure only affects an equilibrium involving gases.
2. If Pressure is increased, the equilibrium tries to reduce it:
   by moving in the direction where there are fewer molecules of gas
3. If Pressure is decreased, the equilibrium tries to increase it:
   by moving in the direction where there are more molecules of gas
4. The balanced symbol equation for a reaction can be used to see which side has more molecules of gas

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

4 molecules 2 molecules

There are 4 moles on the left (1 of N_2 and 3 of H_2) but only 2 on the right.

So, if pressure is increased, the equilibrium shifts to the right
producing more NH_3

Le Chatelier's Principle

Reversible Reactions: Effect of **Concentration**

1. If Concentration is changed for either the reactants or the products, the system will no longer be at equilibrium.
2. So the system responds to bring itself back to equilibrium again
3. If the concentration of reactants is increased, the system tries to decrease it by making more products
4. If the concentration of products is decreased, the system tries to increase it by reducing the amount of reactants

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

If more N_2 or H_2 is added, the forward reaction increases

To produce more NH_3