CAIE Chemistry A-level

32: Hydroxy Compounds

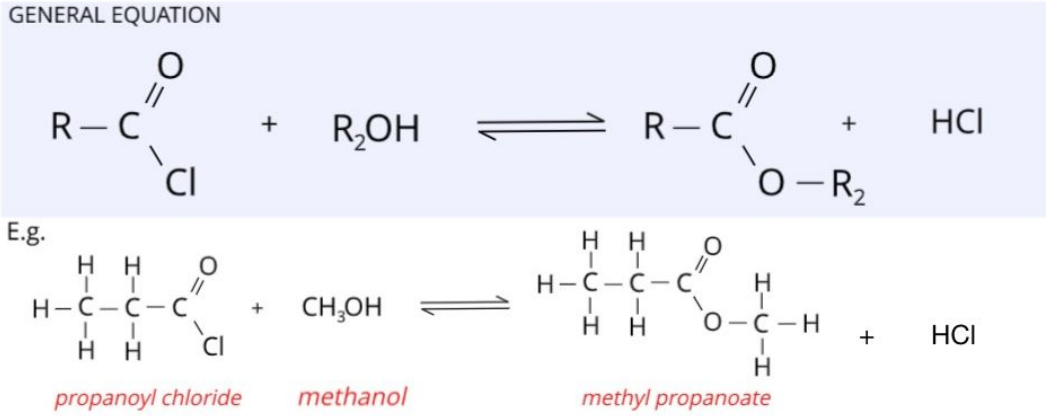
(A-level only)

Notes

Alcohols

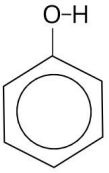
Formation of Esters by Acylation with Acyl Chlorides

Esters can also be produced from **alcohols** and **acyl chlorides**. Alcohol reacts vigorously with acyl chlorides, releasing steamy fumes of hydrochloric acid.



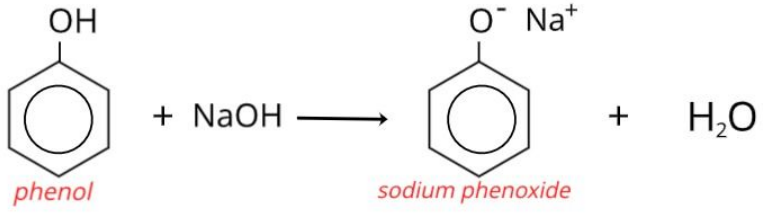
Phenol

Phenol is an aromatic hydrocarbon consisting of one alcohol group bonded to the benzene ring:

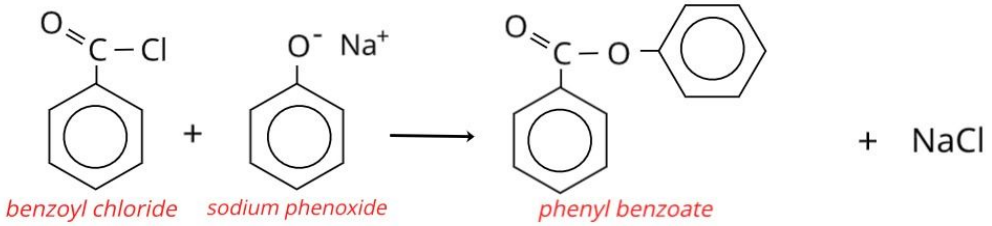


Phenyl benzoate:

Benzoyl chloride is very **unreactive** because the -COCl group is directly attached to a **stable benzene ring**. To produce the ester phenyl benzoate, phenol is first converted into an ionic compound by **dissolving it in sodium hydroxide**. This produces the **phenoxide** ion:

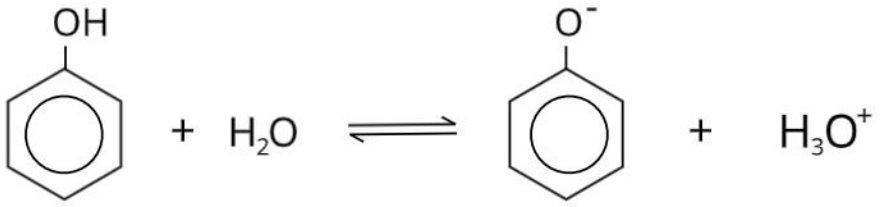


The **phenoxide ion** is **more reactive** than the phenol so this ion can react with benzoyl chloride to produce phenyl benzoate:



Reactions with Bases

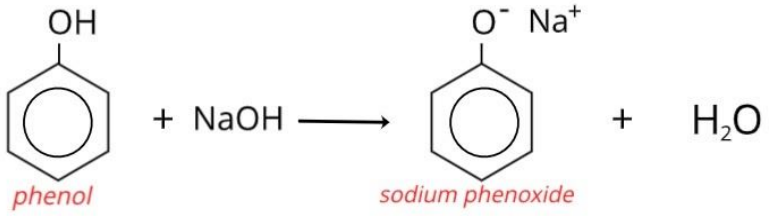
Phenol is a **weak acid**. A hydrogen ion can be removed from the hydroxyl group and transferred to a base. The position of **equilibrium** for the reaction below lies far to the left which means that phenol is a weak acid.



Phenol is able to donate a hydrogen ion because the **phenoxide ion** is **relatively stable**. The **lone pair** on the oxygen atom is delocalised into the **pi system** which is above and below the benzene ring. This means that the **negative charge is dispersed** among the carbon atoms so the compound is more stable.

Reaction with sodium hydroxide

When phenol reacts with sodium hydroxide, colourless **sodium phenoxide** is formed.

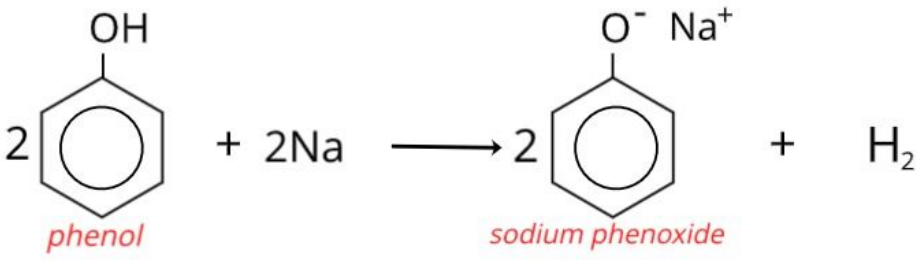


Reaction with sodium carbonate

Phenol isn't acidic enough to react with sodium carbonate.

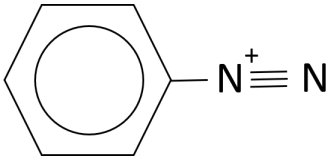
Reactions with Sodium

Phenol reacts with metals in the same way that most acids. **Hydrogen gas** and a salt are produced. The reaction occurs **slower** than comparable acid-metal reactions because phenol is a **weak acid**.

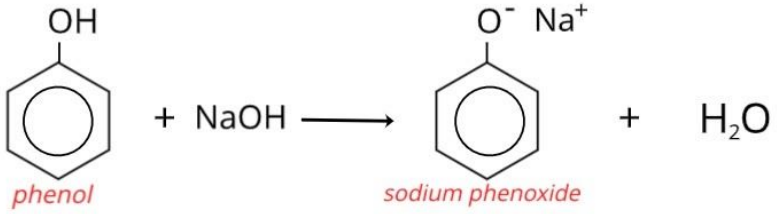


Reactions with diazonium salts

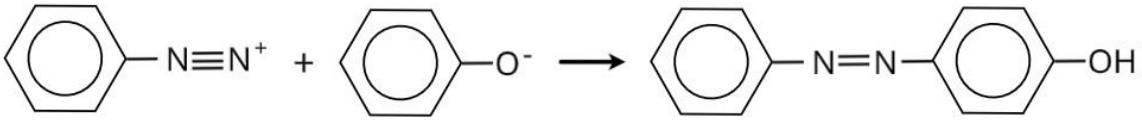
Diazonium salts contain the diazonium ion, **R-N_2^+** (where R is any organic group). In the case of the following example, we will be looking at the diazonium ion when it is attached to a **benzene ring**.



