Identification of Phenols

SECOND STAGE | LABORATORY

From visible change to chemical evidence.

Observe carefully. Compare patterns.
Justify your conclusion.



Asst. Lect. Gheith M. Abbas Alasadi
M.Sc. Pharmaceutical Chemistry

One Functional Group. More Than One Clue.

Can one colour reveal the identity of a phenol?



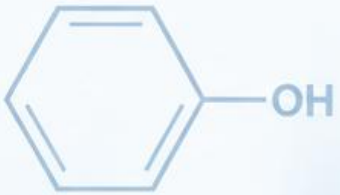
UNKNOWN A



UNKNOWN B



UNKNOWN C



Same appearance does not guarantee the same reaction pattern.

General Objective and Learning Map

GENERAL OBJECTIVE

Recognise phenolic structures and use the lecture's test observations to justify an evidence-based conclusion, while following approved laboratory safety procedures.

1 Engage
Predict before testing

2 Explore
Recognise Ar–OH

3 Explain
Connect reaction and result

4 Practise
Record the evidence

5 Evaluate
Compare and justify

6 Reflect
Identify what is uncertain

Structure → Test result → Chemical meaning → Justified conclusion

What You Will Be Able to Do

By the end of the session, you should be able to:

1. Identify phenolic –OH in at least 4 of 5 structures.
2. Predict an observation for two of the lecture's tests.
3. Separate colour, solid formation and timing from interpretation.
4. Use the reference tables to distinguish two candidate compounds.
5. Support one conclusion with two observations and one limitation.
6. Follow authorised steps and record results honestly.

Now, Let’s Move to Kahoot!

Pre-test activity — answer individually

1. Take out your phone or laptop
2. Scan the QR code or enter the game PIN
3. Answer all questions within the time limit

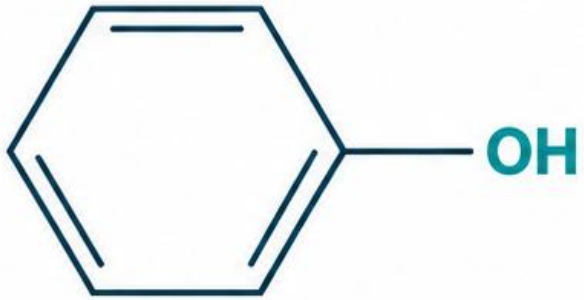


Ready? Let’s begin.

Concept Bridge: Phenol or Alcohol?

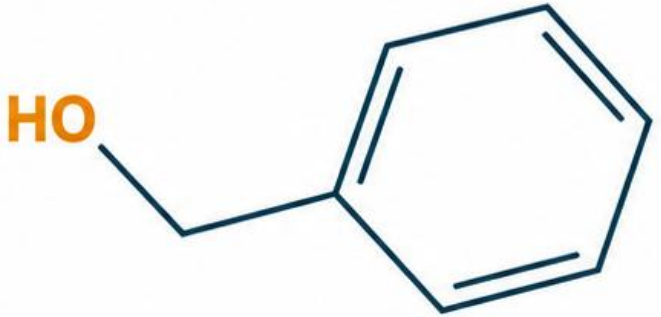
Look at the bond next to oxygen — not just the presence of an –OH group.

Phenol: Ar–OH



–OH is bonded directly to the aromatic ring.

Benzyl alcohol: Ar–CH_2OH

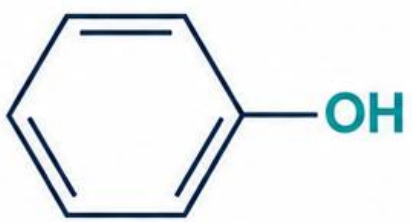


A CH_2 group separates –OH from the ring.

Quick check: Does every compound containing a benzene ring and –OH count as a phenol?

