What's in a Medicine? (WM)

Revision guide

Clarity, confidence, and top grades.

What this storyline covers

- Functional groups: alcohols, phenols, acids, esters
- Aldehydes, ketones and ethers
- Reactions of alcohols
- Properties of phenols
- Making and purifying organic products
- Mass spectrometry
- Infrared spectroscopy
- Green chemistry

Required practicals in this storyline: phenol and alcohol tests (**PAG7**), and the synthesis and purification of a solid (**PAG6**) and a liquid (**PAG5**) organic product.



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How to use this guide

What's in a Medicine? develops the chemistry of the **–OH group** — alcohols and phenols — alongside carboxylic acids and esters, and introduces two analytical tools you will use throughout A-level: **infrared** and **mass spectrometry**. The practical techniques here (reflux, distillation, recrystallisation and TLC) underpin every organic preparation in the course, and aspirin is the running example.

How it is assessed

OCR B is context-led, so WM content can appear in **any** of the three written papers, in any context:

- **Paper 1** — Fundamentals of chemistry (110 marks)
- **Paper 2** — Scientific literacy, including the pre-release Advance Notice article (100 marks)
- **Paper 3** — Practical skills in chemistry (60 marks)

How to revise it

- Learn the **definitions in the teal boxes** word-for-word — they are marks you can guarantee.
- Work every **worked example** yourself before reading the solution.
- Learn the **tests, conditions and observations** exactly — reagents and colour changes are common marks.
- Use the **spec checklist** on the last page to confirm you can do every point.

1 Functional groups and families

Spec references: WM(a), WM(b).

Family	Functional group	Example
Alcohol	–OH	ethanol, CH_3CH_2OH
Phenol	–OH joined directly to a benzene ring	phenol, C_6H_5OH
Carboxylic acid	–COOH	ethanoic acid, CH_3COOH
Ester	–COO–	ethyl ethanoate, $CH_3COOC_2H_5$
Acid anhydride	$(RCO)_2O$	ethanoic anhydride, $(CH_3CO)_2O$
Aldehyde	–CHO	ethanal, CH_3CHO
Ketone	C=O within the chain	propanone, CH_3COCH_3
Ether	R–O–R	methoxymethane, CH_3OCH_3

Primary, secondary and tertiary alcohols WM(b)

- **Primary (1°):** the carbon bonded to the –OH is attached to **one** other carbon (or none, as in methanol).
- **Secondary (2°):** the –OH carbon is attached to **two** other carbons.
- **Tertiary (3°):** the –OH carbon is attached to **three** other carbons.
- This classification decides how the alcohol behaves on **oxidation** (see §2).

2 Reactions of alcohols

Spec references: WM(d), WM(h). Practical: PAG7.

Esterification WM(d)

- Alcohol + carboxylic acid → **ester** + water, warmed with a **concentrated H_2SO_4** (or concentrated HCl) catalyst. Example: ethanol + ethanoic acid → ethyl ethanoate + water.
- Alcohols (and phenols) also form esters with **acid anhydrides**.

Oxidation WM(d)

Warm with **acidified potassium dichromate(VI)** (H_2SO_4 / $K_2Cr_2O_7$); the orange dichromate turns **green** when oxidation occurs.

Alcohol	Product	Note
Primary	aldehyde, then carboxylic acid	**distil** to stop at the aldehyde; **reflux** with excess oxidant for the acid
Secondary	ketone	no further oxidation
Tertiary	not oxidised	stays orange — no reaction

Dehydration and substitution WM(d), WM(h)

Key definition

An **elimination reaction** removes a small molecule (here water) from a single reactant to form a **double bond**.

- **Dehydration (elimination):** alcohol → **alkene** + water, by passing the vapour over **heated Al_2O_3** or refluxing with **concentrated H_2SO_4**.
- **Substitution:** alcohol → **haloalkane**, for example by reaction with a hydrogen halide, in which the –OH is replaced by a halogen.

3 Phenols

Spec reference: WM(c). Practical: PAG7.

A **phenol** has an –OH group joined **directly to a benzene ring**, and it behaves differently from an alcohol.

Acidity WM(c)

- Phenols are **weakly acidic**: they react with **alkalis** (e.g. NaOH) to form salts, but **not** with carbonates.
- **Carboxylic acids are stronger**: they react with **both alkalis and carbonates**, releasing CO_2. So a carboxylic acid **fizzes** with sodium carbonate while a phenol does not — a useful way to tell them apart.

Tests and ester formation WM(c)

- **Iron(III) chloride test:** add **neutral iron(III) chloride** solution — a phenol gives a **purple** colouration.
- **Ester formation:** phenols react with **acid anhydrides** (but not with carboxylic acids) to form esters. This underlies the **aspirin** synthesis: salicylic acid reacts with ethanoic anhydride.

4 Making and purifying organic products

Spec references: WM(e), WM(f). Practicals: PAG6 (solid), PAG5 (liquid).

Purifying a solid: recrystallisation WM(e) — PAG6

- Dissolve the impure solid in the **minimum volume of hot solvent**, then **filter hot** to remove insoluble impurities.
- **Cool** to crystallise the product; soluble impurities stay in solution. **Filter under reduced pressure** (vacuum filtration), then wash and dry the crystals.
- **Choice of solvent:** the product should be much more soluble hot than cold, while impurities are either very soluble (and stay dissolved) or insoluble (and are filtered off hot).

