AQA Chemistry A-Level

3.3.11: Amines

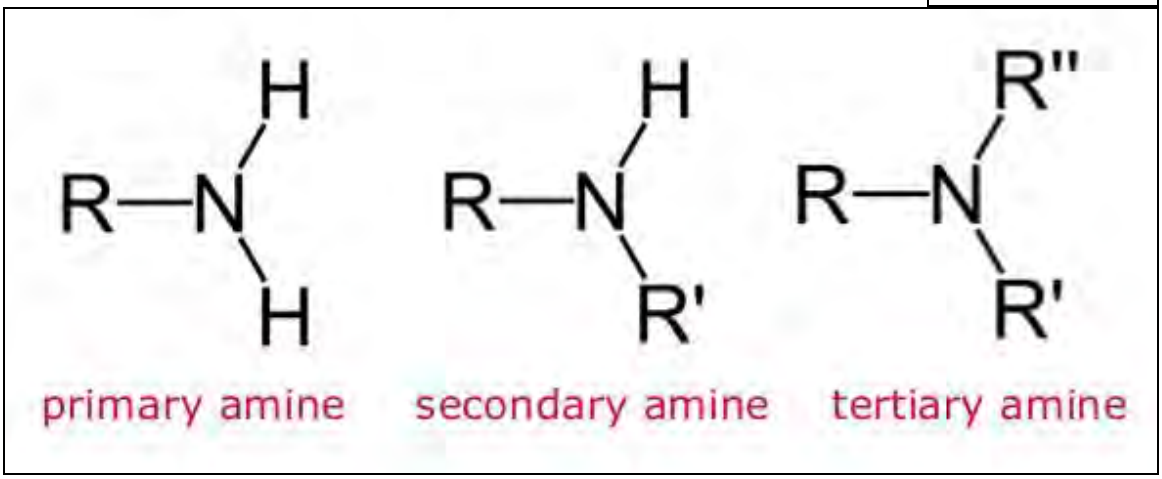
Detailed Notes

3.3.11.1 - Preparation of Amines

Amines are produced when one or more of the hydrogen atoms in ammonia is **replaced with an organic group**. They can be **1°, 2° or 3° amines** depending on how many hydrogen atoms are replaced.

Example:

Image courtesy of SlideShare



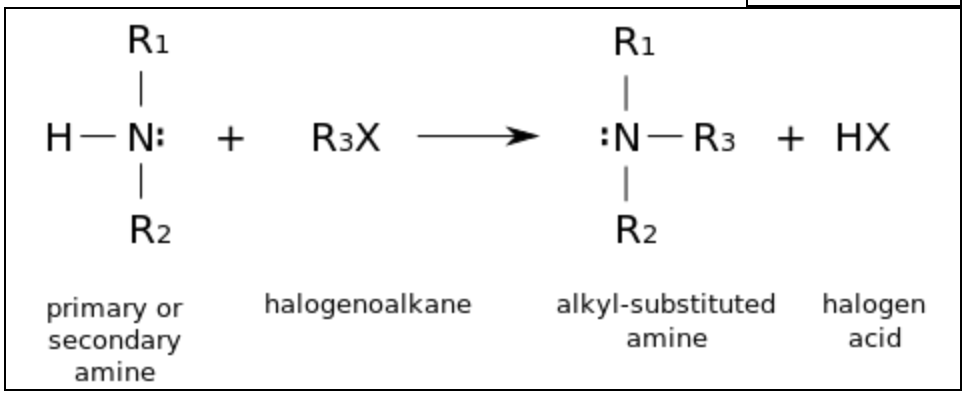
Amines can be produced in two ways.

Nucleophilic Substitution

This reaction produced amines from the reaction of a **halogenoalkane with ammonia** in a sealed tube. One mole of halogenoalkane reacts with two moles of ammonia producing a **primary amine** and an **ammonium salt**.