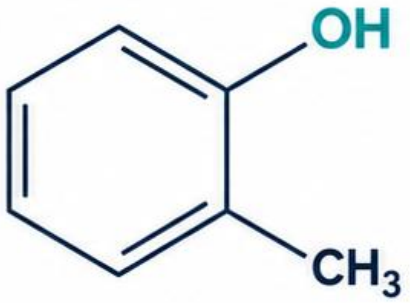
Meet the Phenol Family: Phenol and Cresols

One hydroxyl group; the position of the methyl group changes the isomer.



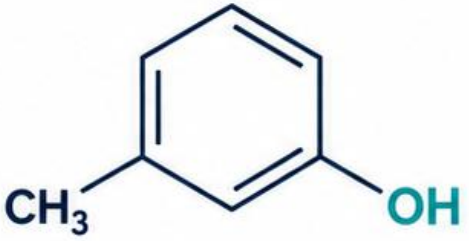
Phenol

Carbolic acid



o-Cresol

2-methylphenol



m-Cresol

3-methylphenol

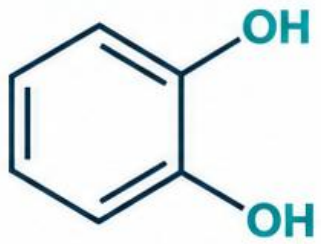


p-Cresol

4-methylphenol

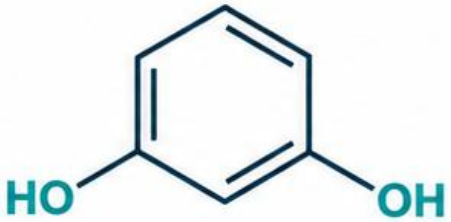
o, m and p describe relative positions on the aromatic ring.

More –OH Groups. A Larger Aromatic System.



Catechol

benzene-1,2-diol



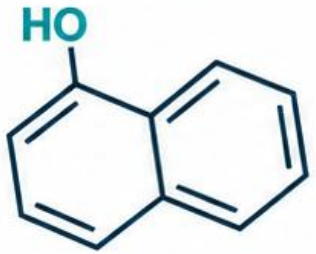
Resorcinol

benzene-1,3-diol



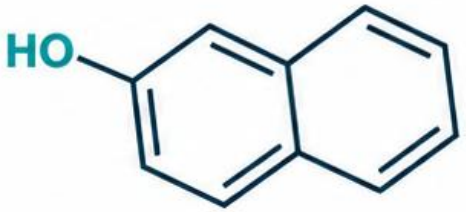
Hydroquinone

benzene-1,4-diol



α-Naphthol

1-naphthol



β-Naphthol

2-naphthol

Physical Properties: Useful Clues, Not Identity

Describe the sample before adding reagents.

1 Appearance

- **Phenols** are **liquids** (e.g. *o*- and *m*-cresol) or **solid crystalline** compounds (e.g. phenol, resorcinol).
- Pure material is usually **colourless**.
- Air oxidation can produce **colour** (yellow, pink or brown).



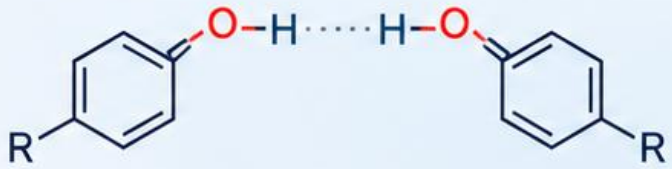
Liquid (o-/m-cresol)



Solid (phenol / resorcinol)

2 Hydrogen bonding

- Phenolic –OH groups can form **hydrogen bonds** with each other (intermolecular).
- They also form hydrogen bonds with water.
- This leads to **higher boiling points** compared with analogous hydrocarbons.



Intermolecular hydrogen bonding between phenol molecules

3 Water solubility

- Phenol itself **dissolves in water** due to hydrogen bonding with water.
- Solubility decreases as molecular weight increases; cresols and naphthols are **poorly water-soluble** for these tests.



