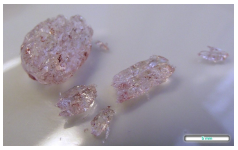
Phenol

A-Level Chemistry ▪ Topic 32

A-Level Chemistry

What we will cover

1. Alcohols with acyl chlorides
2. Phenol & its reactions
3. Acidity of phenol
4. Milder conditions



phenol oxidises pink in air

1 Esters and phenol

Alcohols with acyl chlorides

$$\underset{\text{alcohol}}{CH_3CH_2OH} + \underset{\text{acyl chloride}}{CH_3COCl} \longrightarrow \underset{\text{ester}}{CH_3COOC_2H_5} + HCl$$

An alcohol reacts with an **acyl chloride** 酰氯 to make an **ester** 酯 – faster & more completely than with a carboxylic acid. Ethanol + ethanoyl chloride → ethyl ethanoate + HCl.

Phenol and its reactions

Phenol 苯酚 has −OH joined to a benzene ring:

- + NaOH → sodium phenoxide (alcohols don't react!)
- + Na → H_2
- nitration (dilute) & **bromination** 溴化 at room temp
- + diazonium → a coloured **azo dye** 偶氮化合物

The reactions of phenol

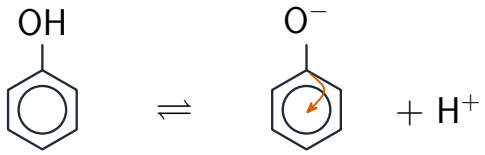
with sodium	fizzes, giving sodium phenoxide and hydrogen – phenol is acidic enough for this
with NaOH(aq)	forms sodium phenoxide; but not with carbonate, since phenol is weaker than carbonic acid
with bromine water	decolourises it immediately and without a catalyst, giving 2,4,6-tribromophenol as a white precipitate
why so easy	a lone pair on the oxygen delocalises into the ring, activating it
with a diazonium salt	in NaOH(aq), forms a coloured **azo compound** 偶氮化合物 – the basis of many dyes

> That last reaction is the whole azo-dye industry. The colour comes from the extended delocalisation across the −N=N− bridge.

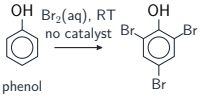
Acidity of phenol

Phenol loses H^+ to a **phenoxide** 苯氧根 ion, stabilised by spreading the charge into the ring.

> So acidity is: ethanol < water < phenol (but phenol is still weaker than a carboxylic acid).



Milder conditions than benzene



phenol

2,4,6-tribromophenol
(white precipitate)

the ring is activated, so milder conditions than benzene

The O lone pair is **delocalised** 离域 into the ring, making it more electron-rich and activated.

> So bromine water brominates phenol at the 2,4,6-positions at room temperature, no catalyst – a white precipitate.

Where phenol's substituents go

the direction	the −OH group directs new substituents to the 2-, 4- and 6-positions
why	the oxygen's lone pair delocalises into the ring, raising electron density most at those positions
the consequence	phenol reacts faster and under milder conditions than benzene – bromine water needs no catalyst
the product	2,4,6-tribromophenol, a white precipitate, formed immediately
the same ideas	apply to other phenols and to **phenylamine** 苯胺, where the $-NH_2$ group activates in the same way

> Activation and direction are one effect: the group that pushes electron density in also decides *where* it is highest, and therefore where the attack happens.

Exam tips

- **Phenol** is a stronger acid than alcohols (its anion is stabilised by delocalisation) but weaker than carboxylic acids – it does **not** react with carbonates.
- Phenol decolourises **bromine water** and gives a white precipitate **without a catalyst** (the ring is activated by oxygen).
- **Acyl chlorides** react with alcohols/phenols to give esters readily (better than the reversible acid route); misty HCl fumes are the observation.

2 Recap

Worked example – which is the stronger acid?

Explain why phenol is a stronger acid than ethanol but weaker than ethanoic acid.

- All three lose H^+ from an O–H. Stabler anion ⇒ stronger acid.
- Ethoxide: charge stuck on one O ⇒ unstable ⇒ very weak acid.
- Phenoxide: charge delocalised into the ring ⇒ stabler ⇒ reacts with NaOH, not Na_2CO_3.
- Ethanoate: charge spread over two O ⇒ most stable ⇒ fizzes with Na_2CO_3.

> Acid strength = anion stability. The carbonate test separates them: only the carboxylic acid gives CO_2.

Topic 32 – key takeaways

1 Acyl chloride

+ alcohol → ester, fast & complete

2 Phenol

reacts with NaOH (more acidic than alcohol)

3 Acidity

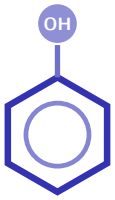
ethanol < water < phenol

4 Activated ring

brominates at room temp, no catalyst

Check yourself

1. What does an acyl chloride make with an alcohol?
2. Why is phenol more acidic than ethanol?
3. Does phenol react with NaOH?
4. What conditions brominate phenol?



Answers **1.** an ester **2.** the phenoxide charge spreads into the ring **3.** yes **4.** bromine water, room temperature, no catalyst