

# Oxidising alcohols and testing carbonyl compounds

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Worksheet

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

These 20 problems train you to classify alcohols, predict oxidation products and apparatus, identify carbonyl compounds from test results and describe nucleophilic addition. They suit A Level, IB Chemistry and Class 11-12 students working on organic chemistry. Levels 1 and 2 build recall and short calculations; level 3 asks for multi-step reasoning, titration data, spectra and mechanism checking. Show formulae, write equations in full and give units.

**Level:** Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.3.5

## Problem 1 Classify the alcohols (easy)

Chiamaka in Lagos lists four alcohols: butan-1-ol, butan-2-ol, 2-methylpropan-1-ol and 2-methylpropan-2-ol.

1. Classify each as primary, secondary or tertiary.
2. State which one resists oxidation.
3. Explain how you decided.

## Problem 2 Colour of dichromate (easy)

Aarav in Pune warms ethanol with acidified potassium dichromate(VI).

1. State the colour change.
2. Name the species responsible for each colour.
3. Predict the observation if 2-methylpropan-2-ol is used.

## Problem 3 Oxidising propan-1-ol (easy)

Propan-1-ol can be oxidised in two ways depending on the apparatus.

1. Name the product when the mixture is distilled.
2. Name the product when it is heated under reflux with excess oxidant.
3. Write an equation for each step using [O].

## Problem 4 Oxidising propan-2-ol (easy)

Propan-2-ol is heated under reflux with acidified dichromate.

1. Name the product and its functional group.
2. Write the equation using [O].
3. Explain why the oxidation stops at this stage.

**Problem 5 Reading the carbonyl tests** (easy)

Wanjiru in Nairobi tests ethanal and propanone.

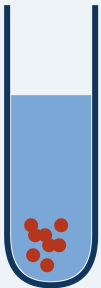
**Positive results for an aldehyde such as ethanal**



**2,4-DNPH**  
orange precipitate



**Tollens'**  
silver mirror



**Fehling's**  
brick-red precipitate

A ketone gives the DNPH precipitate only

Carbonyl tests: DNPH detects any C=O; Tollens' and Fehling's detect aldehydes only.

1. State the results of Tollens' reagent with each compound.
2. State the results of 2,4-DNPH with each compound.
3. Identify which test can separate them.

**Problem 6 Reducing carbonyls** (easy)

Sodium borohydride reduces carbonyl compounds.

1. Name the product from propanal.
2. Name the product from butanone.
3. Classify each product as primary, secondary or tertiary.

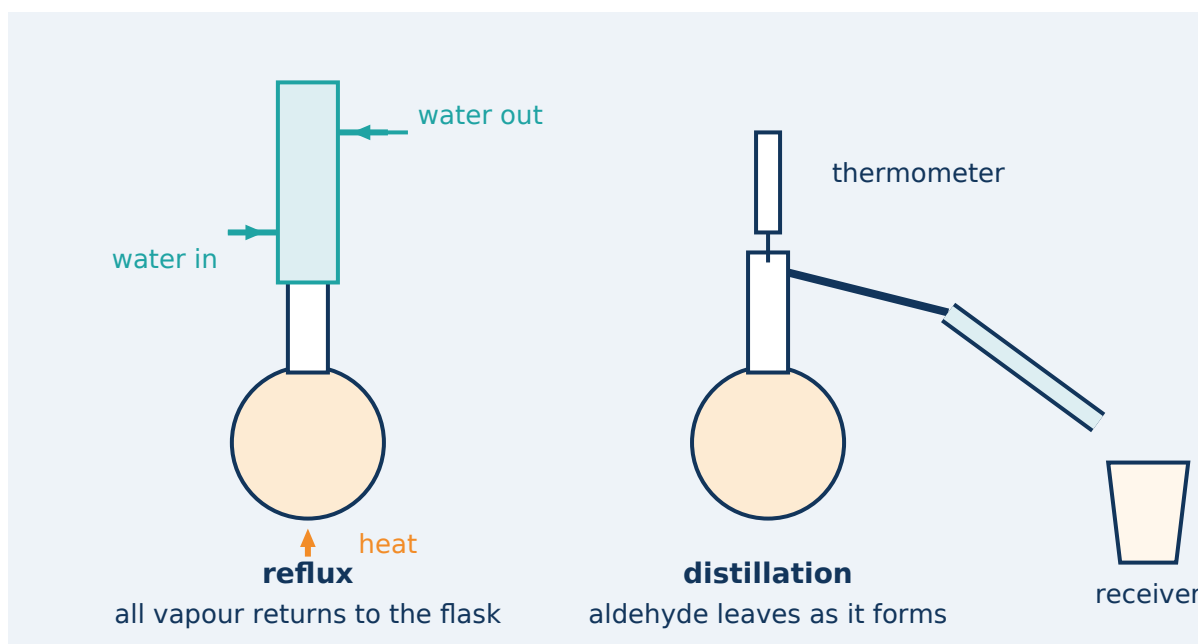
**Problem 7 Yield of a ketone** (medium)