Example:

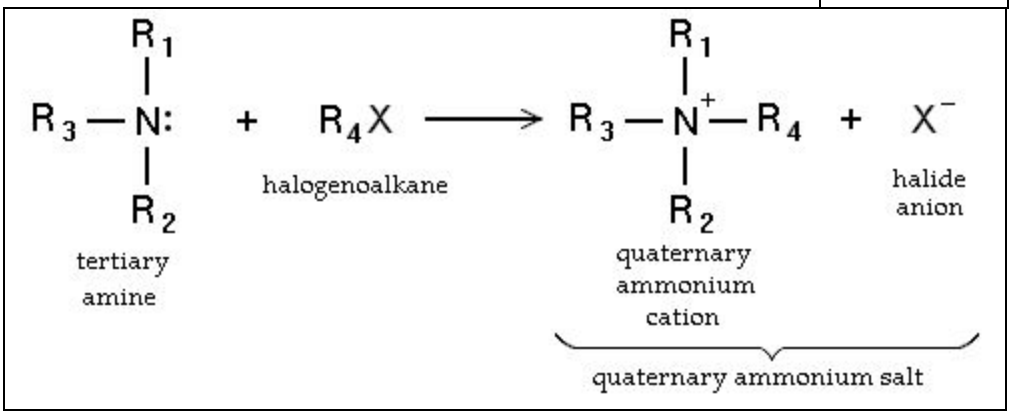
Image courtesy of Wikibooks



This substitution reaction can continue until **all the hydrogen atoms have been replaced** with organic groups. Following this, an additional substitution can occur, producing a **quaternary ammonium salt**.

Example:

Image courtesy of Wikibooks



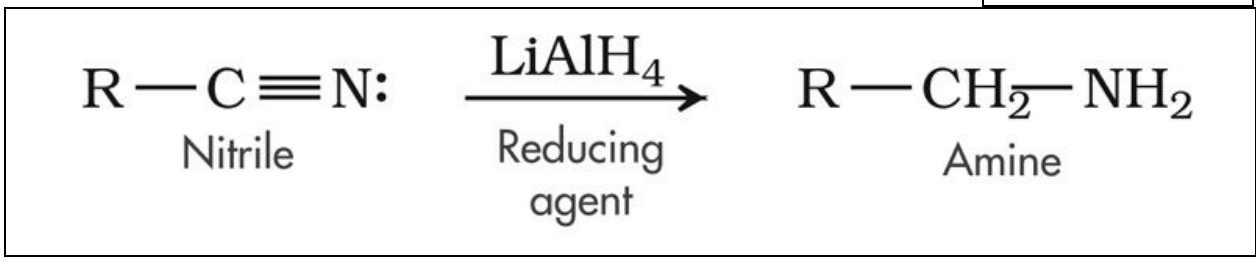
The multiple number of possible substitutions means that a **mixture of products** are produced. Therefore the reaction has **low efficiency** and reaction conditions have to be changed so that only a single substitution occurs. Ammonia can be added **in excess** in order to achieve only the primary amine, or the mixture of products can be **separated using fractional distillation**.

Reduction of Nitriles

Reducing nitriles via **hydrogenation** can produce amines. This reduction require **$LiAlH_4$**, a reducing agent, and **acidic conditions** or a combination of **hydrogen and nickel** (catalytic hydrogenation).

Example:

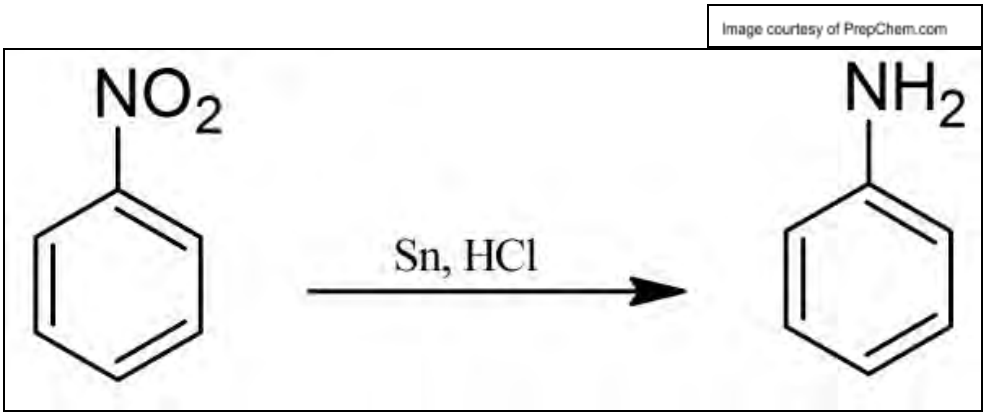
Image courtesy of Google Sites



Aromatic Amines

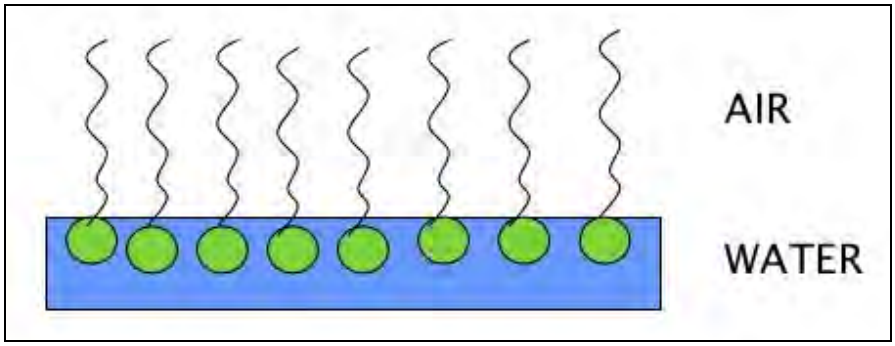
These can be produced from the **reduction of nitrobenzene** using concentrated hydrochloric acid (HCl) and a **tin catalyst**.

Example:



Cationic Surfactants

These molecules are complexes with a **positive and negative end**. This makes them **good conditioners** as the two ends are attracted to different substances, **preventing static** from building up on surfaces. Cationic surfactants are therefore useful in industry.
Example:



3.3.11.2 - Amine Base Properties

Amines are **weak bases** because the **lone electron pair** on the nitrogen atom can accept protons. The base strength of amines depends on **how available** the electron pair is on the molecule. The more available the electrons, the more likely it is to accept a proton meaning it is a stronger base.

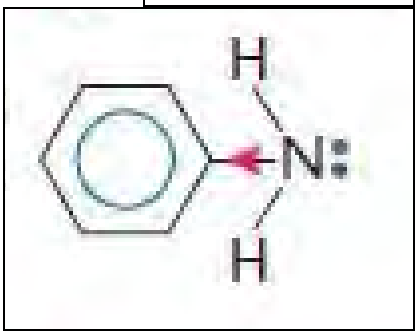
The Inductive Effect

In an organic molecule, different functional groups can affect how available a lone electron pair is by changing **electron density** around the bond.

1. **Benzene rings** - draw electron density **away** from the nitrogen making it 'less available'

Example:

Image courtesy of Revision Science

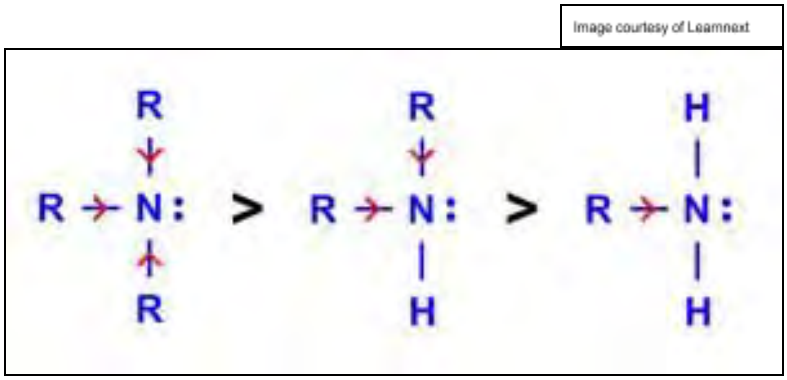


Negative inductive effect.

