PHENOL

**Structure**
- phenol is an aromatic alcohol
- the OH group is attached directly to the benzene ring
- it is an almost colourless crystalline solid of formula C₆H₅OH

**Uses**
- production of plastics
- antiseptics
- disinfectants
- resins for paints

**Preparation**
- you cannot put an OH group directly onto benzene by electrophilic substitution
- phenol is synthesised in a multi-stage process

\[
\begin{align*}
\text{Nitration of benzene} & \\
\text{reagents} & \text{conc. nitric acid and conc. sulphuric acid (catalyst)} \\
\text{conditions} & \text{reflux at } 55°C \\
\text{equation} & \text{C}_6\text{H}_6 + \text{HNO}_3 \rightarrow \text{C}_6\text{H}_5\text{NO}_2 + \text{H}_2\text{O} \\
\text{mechanism} & \text{electrophilic substitution}
\end{align*}
\]

\[
\begin{align*}
\text{Reduction of nitrobenzene} & \\
\text{reagents} & \text{tin and conc. hydrochloric acid} \\
\text{conditions} & \text{reflux} \\
\text{equation} & \text{C}_6\text{H}_5\text{NO}_2 + 6[H] \rightarrow \text{C}_6\text{H}_5\text{NH}_2 + 2\text{H}_2\text{O}
\end{align*}
\]

\[
\begin{align*}
\text{Diazotisation of phenylamine} & \\
\text{reagents} & \text{nitrous acid and hydrochloric acid (use sodium nitrite)} \\
\text{conditions} & \text{keep below } 10°C \\
\text{equation} & \text{C}_6\text{H}_5\text{NH}_2 + \text{HNO}_2 + \text{HCl} \rightarrow \text{C}_6\text{H}_5\text{N}_2^+ \text{Cl}^- + 2\text{H}_2\text{O} \\
\text{reaction type} & \text{diazotisation}
\end{align*}
\]

\[
\begin{align*}
\text{Substitution} & \\
\text{reagents} & \text{water} \\
\text{conditions} & \text{warm above } 10°C \\
\text{equation} & \text{C}_6\text{H}_5\text{N}_2^+ \text{Cl}^- + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_5\text{OH} + \text{N}_2 + \text{HCl}
\end{align*}
\]
CHEMICAL REACTIONS OF PHENOL

Reactions of the -OH group

Water
- phenol is a weak acid
- it is a stronger acid than aliphatic alcohols
- the aromatic ring helps weaken the O-H bond and stabilises the resulting anion
- it dissolves very slightly in water to form a weak acidic solution

\[ \text{C}_6\text{H}_5\text{OH(aq)} \rightleftharpoons \text{C}_6\text{H}_5\text{O}^-\text{(aq)} + \text{H}^+\text{(aq)} \]

NaOH
- phenol reacts with sodium hydroxide to form a salt - sodium phenoxide
- it is ionic and water soluble

\[ \text{C}_6\text{H}_5\text{OH(aq)} + \text{NaOH(aq)} \rightarrow \text{C}_6\text{H}_5\text{O}^-\text{Na}^+(aq) + \text{H}_2\text{O(l)} \]

Sodium
- phenol reacts with sodium to form an ionic salt - sodium phenoxide
- hydrogen is also produced
- this reaction is similar to that with aliphatic alcohols such as ethanol

\[ 2\text{C}_6\text{H}_5\text{OH(s)} + 2\text{Na(s)} \rightarrow 2\text{C}_6\text{H}_5\text{O}^-\text{Na}^+(s) + \text{H}_2(g) \]

Reactions of the benzene ring

ELECTROPHILIC SUBSTITUTION

Bromine
- the OH group is electron releasing
- electron pair donation takes place from a p orbital on oxygen
- it increases the electron density of the delocalised system
- it makes substitution much easier compared to benzene
- the electron density is greatest at the 2,4 and 6 positions
- substitution takes place at the 2,4 and 6 positions
- phenol reacts readily with bromine water WITHOUT A CATALYST
- it is so easy that multiple substitution takes place

\[ \text{PhOH} + 3\text{Br}_2 \rightarrow \text{PhBr}_3 + 3\text{HBr} \]
- other electrophiles such as NO$_2^+$ react in a similar way
Q.1 For each of the following compounds...
(a) work out the molecular formula (b) state its use or importance
(c) classify as 1°, 2° or 3° aliphatic alcohols or phenols (or both)

Vitamin A

Estradiol

Testosterone

Paracetamol

Picric acid

Cholesterol

Menthol

4-chloro-3,5-dimethylphenol
‘Dettol’

Ethane-1,2-diol