

1 (a) For each of the following reactions, identify a catalyst and name the organic product of the reaction.

1 (a) (i) The fermentation of an aqueous solution of glucose.

Catalyst

Name of organic product

(2 marks)

1 (a) (ii) The hydration of but-2-ene.

Catalyst

Name of organic product

(2 marks)

2 (a) Give the **formula** of a Group 2 metal hydroxide used in agriculture.

.....
(1 mark)

(b) Identify a sodium halide that does **not** undergo a redox reaction when added as a solid to concentrated sulfuric acid.

.....
(1 mark)

(c) Chlorine gas reacts with cold dilute sodium hydroxide solution to form sodium chloride and another chlorine-containing compound, **X**. Give the **formula** of **X**.

.....
(1 mark)

(d) Give the **formula** of the substance responsible for the orange colour when chlorine gas is bubbled through an aqueous solution of sodium bromide.

.....
(1 mark)

(e) Solid sodium iodide undergoes a redox reaction with concentrated sulfuric acid. Give the **formula** for each of the following in this reaction.

Formula of the solid reduction product

Formula of the oxidation product

(2 marks)

(f) Draw the structure of each of the following organic compounds.

(f) (i) The hydrocarbon that is a chain isomer of methylpropene, but does **not** exhibit E-Z stereoisomerism.

(1 mark)

(f) (ii) The alcohol that is a position isomer of butan-2-ol.

(1 mark)

(f) (iii) The hydrocarbon that has a peak, due to its molecular ion, at $m/z = 44$ in its mass spectrum.

(1 mark)

(f) (iv) The bromoalkane that reacts with sodium cyanide to produce propanenitrile.

3

Metals are usually extracted from oxides.
Some of these oxides occur naturally. Other oxides are made by roasting sulfide ores in air, producing sulfur dioxide as a by-product.
For the extraction of some metals, the oxide needs to be converted into a chloride.

(a) The ore molybdenite contains molybdenum disulfide (MoS_2).
The first stage in the extraction of molybdenum is to roast the ore in air to form molybdenum oxide (MoO_3) and sulfur dioxide.

(a) (i) Write an equation for the first stage in this extraction.

.....
(1 mark)

(a) (ii) The release of sulfur dioxide into the atmosphere causes environmental problems and wastes a valuable resource. Identify **one** environmental problem and identify **one** use for the sulfur dioxide.

Environmental problem

.....

.....

Use for sulfur dioxide

.....

.....
(2 marks)

(a) (iii) Pure molybdenum is formed in the second stage by the reduction of MoO_3 using hydrogen.
Write an equation for this reaction.

.....
(1 mark)

(a) (iv) State **one** risk in using hydrogen gas in metal extractions.

.....

.....
(1 mark)

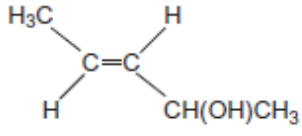
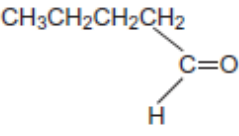
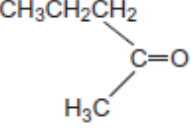
(b) Calcium is an expensive metal. It is extracted by the electrolysis of molten calcium chloride.

(b) (i) State why calcium chloride must be molten for electrolysis to occur.

.....

 (1 mark)

4 The table below shows the structures of three isomers with the molecular formula $C_5H_{10}O$

<p>Isomer 1</p> 	<p>(E)-pent-3-en-2-ol</p>
<p>Isomer 2</p> 	<p>pentanal</p>
<p>Isomer 3</p> 	

(a) Complete the table by naming Isomer 3. (1 mark)

(b) State the type of structural isomerism shown by these three isomers.

.....
 (1 mark)

(c) The compound (Z)-pent-3-en-2-ol is a stereoisomer of (E)-pent-3-en-2-ol.

(c) (i) Draw the structure of (Z)-pent-3-en-2-ol.

- (c) (ii) Identify the feature of the double bond in (*E*)-pent-3-en-2-ol and that in (*Z*)-pent-3-en-2-ol that causes these two compounds to be stereoisomers.

.....
 (1 mark)

- (d) A chemical test can be used to distinguish between separate samples of Isomer 2 and Isomer 3.
 Identify a suitable reagent for the test.
 State what you would observe with Isomer 2 and with Isomer 3.

Test reagent

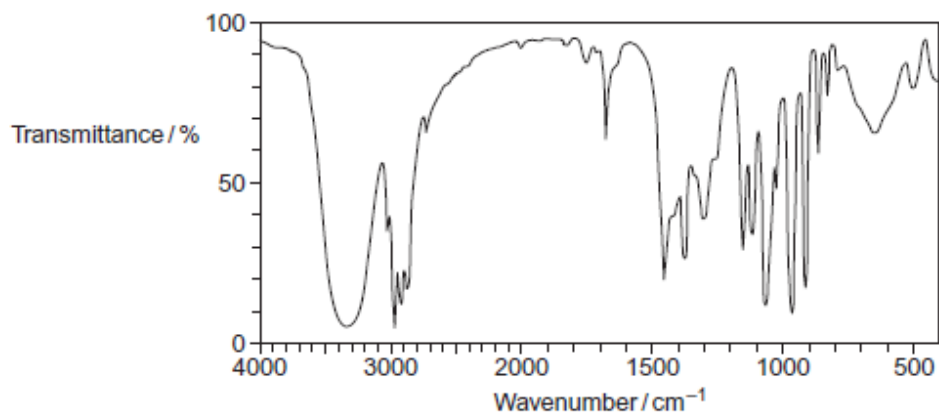
Observation with Isomer 2

.....