Emma in Leeds oxidises 8.80 g of pentan-2-ol ( $M = 88.0 \text{ g/mol}$ ) to pentan-2-one ( $M = 86.0 \text{ g/mol}$ ) and collects 6.45 g.

1. Calculate the amount of alcohol.
2. Calculate the theoretical mass of ketone.
3. Calculate the percentage yield.

**Problem 8 Distilling an aldehyde** (medium)

Look at the set-ups for reflux and distillation.



*Reflux keeps the mixture in the flask until oxidation is complete; distillation removes the lower-boiling aldehyde at once.*

1. State which apparatus is used to make propanal from propan-1-ol.
2. Explain why.
3. Give one use of anti-bumping granules.

### Problem 9 Boiling points and hydrogen bonds (medium)

Propan-1-ol boils at 97 °C, propanal at 49 °C and propanoic acid at 141 °C.

1. Name the strongest intermolecular force in each liquid.
2. Explain why propanal boils at the lowest temperature.
3. Suggest why propanoic acid boils highest.

### Problem 10 Two isomers of C<sub>3</sub>H<sub>6</sub>O (medium)

Two liquids have the formula C<sub>3</sub>H<sub>6</sub>O. Liquid P gives an orange precipitate with 2,4-DNPH and a silver mirror with Tollens' reagent. Liquid Q gives the orange precipitate only.

1. Identify P and Q.
2. Name the functional group each contains.
3. Explain why Q does not react with Tollens' reagent.

### Problem 11 Naming hydroxynitriles (medium)

Write the structure and name of the product of HCN with:

1. ethanal
2. propanone
3. State which product is chiral.

**Problem 12 Why C=O is attacked by nucleophiles** (medium)

Explain.

1. Why is the C=O bond polar?
2. Why does a nucleophile attack the carbon, not the oxygen?
3. Why are alkenes attacked by electrophiles whereas aldehydes are attacked by nucleophiles?

**Problem 13 Tertiary or secondary** (medium)

Bilal in Lahore has two unlabelled C<sub>5</sub> alcohols: pentan-2-ol and 2-methylbutan-2-ol.

1. Describe a test that distinguishes them.
2. State the result for each.
3. Name the organic product from the one that reacts.

**Problem 14 Racemic mixtures** (medium)

Ethanal reacts with HCN.

1. Name the product.
2. State how many stereoisomers form and in what ratio.
3. Explain why the product mixture does not rotate plane-polarised light.

**Problem 15 Identifying by melting point** (medium)

Kofi in Accra makes the 2,4-DNPH derivative of an unknown carbonyl compound. It melts at 154 °C. Derivatives of known compounds melt at: ethanal 168 °C, propanal 154 °C, propanone 126 °C, butanone 115 °C.

1. Identify the unknown.
2. The unknown gives a silver mirror. Does this agree?
3. Explain why the derivative is recrystallised before the melting point is taken.

