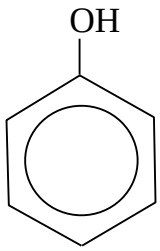
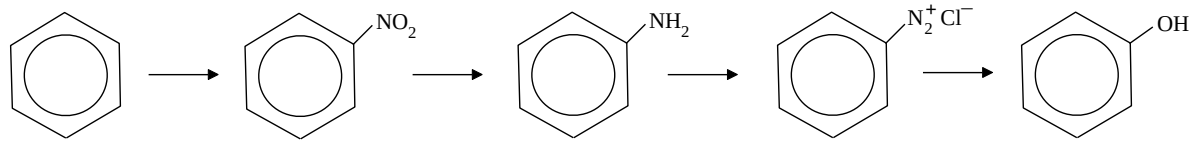
PHENOL



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 C_6H_5OH

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

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



benzene → nitrobenzene → phenylamine *(aniline)* → benzene diazonium chloride → phenol

Nitration of benzene

reagents: **conc**. nitric acid and **conc**. sulphuric acid (catalyst)

conditions: reflux at 55°C

equation: $C_6H_6 + HNO_3 \longrightarrow C_6H_5NO_2 + H_2O$ (*nitrobenzene*)

mechanism: electrophilic substitution

Reduction of nitrobenzene

reagents: tin and **conc**. hydrochloric acid

conditions: reflux

equation: $C_6H_5NO_2 + 6\,[H] \longrightarrow C_6H_5NH_2 + 2H_2O$ (*phenylamine*)

Diazotisation of phenylamine

reagents: nitrous acid and hydrochloric acid (use sodium nitrite)

conditions: keep below 10°C

equation: $C_6H_5NH_2 + HNO_2 + HCl \longrightarrow C_6H_5N_2^+\,Cl^- + 2H_2O$ (*benzene diazonium chloride*)

reaction type: diazotisation

Substitution

reagents: water

conditions: warm above 10°C

equation: $C_6H_5N_2^+\,Cl^- + H_2O \longrightarrow C_6H_5OH + N_2 + HCl$

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

$$C_6H_5OH(aq) \rightleftharpoons C_6H_5O^-(aq) + H^+(aq)$$

NaOH

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

$$C_6H_5OH(aq) + NaOH(aq) \longrightarrow C_6H_5O^-Na^+(aq) + H_2O(l)$$

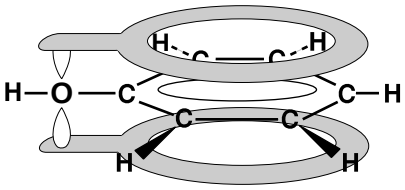
Na_2CO_3

- phenol **doesn't react with carbonates to produce CO_2**
- it is not a strong enough acid
- **used to differentiate between phenols and carboxylic acids**

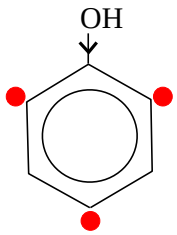
ELECTROPHILIC SUBSTITUTION REACTIONS

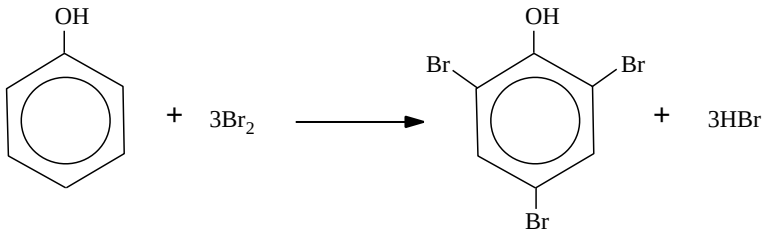
Bromine

- the OH group is electron releasing
- electron pair donation takes place from a p orbital on oxygen



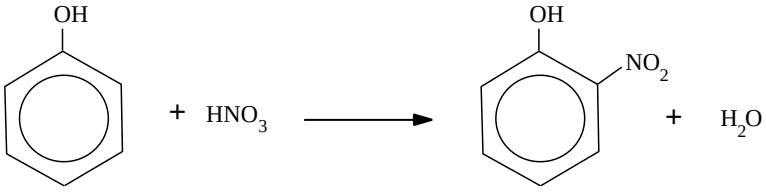
- it increases the electron density of the delocalised system
- it makes substitution much easier compared to benzene
- the electron density is greatest at the **2, 4** and **6** positions
- substitution takes place at the **2, 4** and **6** positions
- phenol reacts readily with bromine water WITHOUT A CATALYST
- it is so easy that multiple substitution takes place





HNO_3

- other electrophiles such as NO_2^+ react in a similar way
- phenol is nitrated with **dilute** nitric acid **(benzene requires c.HNO_3/c.H_2SO_4)**

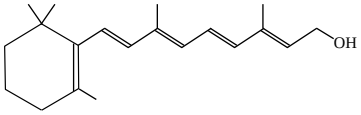


Q.1 *For each of the following compounds...*

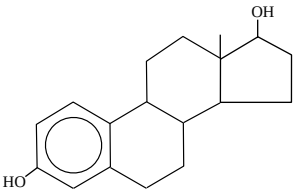
(a) work out the molecular formula (b) state its use or importance

(c) classify as 1°, 2° or 3° aliphatic alcohols or phenols (or both)

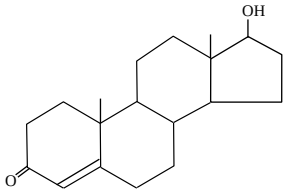
Vitamin A



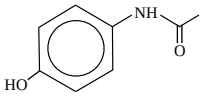
Estradiol



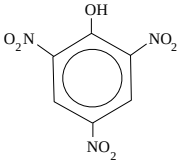
Testosterone



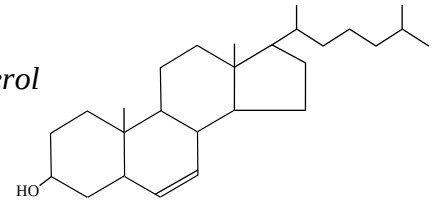
Paracetamol



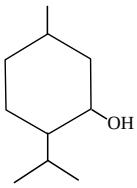
Picric acid



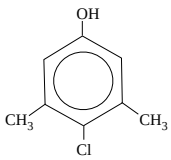
Cholesterol



Menthol



4-chloro-3,5-dimethylphenol
'Dettol'



Ethane-1,2-diol