A-LEVEL CHEMISTRY • EXERCISE SHEET

32.2 Phenol

Name: _____ Class: _____ Date: _____ **Total: 22 marks**

KEY WORDS acidity 酸性 • phenol 苯酚 • benzene 苯 • delocalised 离域 • alcohol 醇

Objective

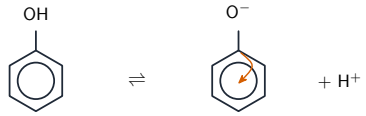
Build the skills to answer exam questions on **phenol** 苯酚 — its reactions, its **acidity** 酸性, and why its ring is more reactive than benzene.

You must be able to:

- give the reactions of phenol (with bases, sodium, bromine water, dilute HNO_3)
- explain why phenol is more acidic than water or an alcohol
- explain why phenol reacts under milder conditions than benzene

1 Worked examples

■ Acidity and ring reactivity

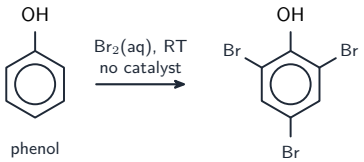


phenol phenoxide (charge spread into ring)

acidity: ethanol < water < phenol

Phenol is more acidic than water or an alcohol: the phenoxide ion's charge spreads into the ring, stabilising it

- **acidity order:** ethanol < water < **phenol** (< carboxylic acid).
- phenol's –OH loses H^+ → phenoxide; the charge is delocalised into the ring → stable ion → more acidic.



phenol 2,4,6-tribromophenol (white precipitate)

the ring is activated, so milder conditions than benzene

Phenol's ring is activated, so bromine water brominates positions 2, 4, 6 at room temperature, no catalyst — a white precipitate

- the O lone pair feeds into the ring → ring is electron-rich → reacts faster and milder than benzene.

2 Practice

2.1 Name the organic product when phenol reacts with bromine water. [1]

2.2 State what you would see when phenol reacts with bromine water. [1]

3 Exam-style questions

3.1 Phenol is more acidic than ethanol because: [1]

- **A** the phenoxide ion's charge is delocalised into the ring
- **B** phenol contains a benzene ring
- **C** ethanol has no –OH group
- **D** phenol is a strong acid

3.2 Phenol reacts with bromine water **faster** than benzene reacts with bromine because in phenol: [1]

- **A** the ring is electron-poor
- **B** an O lone pair feeds electron density into the ring
- **C** the –OH removes electrons from the ring
- **D** a catalyst is present

3.3 Phenol reacts with sodium hydroxide solution, but ethanol does not.

(a) Write the equation for phenol with NaOH(aq). [2]

(b) State what this difference shows about phenol. [1]

3.4 Explain why phenol can be brominated with bromine water at room temperature with no catalyst, while benzene needs a halogen carrier. [3]

3.5 Phenol, C_6H_5OH, is a weak acid; ethanol is not acidic in water.

(a) Write the equation for the reaction of phenol with aqueous sodium hydroxide, and name the salt formed. [2]

(b) Explain, in terms of the stability of the anion, why phenol is a stronger acid than ethanol but weaker than ethanoic acid. [4]

(c) Phenol reacts with bromine **water** at room temperature to give a white precipitate, whereas benzene needs a halogen carrier and heat. Write the equation for the phenol reaction and explain the difference in reactivity. [4]

(d) State a chemical test that distinguishes phenol from ethanol, with the result for each. [2]

Solutions

2.1 2,4,6-tribromophenol.

2.2 a white precipitate forms / the bromine water decolourises.

3.1 A. The negative charge on the phenoxide ion is delocalised into the ring, stabilising it.

3.2 B. An oxygen lone pair feeds into the ring, making it more electron-rich and reactive.

3.3 (a) $C_6H_5OH + NaOH \rightarrow C_6H_5ONa + H_2O$.
(b) phenol is acidic (more acidic than an alcohol — it reacts with a base).

3.4 a lone pair on the phenol oxygen is delocalised into the ring; this makes the ring more electron-rich, so it attracts electrophiles more strongly; benzene's ring is less electron-rich, so it needs a halogen carrier to make a strong enough electrophile.

3.5 (a) $C_6H_5OH + NaOH \rightarrow C_6H_5O^-Na^+ + H_2O$; the salt is **sodium phenoxide**.
(b) In the phenoxide ion a lone pair on the oxygen is delocalised into the ring's π system, so the negative charge is spread out and the ion is stabilised — the equilibrium therefore lies further to the right than for ethanol, whose ethoxide has no such delocalisation. In ethanoate the charge is delocalised over **two electronegative oxygens** only, which stabilises it far more effectively than spreading it round a carbon ring, so ethanoic acid is the strongest of the three.
(c) $C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$ — white 2,4,6-tribromophenol. The oxygen's lone pair is donated into the ring, raising its electron density so it polarises an approaching bromine molecule by itself — no halogen carrier is needed.
(d) Add neutral iron(III) chloride solution: phenol gives a violet/purple colour, ethanol gives no change. (Sodium carbonate is **not** a valid test — neither gives carbon dioxide.)