**Problem 16 Alcohol in wine** (hard)

Mei in Singapore analyses a light wine. 5.00 cm<sup>3</sup> of wine is diluted to 250 cm<sup>3</sup>. A 25.0 cm<sup>3</sup> portion needs 18.4 cm<sup>3</sup> of 0.0200 mol/dm<sup>3</sup> K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> in excess acid. The balanced equation is  $3\text{C}_2\text{H}_5\text{OH} + 2\text{Cr}_2\text{O}_7^{2-} + 16\text{H}^+ \rightarrow 3\text{CH}_3\text{COOH} + 4\text{Cr}^{3+} + 11\text{H}_2\text{O}$ .

1. Show that the equation balances for atoms and charge.
2. Calculate the amount of ethanol in the 25.0 cm<sup>3</sup> portion.
3. Calculate the percentage by volume of ethanol in the wine (M = 46.0 g/mol, density 0.789 g/cm<sup>3</sup>).

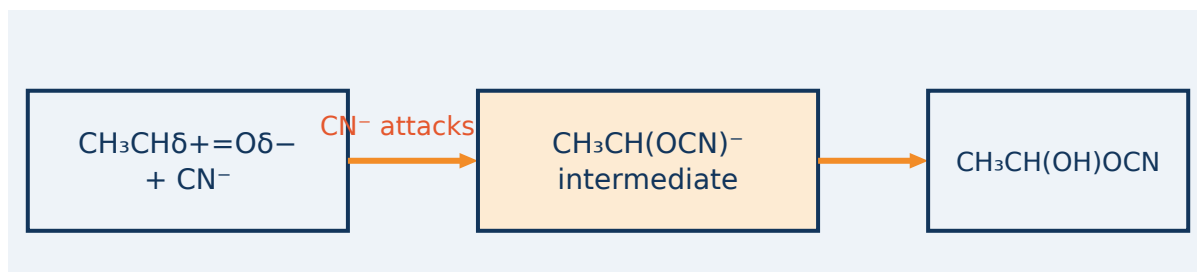
**Problem 17 Four butanols** (hard)

Four alcohols W, X, Y and Z have the formula C<sub>4</sub>H<sub>10</sub>O. W is oxidised to a straight-chain compound that gives a silver mirror. X is oxidised to a ketone. Y does not react with acidified dichromate. Z is oxidised to a branched compound that gives a silver mirror.

1. Identify W, X, Y and Z.
2. Give the name of each oxidation product.
3. Explain how you ruled out the other structures.

### Problem 18 Find the error in the mechanism (hard)

A student drew this scheme for ethanal and HCN.



*A student scheme for ethanal and HCN. It contains an error to find.*

1. Identify the main error.
2. Draw the correct intermediate and product (formulae).
3. State what kind of species  $\text{CN}^-$  is and why it attacks that atom.

### Problem 19 Identify a compound by data (hard)

Compound X has  $\text{M}^+$  at  $m/z$  72 and the formula  $\text{C}_4\text{H}_8\text{O}$ . Its infrared spectrum shows a strong peak at  $1715\text{ cm}^{-1}$  and no broad peak near  $3300\text{ cm}^{-1}$ . It gives an orange precipitate with 2,4-DNPH but no silver mirror.

1. Explain what each piece of evidence shows.
2. Name X.
3. Give the structure of the product with HCN and state whether it is chiral.

### Problem 20 Silver from ethanal (hard)

Diego in Texas warms  $2.20\text{ g}$  of ethanal ( $M = 44.0\text{ g/mol}$ ) with excess Tollens' reagent. Each aldehyde molecule produces two silver atoms ( $\text{Ag} = 107.9\text{ g/mol}$ ).

1. Calculate the amount of ethanal.
2. Calculate the mass of silver deposited.
3. Calculate the minimum volume of  $0.200\text{ mol/dm}^3$  silver nitrate needed.