Phenol (soluble in water)

o-Cresol (poorly soluble)

Do not identify unknowns by smelling or burning them.

Safety First: Protect Before You Test

SAFETY GUIDANCE

01 Protect skin and eyes

Wear a lab coat, splash goggles and gloves selected for the reagents. Phenol can be absorbed through skin.



02 Control vapours

Use a chemical fume hood for bromine, chloroform and the authorised heating steps.



03 Ask before heating

Concentrated acid and strong base require supervised handling. Review the source's direct-flame step first.



04 Separate and report

Use labelled, fresh portions for different tests. Follow local waste and spill procedures; report incidents immediately.



Run only tests and conditions approved by the laboratory instructor.

Testing Strategy: Five Complementary Views



UNKNOWN PHENOL SAMPLE

Separate labelled portions for separate tests.

1 Ferric chloride

Colour of the complex.



Purple / violet colour

2 Bromine water

Colour loss + new solid.



Decolourization + white/yellowish precipitate

3 Phthalein

Colour after adding base.



Pink/red colour (in alkaline medium)

4 Reimer–Tiemann

Colour of the aqueous layer.



Yellow colour (aqueous layer)

5 Permanganate

Purple loss + brown solid.



Decolourization + brown precipitate

A conclusion should explain the full reaction pattern — including exceptions.

Ferric Chloride: A Colour Is Evidence

Fe^{3+}

SCHEMATIC OBSERVATION



What to record

- The resulting **colour**.
- Whether a **new solid** forms.
- The **difference** from the blank.

A **coloured result** supports a reaction with Fe(III); it does not identify one compound on its own.

Clarification: coloured complex formation is **not a phenol-only identity test.**

Ferric Chloride: Source Procedure

PRACTISE

1 Prepare the aqueous sample

Route A 30–50 mg in 1–2 mL water.



Route B 50–100 mg of solid dissolved in water.



2 Add reagent

Add 1 drop of ferric chloride solution.



3 Observe

Record the resulting colour before discussion.



Compare with a blank

Added quality-control step



Blank
(reagent only)



Sample
(with $FeCl_3$)

Instructor check: $FeCl_3$ stock strength and Route B water volume are not stated in the source.

Formative Checkpoint: Predict → Observe → Explain

Record your prediction before comparing the sample with the reference table.

1 Predict

What visible change do you expect after adding $FeCl_3$?

Write one prediction before the reagent is added.

2 Observe

Record only what you see: colour, a new solid, clarity.

How does the sample differ from the blank?

3 Explain

What does your observation support?

Can one colour identify the unknown? State one limitation.

“I observed _____. This supports _____, but it does not prove _____.”

Ferric Chloride: Reference Observations

Original lecture reference table — compare under the same laboratory conditions.

Compound(s)	Reported colour
Phenol, m-cresol, resorcinol	Violet or blue
o- and p-cresol	Greenish blue
Hydroquinone	Deep green
α- and β-naphthol	No special colour

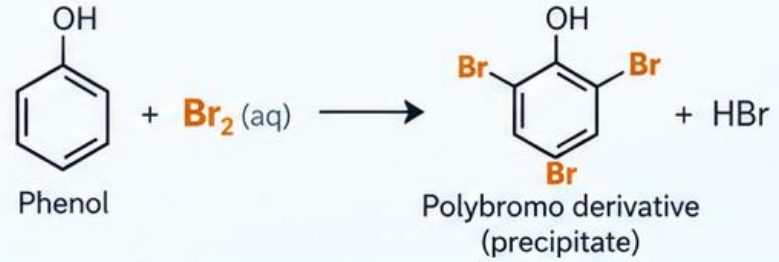
Several compounds share a colour. Use another observation to narrow the possibilities.

Reaction with Bromine Water

Aromatic substitution on the phenyl ring: watch the sequence, not a single clue.