2. **Alkyl groups** - push electron density **towards** the nitrogen making it 'more available'. More alkyl groups means more 'pushing'.

Example:

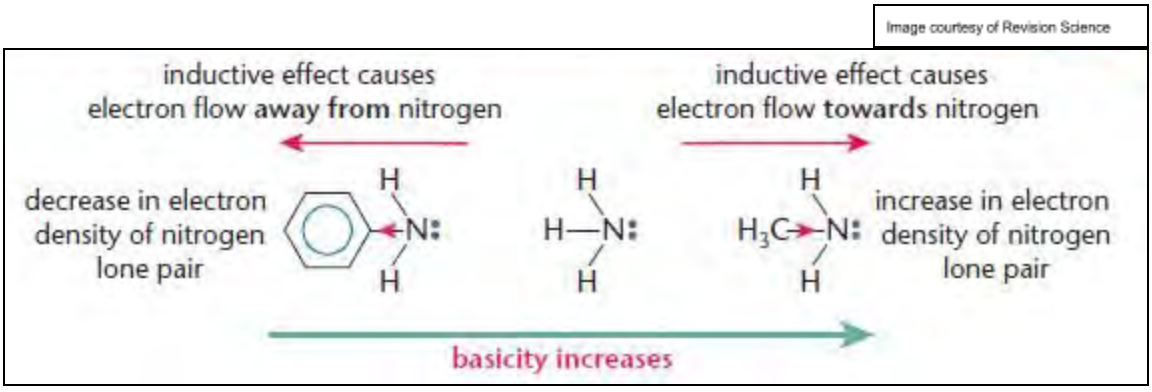
Image courtesy of Learnnext



Positive inductive effect.

This means **aliphatic amines are stronger** bases and **aromatic amines are weaker**.

Image courtesy of Revision Science



3.3.11.3 - Nucleophilic Properties

Nucleophilic Substitution

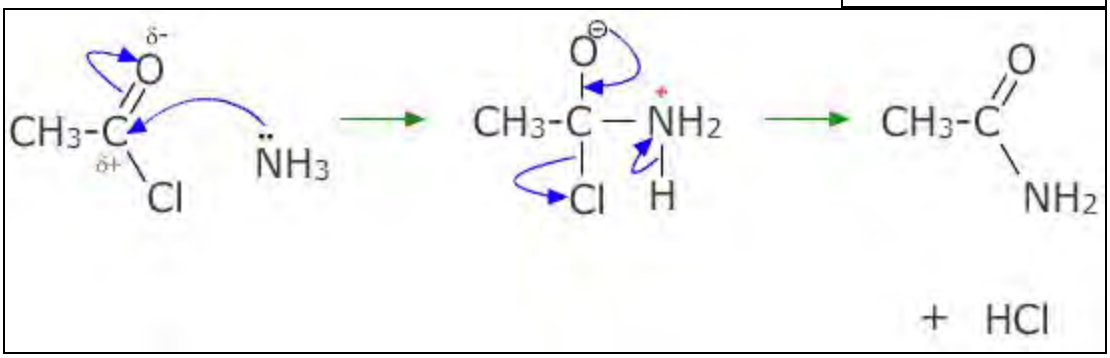
Amines can act as **nucleophiles** because the lone electron pair is **attracted to ∂+ regions** on other molecules. This mean amines can **substitute halides** on halogenoalkanes to form 1°, 2° or 3° amines and quaternary ammonium salts.

Nucleophilic Addition-Elimination

Amines can also undergo **nucleophilic addition-elimination** reactions with acyl chlorides to produce **amides** and **N-substituted amides**.

Mechanism

Image courtesy of alevelchem.com



This same reaction mechanism can also occur with **acid anhydrides** to produce an amide and a carboxylic acid.

N-substituted Amides

When naming n-substituted amides, they are treated in a similar way to esters.

Example:

Image courtesy of callmedrrob.com