CIE Chemistry A Level

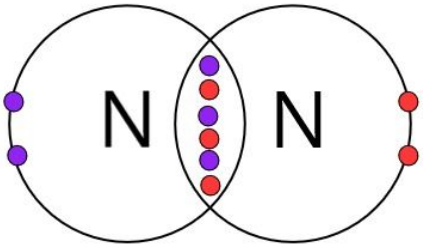
13 : Nitrogen and Sulfur

Notes

Nitrogen

Reactivity of nitrogen

Nitrogen, N_2, has a **low reactivity** due to its bonding.



A nitrogen molecule, shown on the left, has a **triple covalent bond** between two nitrogen atoms. Chemical reactions normally involve breaking bonds so that new bonds can be formed. This is why nitrogen is so unreactive as such a large amount of energy is required to break the strong triple covalent bond.

The basicity of ammonia

Ammonia is a **weak base** as it only **partially dissociates** (ionises) in water:

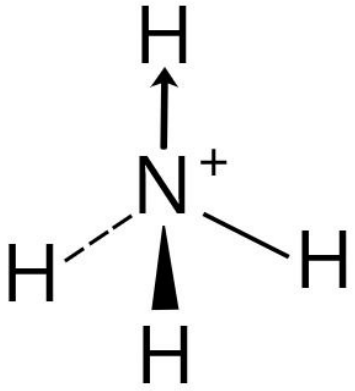
$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Ammonia is a **Bronsted-Lowry base** because it accepts hydrogen ions. The hydrogen ion bonds to the ammonia molecule by forming a **coordinate bond**. This produces an ammonium ion. The production of the hydroxide ions are what gives ammonia its basic character.

The ammonium ion

Ammonium ions are produced during **acid-base reactions**.

The ammonium ion has a **tetrahedral** shape. The structure of the ion is shown below:



Displacement of ammonia from its salts

Ammonia can be **displaced** from its salts by heating an ammonium with an alkali. The ionic equation for the reaction that takes place is:

$$NH_4^+ + OH^- \rightarrow NH_3 + H_2O$$

This is a common **laboratory method** of obtaining ammonia. Examples of these reactions can be seen below:

$$NH_4Cl + NaOH \rightarrow NH_3 + H_2O + NaCl$$

$$2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + 2H_2O + CaCl_2$$

Industrial importance of ammonia and nitrogen compounds

Ammonia compounds

Ammonia compounds are used in **fertilisers** to provide plants with nutrients to **help growth** and development. These compounds provide plants with nitrogen to **replace the nitrogen** that has been lost from the soil. A very common nitrogen based compound used in fertilisers is **ammonium nitrate**, NH_4NO_3, formed from the following reaction:

$$NH_3 + HNO_3 \rightarrow NH_4NO_3$$

This compound contains two sources of nitrogen making it a useful fertiliser.

Nitrogen compounds

Nitric acid is used to make:

- Fertilisers (e.g.ammonium nitrate)
- Explosives (e.g. TNT)
- Dyes
- Polymers
- Paints
- Detergents
- Drugs

Consequences of uncontrolled use of nitrate fertilisers

Nitrates are **water soluble**. When crops are treated with fertilisers containing nitrate compounds, nitrates **dissolve in rain water** and **leach** into lakes and rivers. This fertilises plants and algae in water. This has negative environmental consequences because **algal bloom** forms over the surface of the water, **preventing light** reaching plants below the surface. This results in the death of aquatic plants, meaning that the **oxygen supply in the water is reduced**. This kills fish and other aquatic life. This process is called **eutrophication**.

Oxides of nitrogen

Nitrogen monoxide, NO, can be formed as a result of **combustion in car engines**. The reaction between oxygen and nitrogen takes place at the **high pressures and temperatures** which are created by car engine. The reaction that takes place is:

$$N_2 + O_2 \rightarrow 2NO$$

Removal using catalytic converters

Catalytic converters can be used to **remove nitrogen monoxide** from car exhaust fumes. Catalytic converters contain a ceramic honeycomb structure which is coated in a thin layer of metal catalysts like **rhodium** and **platinum**. This creates a **larger surface area** of metal. Catalytic converters catalyse the reaction between carbon monoxide with nitrogen monoxide (harmful gases) to produce nitrogen and carbon dioxide.

$$2NO + 2CO \rightarrow N_2 + 2CO_2$$

Catalytic role of oxides of nitrogen in the production of sulfur dioxide

Nitrogen dioxide catalyses the reaction for the formation of **sulfur trioxide** from sulfur dioxide:

$$SO_2 + NO_2 \rightarrow SO_3 + NO$$

Nitrogen monoxide reacts with oxygen to reform the catalyst (nitrogen dioxide):

$$2NO + O_2 \rightarrow 2NO_2$$

Sulfur trioxide is a **pollutant** because it reacts with water vapour in clouds to form **acid rain** which causes various environmental problems.

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Sulfur

Formation of sulfur dioxide

Sulfur dioxide is formed when fossil fuels, containing **sulfur impurities**, are burnt in **oxygen**.

$$S + O_2 \rightarrow SO_2$$

Acid rain

Sulfur dioxide reacts with oxygen in the atmosphere to form **sulfur trioxide**. When sulfur trioxide dissolved in **water vapour** in clouds, **acid rain** is produced. Acid rain causes environmental damage such as:

- **Corrosion** of limestone buildings.
- **Acidification of lakes and rivers**, damaging the ecosystems in the water.
- Damage to **vegetation**.