Reaction principle

Phenolic ring + bromine water → loss of bromine colour + polybromo derivative precipitate



1 Start

Use a **concentrated aqueous solution** of the phenol.

First record the **original appearance** before adding reagent.



Phenol solution (before)

2 Add gradually

Add **bromine water gradually**.

Observation 1: bromine colour is decolourized.



3 Then excess

On adding **excess bromine water**, a **white or yellowish-white precipitate** of a polybromo derivative is produced.



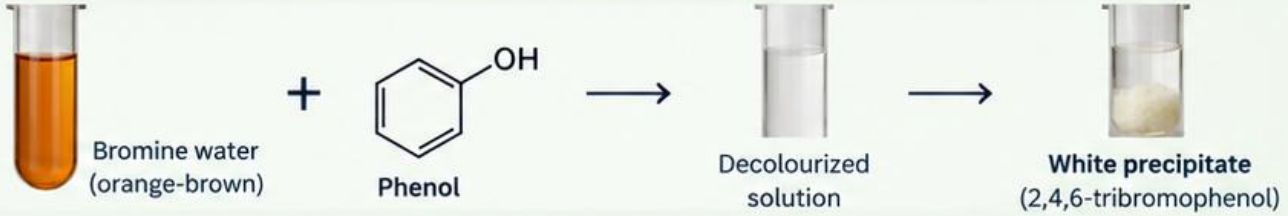
Record the two changes separately: colour loss first, then precipitate formation.

Bromine Water: Exceptions Are Part of the Evidence

Most phenols follow the expected pattern, but three important exceptions must be interpreted carefully.

Expected for most phenols

Bromine decolourization followed by a white/yellowish-white bromo derivative precipitate.



Bromine water (orange-brown) + Phenol → Decolourized solution → **White precipitate** (2,4,6-tribromophenol)

1 Hydroquinone

Not a simple white precipitate pattern.



Bromine water (orange-brown) → Deep red coloration → Deep green crystals separate → Crystals dissolve to give a yellow solution

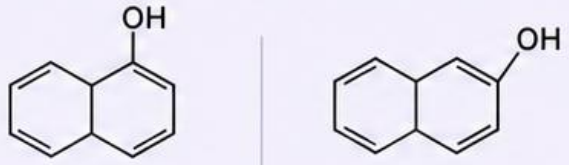


Hydroquinone

On gradually adding bromine water to a solution of hydroquinone, a deep red coloration is produced, followed by separation of deep green crystals which then dissolve giving a yellow solution.

2 α- and β-naphthol

Decolourize bromine water but usually no precipitate is obtained.



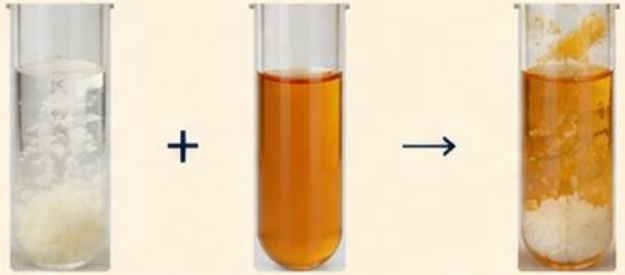
α-Naphthol (1-naphthol) | β-Naphthol (2-naphthol)



Bromine water (orange-brown) → Decolourized solution → **No precipitate (usually)**

3 Poorly soluble phenols

This test is not very satisfactory when phenols are insoluble in water.