Observation with Isomer 3

.....
 (3 marks)

- (e) The following is the infrared spectrum of one of the isomers 1, 2 or 3.



- (e) (i) Deduce which of the isomers (1, 2 or 3) would give this infrared spectrum.
 You may find it helpful to refer to Table 1 on the Data Sheet.

.....
 (1 mark)

- (e) (ii) Identify two features of the infrared spectrum that support your deduction.
 In each case, identify the functional group responsible.

Feature 1 and functional group

.....

.....

.....

Feature 2 and functional group

5 Halogens are used to make halogenated organic compounds.

- (a) The refrigerant used in air conditioners is a mixture of fluorinated alkanes. These compounds are made by fluorination reactions. The mechanism for the reaction of fluorine with an alkane or with a fluoroalkane is a free-radical substitution similar to the reaction of chlorine with methane.

- (a) (i) Write the overall equation for the reaction of fluorine with methane to form trifluoromethane (CHF_3).

.....
(1 mark)

- (a) (ii) Write equations for the following steps in the mechanism for the reaction of fluorine with trifluoromethane (CHF_3) to form tetrafluoromethane (CF_4).

Initiation step

.....
First propagation step

.....
Second propagation step

.....
A termination step leading to the formation of hexafluoroethane.

.....
(4 marks)

- (b) Chlorofluorocarbons (CFCs) were used as refrigerants. In the upper atmosphere, ultra-violet radiation breaks bonds in the CFCs to produce a reactive intermediate that catalyses the decomposition of ozone.

- (b) (i) An example of a CFC is 1,1,1-trichloro-2,2-difluoroethane. Draw the displayed formula of this CFC.

(1 mark)

- (b) (ii) Identify a bond in a CFC that is broken by ultra-violet radiation to produce a reactive intermediate.
Give the name of this reactive intermediate that catalyses the decomposition of ozone.
Write an overall equation for this decomposition of ozone.

Bond broken

Name of the reactive intermediate

Overall equation

.....

(3 marks)

- 6(a) Some scientists thought that the waste water from a waste disposal factory contained **two** sodium halides.

They tested a sample of the waste water.

They added three reagents, one after the other, to the same test tube containing the waste water.

The table below shows their results.

Reagent added	Observations
1. Silver nitrate solution (acidified with dilute nitric acid)	A cream precipitate formed
2. Dilute ammonia solution	A yellow precipitate remained
3. Concentrated ammonia solution	The yellow precipitate did not dissolve

- (a) (i) Identify the yellow precipitate that did **not** dissolve in concentrated ammonia solution. Write the **simplest** ionic equation for the formation of this precipitate from silver ions and the correct halide ion.
Identify the other sodium halide that must be present in this mixture of two sodium halides.

.....
.....
.....
.....

(3 marks)

- (a) (ii) Give **one** reason why the silver nitrate solution was acidified before it was used in this test.

- (a) (iii) The method that the scientists used could **not** detect one type of halide ion. Identify this halide ion. Give **one** reason for your answer.

.....
.....
.....
.....

(2 marks)

- (b) The scientists thought that the waste water also contained dissolved barium ions. An aqueous solution of sodium sulfate can be used to test for the presence of dissolved barium ions.

Write the **simplest** ionic equation for the reaction between barium ions and sulfate ions to form barium sulfate.

State what is observed in this reaction.

Give a use for barium sulfate in medicine and explain why this use is possible, given that solutions containing barium ions are poisonous.

.....
.....
.....
.....
.....
.....
.....
.....
.....

(4 marks)

- (c) The scientists also analysed the exhaust gases from an incinerator used to destroy waste poly(ethene).
Mass spectrometry showed that there was a trace gas with a precise $M_r = 28.03176$ in the exhaust gases from the incinerator.

The table below contains some precise relative atomic mass data.

Atom	Precise relative atomic mass
^{12}C	12.00000
^1H	1.00794
^{16}O	15.99491

Use the data to show that the trace gas is ethene. Show your working.

Suggest why both ethene and carbon monoxide might have been identified as the trace gas if the scientists had used relative atomic masses to a precision of only one decimal place.

Write an equation for the incomplete combustion of ethene to form carbon monoxide and water only.

Ethene is used to make poly(ethene).

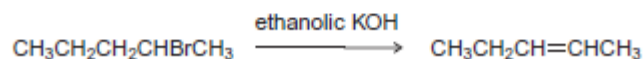
Draw the displayed formula for the repeating unit of poly(ethene).

Name this type of polymer.

- 7 Organic reaction mechanisms help chemists to understand how the reactions of organic compounds occur.
The following conversions illustrate a number of different types of reaction mechanism.

- (a) When 2-bromopentane reacts with ethanolic KOH, two structurally isomeric alkenes are formed.

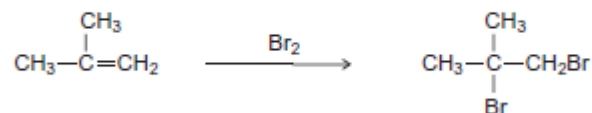
- (a) (i) Name and outline a mechanism for the conversion of 2-bromopentane into pent-2-ene as shown below.



(4 marks)

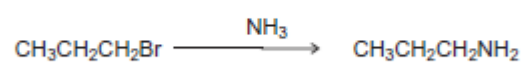
- (a) (ii) Draw the structure of the other structurally isomeric alkene produced when 2-bromopentane reacts with ethanolic KOH.

- (b) Name and outline a mechanism for the following conversion.



(5 marks)

- (c) Name and outline a mechanism for the following conversion.



(5 marks)