A-Level Chemistry

Oxidation of Alcohols

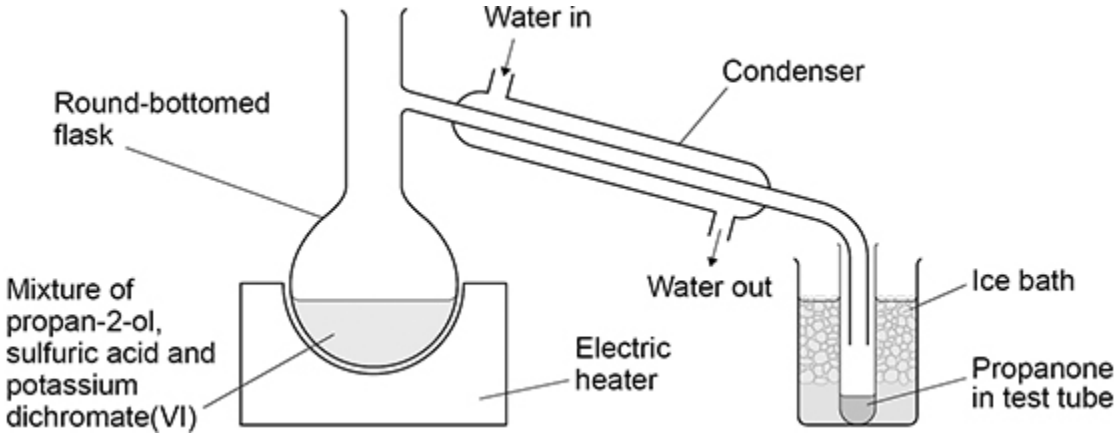
Question Paper

Time available: 88 minutes
Marks available: 73 marks

1. Propanone can be made by reacting propan-2-ol with an excess of acidified potassium dichromate(VI).

The propanone is removed from the reaction mixture by distillation.

(a) The figure below shows the apparatus set up by a student to make propanone by this method. Suitable clamps are used to hold all the apparatus firmly in place.



There are **three** problems with the apparatus set up in the figure above.

For each problem:

- identify the problem
- describe the issue it would cause
- suggest how the problem can be solved.

(6)

Another student completes the experiment using apparatus that is set up correctly.

(b) The student reacts 2.0 cm^3 of propan-2-ol ($CH_3CH(OH)CH_3$) with an excess of acidified potassium dichromate(VI).

The student obtains 0.954 g of propanone (CH_3COCH_3).

Calculate the percentage yield of propanone in this experiment.
Give your answer to the appropriate number of significant figures.

Density of propan-2-ol = 0.786 g cm^{-3}

Percentage yield _____

(4)

(c) Molecules of propan-2-ol and propanone each contain three carbon atoms.

Complete the table below to suggest the shape and a bond angle around the central C atom in a molecule of each compound.

Compound	propan-2-ol $CH_3CH(OH)CH_3$	propanone CH_3COCH_3
Shape around central C atom		
Bond angle around central C atom		

(2)

(d) Explain why propanone has a lower boiling point than propan-2-ol.

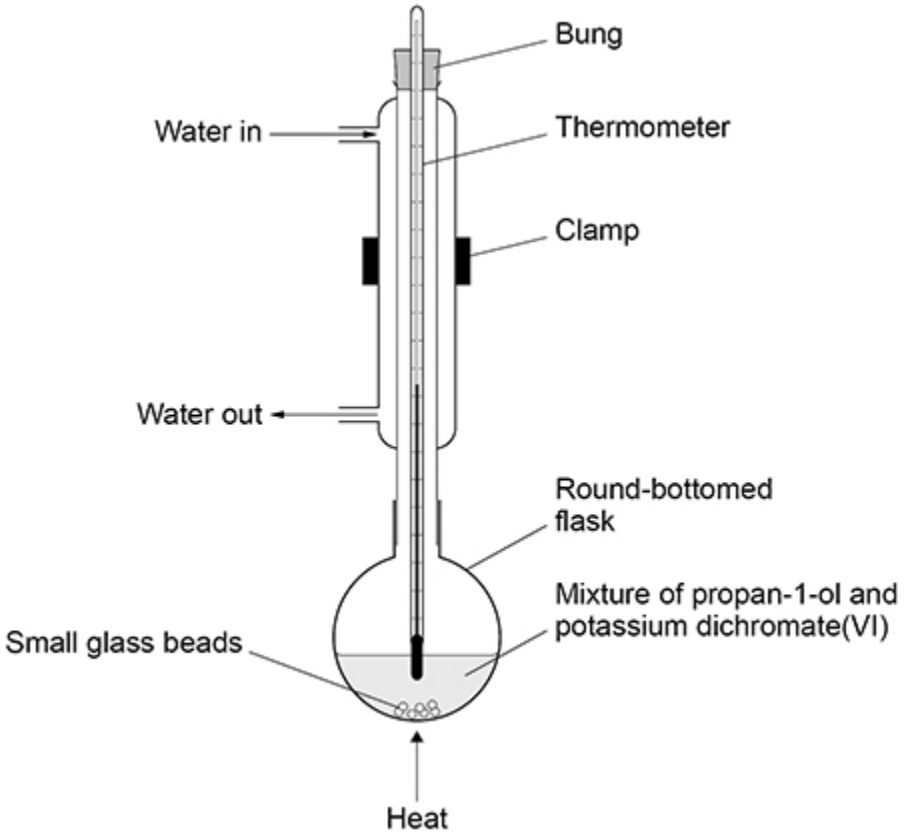
(3)