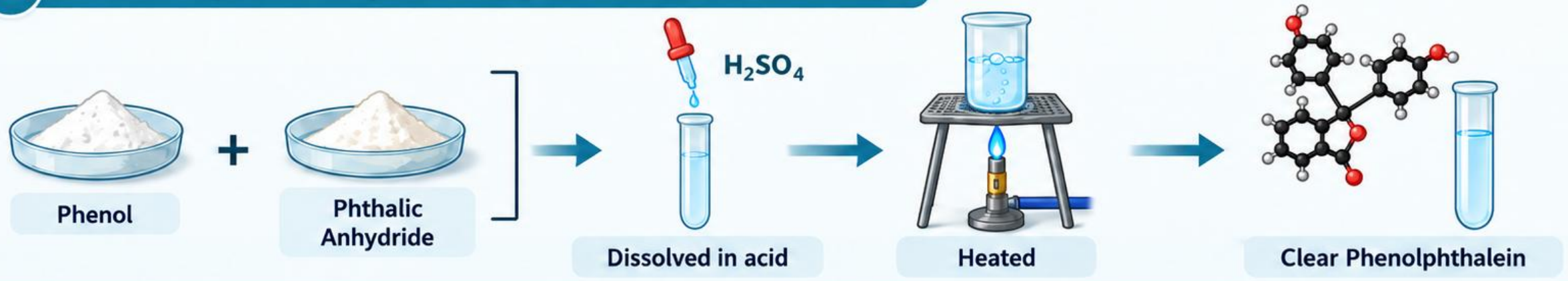
Insoluble phenol (suspension) + Bromine water → Difficult to distinguish the bromo compound from the original phenol.

Conclusion: No single observation is enough; explain the full pattern — including exceptions.

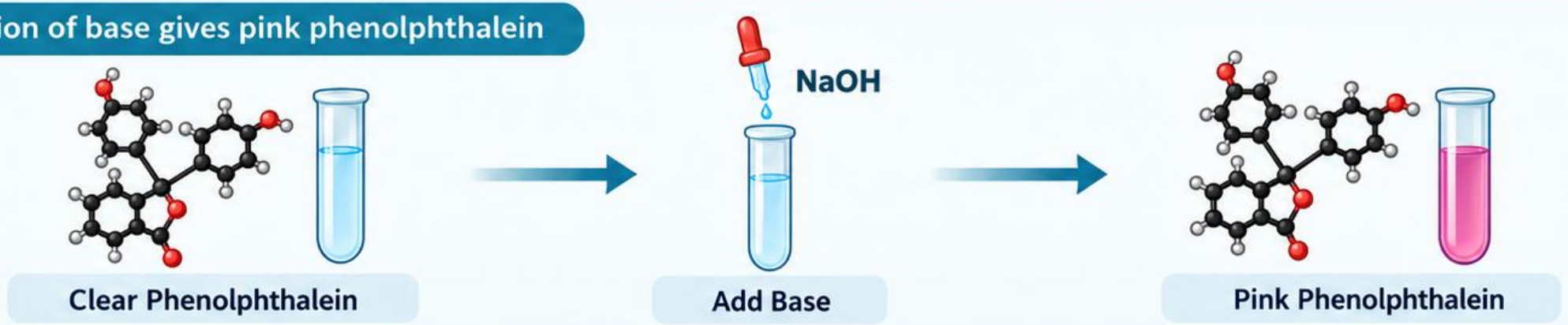
Phthalein Reaction

Phenol reacts with **phthalic anhydride** in acidic conditions and, after heating, forms phenolphthalein, which becomes pink after adding base.

1 Reaction of phenol with phthalic anhydride under acidic conditions



2 Addition of base gives pink phenolphthalein



Phthalein Reaction: Source Steps and Review Point

PRACTISE

1 Prepare

- Dry test tube.
- About 0.1 g phenol + an equal mass of phthalic anhydride or phthalic acid.



2 Acid + heat

- Add 1–2 drops concentrated H_2SO_4.
- Heating / fusion requires instructor approval.



3 Cool + add base

- Cool the tube.
- Then add excess 10% NaOH under supervision.



4 Read the colour

- Compare with the reference table.
- If unclear, the source permits dilution with water.



Source review: “direct flame for 1 minute” is flagged for local safety approval, not routine student use.