Before a diazonium salt is reacted with phenol, phenol is dissolved in **sodium hydroxide** to give the **phenoxide ion**:



Cold **benzenediazonium chloride** is then added to the **sodium phenoxide** solution. The diazonium and phenoxide ions react together to form an **azo compound**. An azo compound contains two benzene rings that are joined together with a nitrogen bridge. The product can be identified as a **yellow solution** or **precipitate**.



Nitration and Bromination of the Aromatic Ring

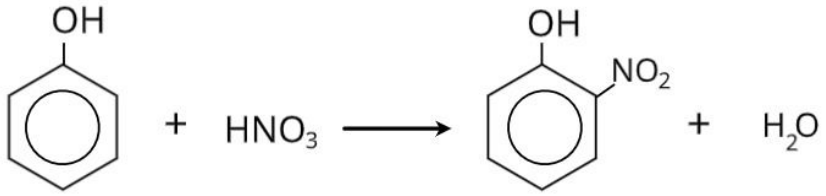
Phenol is **more reactive than benzene** because it contains an -OH functional group. The lone pair on the oxygen atom is delocalised into the **pi system**. This **increases the electron density**, making phenol more likely to be **attacked by electrophiles.**

The effect of the OH group is sometimes referred to as the **2,4-directing effect**. This is because the incoming groups tend to bond to the second and fourth carbons from the hydroxyl group.

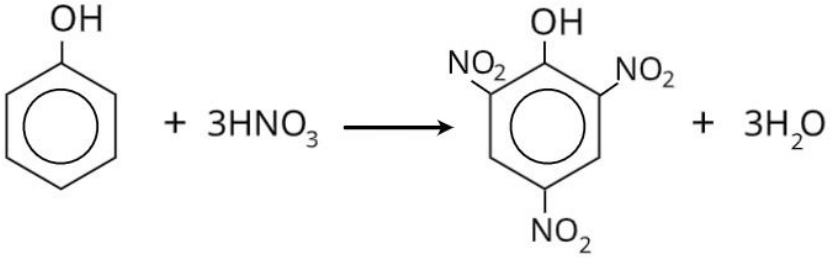
Nitration

Phenol reacts with dilute and concentrated nitric acid:

- ***Dilute*** *nitric acid*
  The 2,4-directing effect of the hydroxyl group causes a mixture of **2-nitrophenol** and **4-nitrophenol** to be produced. The reaction for 2-nitrophenol is shown below.

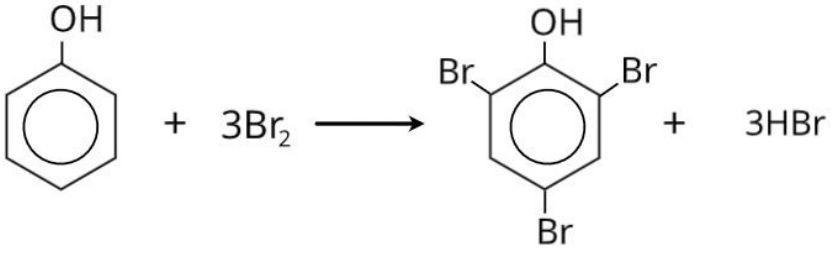


- ***Concentrated*** *nitric acid*
  The compound **2,4,6-trinitrophenol** is formed.



Bromination

When bromine water is added to a solution of phenol, the orange bromine water is decolourised. **2,4,6-tribromophenol (white precipitate)** and hydrogen bromide are formed.



Relative Acidities of Water, Phenol and Ethanol

The relative acidities are as follows: **phenol > water > ethanol**

- Phenol is the **most acidic** because the **phenoxide ion** (formed when phenol donates a proton) is **relatively stable**. The **lone pair** on the oxygen atom is **delocalised** into the pi system meaning the negative charge is dispersed among the carbon atoms. This means that phenol is **more likely to donate a hydrogen ion** than water or ethanol.

- Ethanol and water have similar acidities but **ethanol is the least acidic**. This is because of the **positive inductive effect**. The alkyl group in the **ethoxide** ion **"pushes" electrons** away from itself, towards the oxygen. This **increases the electron density of the oxygen**, making it more likely to bond to a hydrogen ion and reform ethanol.