(Total 15 marks)

2. A student plans an experiment to investigate the yield of propanoic acid when a sample of propan-1-ol is oxidised.

The figure below shows the apparatus that the student plans to use for the experiment.

The student's teacher says that the apparatus is not safe.



(a) Give **two** reasons why the apparatus shown in above figure is not safe.

1 _____

_____

2 _____

_____

(2)

(b) Give **one** additional reagent that is needed to form any propanoic acid.

_____

(1)

(c) State **two** more mistakes in the way the apparatus is set up in above figure.

1 _____

_____

2 _____

_____

(2)

(d) State the purpose of the small glass beads in the flask in above figure.

_____

_____

_____

(1)

(e) After correcting the mistakes, the student heats a reaction mixture containing 6.50 g of propan-1-ol with an excess of the oxidising agent.
The propanoic acid separated from the reaction mixture has a mass of 3.25 g

State the name of the technique used to separate the propanoic acid from the reaction mixture.

Calculate the percentage yield of propanoic acid.

Technique _____

Percentage yield _____

(4)

(f) State a simple chemical test that distinguishes the propanoic acid from the propan-1-ol.

Give **one** observation for the test with each substance.

Test _____

Propanoic acid _____

Propan-1-ol _____

(3)

(Total 13 marks)

3. Ethanol can be oxidised by acidified potassium dichromate(VI) to ethanoic acid in a two-step process.

ethanol ⟶ ethanal ⟶ ethanoic acid

(a) In order to ensure that the oxidation to ethanoic acid is complete, the reaction is carried out under reflux.

Describe what happens when a reaction mixture is refluxed and why it is necessary, in this case, for complete oxidation to ethanoic acid.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

(b) Write a half-equation for the overall oxidation of ethanol into ethanoic acid.

_____

(1)

(c) The boiling points of the organic compounds in a reaction mixture are shown in the following table.

Compound	ethanol	ethanal	ethanoic acid
Boiling point / °C	78	21	118

Use these data to describe how you would obtain a sample of ethanal from a mixture of these three compounds. Include in your answer a description of the apparatus you would use and how you would minimise the loss of ethanal. Your description of the apparatus can be either a description in words or a labelled sketch.

(5)

(d) Use your knowledge of structure and bonding to explain why it is possible to separate ethanal in this way.

(2)

(e) A student obtained a sample of a liquid using the apparatus in part **(c)**.

Describe how the student could use chemical tests to confirm that the liquid contained ethanal and did **not** contain ethanoic acid.