Phthalein Reaction: Reference Colours

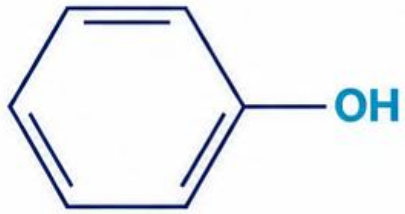
After cooling and adding excess 10% NaOH — original lecture reference table.

Compound	Reported result
α-Naphthol	Green colour
β-Naphthol	Very pale green with slight fluorescence
Phenol	Red to pink
o-Cresol	Red-violet
m-Cresol	Blue to pink
p-Cresol	No change
Resorcinol	Pale red colour with green fluorescence
Hydroquinone	Violet colour

Colour names are retained from the source; compare with a matched reference rather than a colour alone.

Reimer–Tiemann: Reaction and Source Procedure

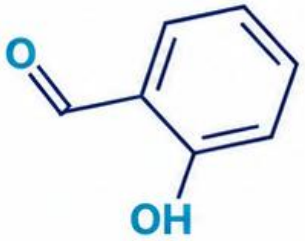
PRACTISE



Phenol

$CHCl_3$ / aqueous NaOH

Formylation of the ring



2-hydroxybenzaldehyde
(ortho example)

Ortho example (para also described)

1 **0.2 g**
Phenol



Weigh 0.2 g phenol.

2 **1 mL**
30% NaOH



Add 1 mL of 30% NaOH.

3 **1 mL**
Chloroform ($CHCl_3$)



Add 1 mL of chloroform.

4 **Water bath**



Observe the aqueous layer.

Reimer–Tiemann: Aqueous-Layer Colours

Record the colour of the aqueous layer, not simply the whole tube.

Compound	Reported aqueous-layer result
Phenol	Yellow or no colour
Resorcinol	Red colour with weak fluorescence
α-Naphthol	Dark green
β-Naphthol	Deep blue that turns to green
o-Cresol	Deep orange
m-Cresol	Pale orange
p-Cresol	Yellow
Hydroquinone	Deep brown

These source reference colours are not a substitute for a complete pattern of evidence.

Reduction of Potassium Permanganate

This test is highly successful with dihydroxylated phenols more than phenol itself.

Procedure

1 Add **0.1 g** of a solid compound or **0.2 mL (3–4 drops)** of a liquid compound to **2 mL** of water or ethanol.



2 Add **2% aqueous potassium permanganate solution** drop by drop with shaking until the purple colour of the permanganate persists.



3 If the permanganate colour is not changed in **0.5–1 minute**, allow the mixture to stand for **5 minutes** with occasional vigorous shaking.



Stand for **5 minutes** with occasional vigorous shaking.

Result / Observation



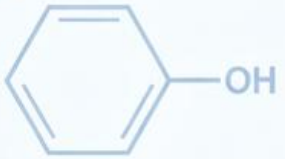
Purple colour of permanganate (present)

The **disappearance of the purple colour** and the **formation of a brown suspension** at the bottom of the test tube indicate a **positive result for the presence of phenols.**

The brown suspension is described in the source as **manganese(II) oxide.**

Watch colour change, time, and brown suspension formation.

Why Do We Need Several Tests?



Each test checks a different chemical behaviour of phenols.

Ferric chloride



Checks complex formation with phenolic –OH.

Clue:
coloured complex

Bromine water



Checks aromatic substitution.

Clue:
decolourization ± white precipitate

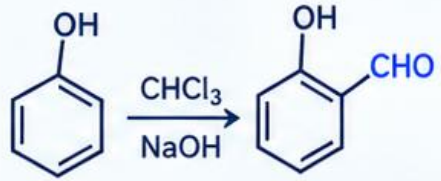
Phthalein reaction



Checks condensation behaviour.

Clue:
colourr appears after base

Reimer–Tiemann



Checks formylation of the ring.

Clue:
aldehyde product forms

$KMnO_4$



Checks oxidation.