Checking purity: melting point and TLC WM(e)

- A **pure solid** has a **sharp** melting point; impurities **lower** it and make it melt over a **range**. Compare with the data-book value.
- **Thin-layer chromatography (TLC):** spot the sample on a plate, run it in a solvent, then locate the spots (under UV or with a stain). A pure compound gives **one spot**.

Worked example — R_f value

On a TLC plate a spot moves 3.6 cm while the solvent front moves 4.8 cm. Find its R_f value.

R_f = distance moved by spot / distance moved by solvent = 3.6 / 4.8 = 0.75

Making and purifying a liquid WM(f) — PAG5

- **Heating under reflux:** heat the mixture with a **vertical condenser** so vapours condense and return, allowing prolonged heating without losing volatile substances.
- **Distillation:** separate the product by **boiling point**, collecting the fraction over the right temperature range.
- **Separating funnel:** shake the product with an aqueous wash to remove soluble impurities, run off and discard the aqueous layer, then **dry** the organic layer.

5 Mass spectrometry

Spec reference: WM(i).

- The **molecular ion peak (M^+)** — the peak at the highest m/z, apart from M+1 — gives the **molecular mass (M_r)** of the compound.
- **Fragment peaks:** the molecular ion breaks into smaller positive ions. The masses lost help identify the structure, e.g. loss of 15 = CH_3, loss of 17 = OH, loss of 29 = CHO or C_2H_5.
- The small **M+1 peak** (one unit above M^+) is caused by the small proportion of **carbon-13** present. Calculations based on the M+1 peak are not required.

Worked example — reading a mass spectrum

A compound shows M^+ at 46 and a fragment at 31.

$M^+ = 46 \rightarrow M_r = 46$

loss of 15 (a CH_3 group) leaves 31 = CH_2OH^+ → the compound is ethanol, CH_3CH_2OH

6 Infrared spectroscopy

Spec reference: WM(j).

- Bonds **absorb infrared radiation** and vibrate more (stretching and bending). Each type of bond absorbs at a characteristic **wavenumber** (cm^{-1}).
- The absorptions show which **functional groups** are present. The **Data Sheet gives the ranges**, so you interpret the spectrum rather than recall the values.

Bond	Where it appears (typical)
O–H (alcohol)	broad, around 3200–3550 cm^{-1}
O–H (carboxylic acid)	very broad, around 2500–3300 cm^{-1}
C=O	strong, around 1700 cm^{-1}
C–H	around 2850–3100 cm^{-1}

Exam tip — use IR to follow a reaction

IR shows when a functional group has changed. On oxidising a primary alcohol to a carboxylic acid, the alcohol **O–H** is replaced by a strong **C=O** peak and a very broad acid **O–H**. Always read the values from the Data Sheet.

7 Green chemistry

Spec reference: WM(g).

Green chemistry aims to make industrial processes more **sustainable** and less harmful. You are expected to apply the ideas behind the **12 principles of green chemistry** to given information, rather than to quote them.

- Use a **high atom economy** and produce **less waste**.
- Use **safer reagents and solvents**, and **renewable feedstocks** where possible.
- Save **energy** by using mild conditions and **catalysts**.
- Design **safer products** and avoid hazardous substances.

P Required practicals in this storyline

These PAG activities are most likely to be examined in Paper 3, but the techniques can appear in any paper.

Activity	What to be able to do
Tests for alcohols and phenols (PAG7)	use iron(III) chloride (purple for a phenol), sodium carbonate (fizz for a carboxylic acid, not a phenol) and acidified dichromate (orange to green for primary and secondary alcohols)
Solid organic product (PAG6)	e.g. aspirin — carry out the synthesis, recrystallise, filter under reduced pressure, and check purity by melting point and TLC
Liquid organic product (PAG5)	e.g. an ester or haloalkane — heat under reflux, distil, wash in a separating funnel, and dry

Exam tip — explain why each step works

Marks come from the reasoning, not just the method: hot filtration removes **insoluble** impurities, cooling **crystallises the product** while soluble impurities stay dissolved, and a **sharp melting point** confirms purity. For spectra, quote the **wavenumber** and the **functional group** it shows.

Spec coverage checklist — can you do every point?

Every assessable learning outcome for What's in a Medicine?, with where it is covered in this guide. Tick each one once you can do it confidently.

WM(a)	Formulae of carboxylic acids, phenols, acid anhydrides, esters, aldehydes, ketones and ethers — §1
WM(b)	Primary, secondary and tertiary alcohols by structure — §1
WM(c)	Properties of phenols: acidity, iron(III) chloride test, ester formation with anhydrides — §3
WM(d)	Reactions of alcohols: esterification, oxidation (with conditions), dehydration, substitution — §2
WM(e)	Making and purifying a solid product; recrystallisation, melting point, TLC — §4
WM(f)	Making and purifying a liquid product; reflux, distillation, separating funnel — §4
WM(g)	The principles of green chemistry in industrial processes — §7
WM(h)	The term elimination reaction — §2
WM(i)	Interpreting mass spectra: M^+, fragment peaks and the M+1 peak — §5
WM(j)	Interpreting infrared spectra in terms of functional groups — §6