_____

_____

_____

_____

_____

_____

_____

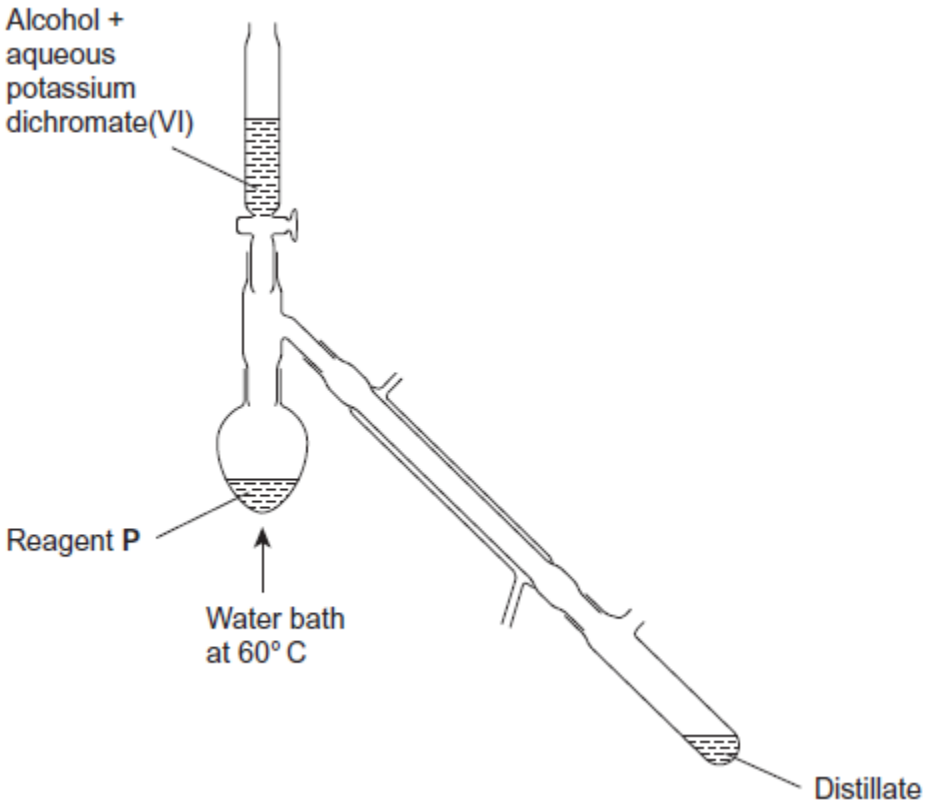
_____

(5)

(Total 16 marks)

4. This question concerns the oxidation of a primary alcohol.

The experiment was carried out using the distillation apparatus shown in the diagram. The oxidation product was distilled off as soon as it was formed.



(a) Suggest the identity of reagent **P**.

_____

(1)

(b) State the chemical change that causes the solution in the flask to appear green at the end of the reaction.

_____

(1)

(c) Give **one** reason why using a water bath is better than direct heating with a Bunsen burner.

_____

_____

(1)

(d) Suggest a reagent that could be used to confirm the presence of an aldehyde in the distillate.
State the observation you would expect to make if an aldehyde were present.

Reagent _____

Observation _____

(2)

(Total 5 marks)

5. Consider the following reaction schemes involving two alcohols, **A** and **B**, which are position isomers of each other.

$CH_3CH_2CH_2CH_2OH \rightarrow CH_3CH_2CH_2CHO \rightarrow CH_3CH_2CH_2COOH$

A butanal butanoic acid

$CH_3CH_2CH(OH)CH_3 \rightarrow CH_3CH_2COCH_3$

B **C**

(a) State what is meant by the term *position isomers*.

_____

_____

_____

(2)

(b) Name compound **A** and compound **C**.

*Compound **A*** _____

*Compound **C*** _____

(2)

(c) Each of the reactions shown in the schemes above is of the same type and uses the same combination of reagents.

(i) State the type of reaction.

_____

(ii) Identify a suitable combination of reagents.

_____

(iii) State how you would ensure that compound **A** is converted into butanoic acid rather than into butanal.

_____

_____

(iv) Draw the structure of an isomer of compound **A** which does not react with this combination of reagents.

(v) Draw the structure of the carboxylic acid formed by the reaction of methanol with this combination of reagents.

(6)

(d) (i) State a reagent which could be used to distinguish between butanal and compound **C**.

_____

(ii) Draw the structure of another aldehyde which is an isomer of butanal.

(2)

(Total 12 marks)

6. (a) One of the isomers in part (a) is resistant to oxidation by acidified potassium dichromate(VI).

(i) Identify this isomer.

_____

(ii) This isomer can be dehydrated. Give a suitable dehydrating agent and write an equation for this dehydration reaction.

Dehydrating agent _____

Equation _____

(3)

(b) (i) Identify the isomer in part (a) which can be oxidised to a ketone. Give the structure of the ketone formed.

Isomer _____

Structure of the ketone

(ii) Identify **one** of the isomers in part (a) which can be oxidised to an aldehyde. Give the structure of the aldehyde formed.

Isomer _____

Structure of the aldehyde

(iii) Give a reagent that can be used in a test to distinguish between a ketone and an aldehyde. State what you would observe in the test.

Reagent _____

Observation with ketone _____

_____

Observation with aldehyde _____

_____

(7)

(c) Butan-1-ol can be oxidised to form a carboxylic acid. Using [O] to represent the oxidising agent, write an equation for this reaction and name the product.

Equation _____

Name of product _____

(2)

(Total 12 marks)