Clue:
purple loss + brown MnO_2

One test gives one clue. Several tests give stronger evidence.

This helps distinguish phenols more confidently and explains exceptions.

Student Practice: Build an Evidence Table

Record first. Interpret second. Use only the tests authorised for your group.

Test	Observation	Chemical meaning	Supports / limits
Ferric chloride			
Bromine water			
Phthalein			
Reimer–Tiemann			
Permanganate			

Conclude with at least two supporting observations AND one limitation.

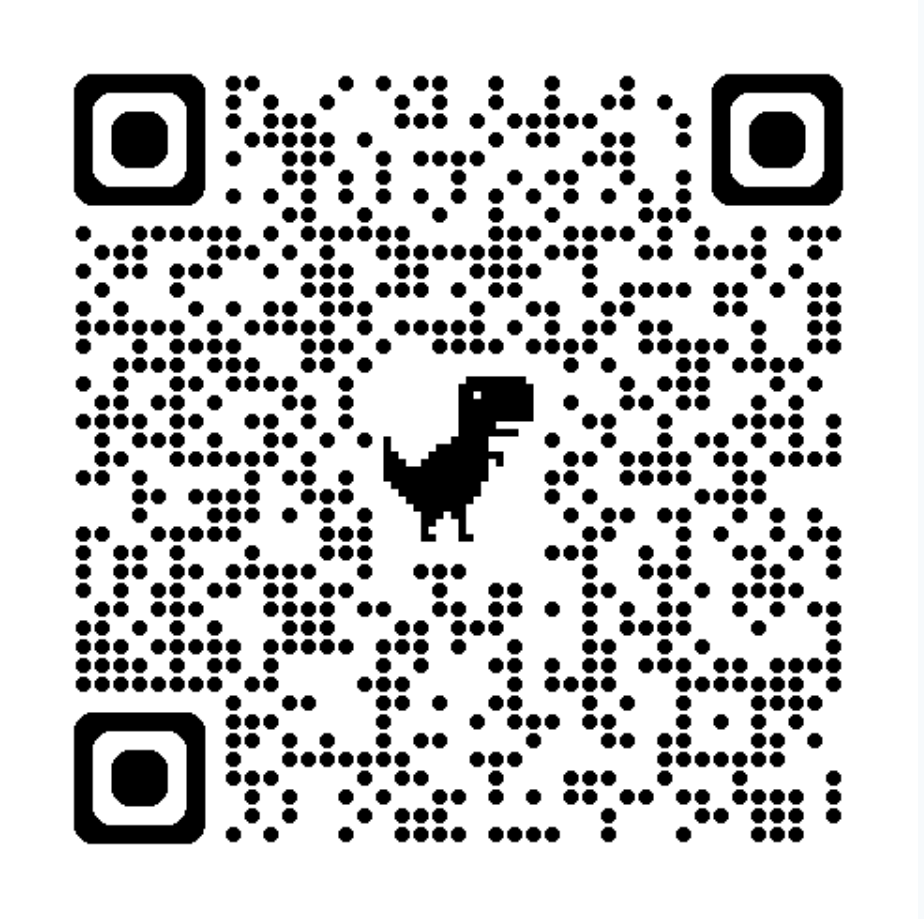
Lecture Summary: From Results to Reasoning

Evidence	What to remember
Structure	Ar–OH: hydroxyl directly on the aromatic ring.
Ferric chloride	Coloured complexes; several compounds may share a result.
Bromine water	Colour loss and new solid; hydroquinone / naphthol exceptions.
Phthalein	Follow acid / heat / cool / base sequence, then compare colour.
Reimer–Tiemann	Observe the aqueous layer; compare the source reference table.
Permanganate	Purple loss + brown product; controls and specificity matter.

One observation is a clue. A consistent pattern supports a conclusion.

Post-Test: Scan and Answer

Identification of Phenols | Individual response



Thank You

Questions and Discussion

Observe carefully. Explain honestly.



