Reversible Reactions

- **Reversible reactions** occur when the products of a reaction can react with each other or decompose to form the original reactants. This means that the reaction can go both ways, as represented by the **symbol ⇌,** which is made up of two half arrows pointing in opposite directions.

- One arrow represents the forward reaction, and the other represents the backward reaction

- For example, the reaction **A + B ⇌ C + D** can go in two directions.

① The **forward reaction** goes to the **right**, meaning that the reactants A and B form the products C and D:

$$A + B \rightarrow C + D$$

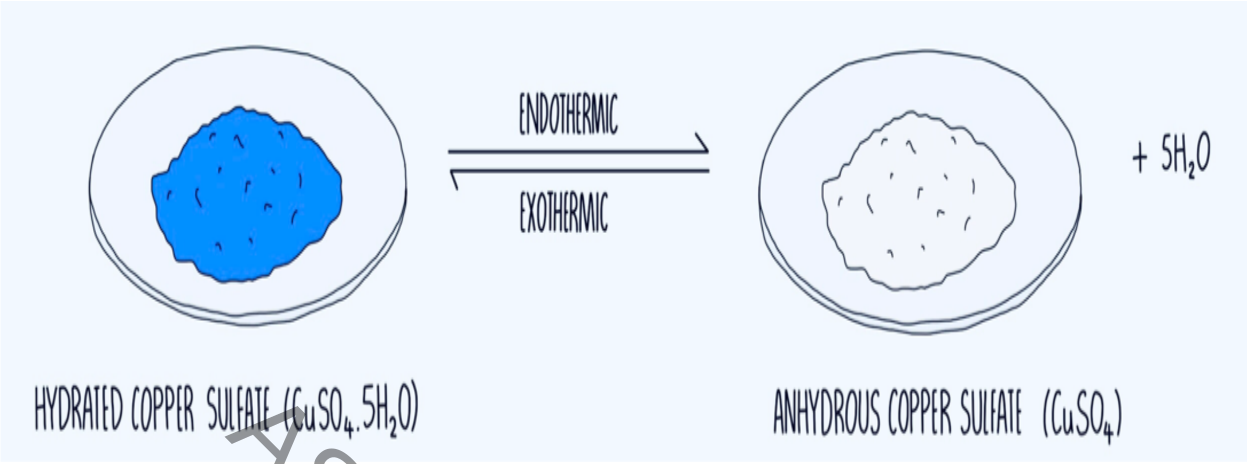
② The **backward reaction** goes to the **left**, meaning that the products C and D form the reactants A and B:

$$C + D \rightarrow A + B$$

Reversible reaction: dehydration of blue copper sulfate

- Reversible reactions can be seen in some **hydrated** salts. These are salts that contain **water of crystallisation** which affects their shape and colour.
- Water of crystallisation is the water that is included in the structure of some salts during the crystallisation process.
- A common example is **copper(II)** sulfate which crystallises forming the **salt copper(II) sulfate pentahydrate, CuSO4.5H2O.**
- Water of crystallisation is indicated with a dot written in between the salt and the surrounding water molecules.
- **Anhydrous** salts are those that have lost their water of crystallisation, usually by heating, in which the salt becomes **dehydrated.**
- When **anhydrous copper(II)** sulfate is added to water, it turns **blue** and heat is given off so the reaction is **exothermic**
- When hydrated copper(II) sulfate crystals are heated in a test tube, the blue crystals turn into a **white** powder and a clear, colourless liquid (water) collects at the top of the test tube.
- The equation for the reaction is:

$CuSO4.5H2O\ (s) \rightleftharpoons CuSO4\ (s) + 5H2O\ (l)$



Reversible reaction: Thermal decomposition of Ammonium chloride

- **Ammonium chloride** is a **white solid** which breaks down when heated into **ammonia gas** and **hydrogen chloride gas**.

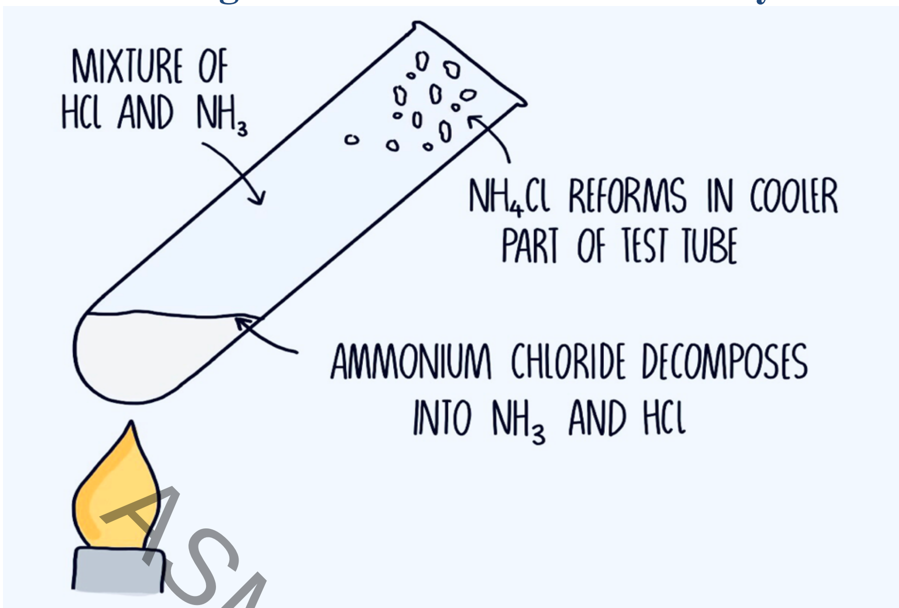
$$NH4Cl\ (s) \rightarrow NH3\ (g) + HCl\ (g)$$

- Under **cool** conditions the ammonia and hydrogen chloride will react to **reform ammonium chloride**. The forward reaction is **endothermic** while the reverse reaction is exothermic.

$$NH3\ (g) + HCl\ (g) \rightarrow NH4Cl\ (s)$$

- So, the reversible reaction is represented like this:

$$NH4Cl\ (s) \rightleftharpoons NH3\ (g) + HCl\ (g)$$



Dynamic Equilibrium

- In a **closed system** (one in which no reactants or products can escape e.g. a sealed container), reversible reactions can reach **dynamic equilibrium.**

- Dynamic equilibrium describes how reactants are being formed **just as fast** as the products are being formed, resulting in the **concentrations** of the reactants and products staying the **same** (be careful: this doesn't mean that the concentrations of reactants and products are equal).

- **At equilibrium:**

  1. The forward and reverse reactions are **still happening**
  2. The **rate** of the forward and reverse reactions is the **same**
  3. The **concentration** of reactants and products remains **constant**

- When a reaction has reached dynamic equilibrium and a **change** occurs (such as a change in **concentration, pressure** or **temperature**), the **position of equilibrium will move to counteract the change.**