CAIE Chemistry A-level

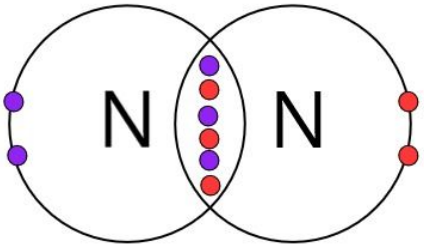
12: Nitrogen and Sulfur

Notes

Nitrogen

Reactivity of Nitrogen

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



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

Nitrogen molecules are also **unreactive** since the bonds in nitrogen molecules are **nonpolar** and are **not easily polarisable**. This means **electrophiles** and **nucleophiles** are not attracted to nitrogen molecules, making the molecules less likely to be involved in reactions.

The Basicity of Ammonia

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

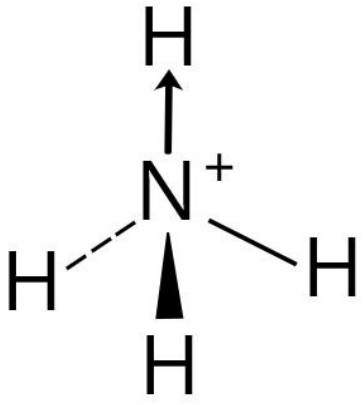
$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

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 salt** 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:

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

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

Oxides of Nitrogen

Oxides of nitrogen, such as **nitrogen monoxide**, can be formed as a result of **combustion reactions in car engines**. Nitrogen oxides are also produced **naturally** by the occurrence of **lightning**. The reaction between oxygen and nitrogen takes place at **high pressures and temperatures** - which occur in car engines. The reaction that takes place for the formation of nitrogen monoxide is:

$$N_2 + O_2 \rightarrow 2NO$$

Removal using catalytic converters

Catalytic converters can be used to **remove oxides of nitrogen** 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**. The honeycomb 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:

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

If **atmospheric oxides of nitrogen** (NO and NO_2) are not removed from the air, they can react with **unburned hydrocarbons** to form peroxyacetyl nitrate (**PAN**). PAN is a component of photochemical smog - a type of air pollution which causes various **respiratory problems**.

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 nitrogen dioxide catalyst:

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

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 is dissolved in **water vapour** in clouds, **acid rain** is produced. Acid rain causes environmental damage such as:

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