

2 Iodine reacts with concentrated nitric acid to produce nitrogen dioxide (NO<sub>2</sub>).

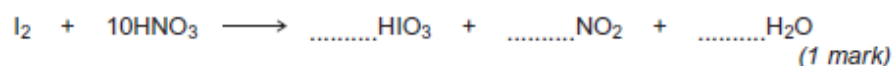
(a) (i) Give the oxidation state of iodine in each of the following.

I<sub>2</sub> .....

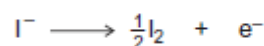
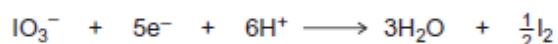
HIO<sub>3</sub> .....

(2 marks)

(a) (ii) Complete the balancing of the following equation.



(b) In industry, iodine is produced from the NaIO<sub>3</sub> that remains after sodium nitrate has been crystallised from the mineral Chile saltpetre. The final stage involves the reaction between NaIO<sub>3</sub> and NaI in acidic solution. Half-equations for the redox processes are given below.



Use these half-equations to deduce an overall ionic equation for the production of iodine by this process. Identify the oxidising agent.

Overall ionic equation

The oxidising agent .....

(2 marks)

- 1 (c) State and explain the general trend in the first ionisation energies of the Period 3 elements sodium to chlorine.

Trend .....

Explanation .....

.....

..... (3 marks)

(Extra space) .....

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- 1 (d) State how the element sulfur deviates from the general trend in first ionisation energies across Period 3. Explain your answer.

How sulfur deviates from the trend .....

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Explanation .....

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..... (3 marks)

(Extra space) .....

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- 1 (e) A general trend exists in the first ionisation energies of the Period 2 elements lithium to fluorine. Identify **one** element which deviates from this general trend.

..... (1 mark)

- (c) When concentrated sulfuric acid is added to potassium iodide, solid sulfur and a black solid are formed.

- (c) (i) Identify the black solid.

..... (1 mark)

- (c) (ii) Deduce the half-equation for the formation of sulfur from concentrated sulfuric acid.

..... (1 mark)

- (d) When iodide ions react with concentrated sulfuric acid in a different redox reaction, the oxidation state of sulfur changes from +6 to -2. The reduction product of this reaction is a poisonous gas that has an unpleasant smell. Identify this gas.

..... (1 mark)

(e) A yellow precipitate is formed when silver nitrate solution, acidified with dilute nitric acid, is added to an aqueous solution containing iodide ions.

(e) (i) Write the **simplest ionic** equation for the formation of the yellow precipitate.

.....  
(1 mark)

(e) (ii) State what is observed when concentrated ammonia solution is added to this precipitate.

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.....  
(1 mark)

(e) (iii) State why the silver nitrate is acidified when testing for iodide ions.

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.....  
(1 mark)

(f) Consider the following reaction in which iodide ions behave as reducing agents.



(f) (i) In terms of electrons, state the meaning of the term *reducing agent*.

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.....  
*(1 mark)*

(f) (ii) Write a half-equation for the conversion of chlorine into chloride ions.

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*(1 mark)*

(f) (iii) Suggest why iodide ions are stronger reducing agents than chloride ions.

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*(2 marks)*  
*(Extra space)* .....

- 3 The table shows the structures and names of three compounds with  $M_r = 72.0$

Compound	Formula	Name
1	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$	butanal
2	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	pentane
3	$\text{CH}_3\text{CH}_2\text{COCH}_3$	butanone

- (a) Explain why  $M_r$  values, measured to five decimal places, cannot distinguish between compounds 1 and 3 but can distinguish between compounds 1 and 2.

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(2 marks)

- (b) A simple chemical test, using either Fehling's solution or Tollens' reagent, can be used to distinguish between compound 1 and compound 3. Choose one of these two reagents and state what you would observe with each of compound 1 and compound 3.

Chosen reagent .....

Observation with compound 1.....

.....

Observation with compound 3.....

.....

(2 marks)

4 Group 2 elements and their compounds have a wide range of uses.

(a) For parts (a)(i) to (a)(iii), draw a ring around the correct answer to complete each sentence.

(a) (i) From  $\text{Mg}(\text{OH})_2$  to  $\text{Ba}(\text{OH})_2$ , the solubility in water

- |                 |
|-----------------|
| decreases.      |
| increases.      |
| stays the same. |

(1 mark)

(a) (ii) From Mg to Ba, the first ionisation energy

- |                 |
|-----------------|
| decreases.      |
| increases.      |
| stays the same. |

(1 mark)

(a) (iii) From Mg to Ba, the atomic radius

- |                 |
|-----------------|
| decreases.      |
| increases.      |
| stays the same. |

(1 mark)

(b) Explain why calcium has a higher melting point than strontium.

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(2 marks)

(Extra space) .....

(c) Acidified barium chloride solution is used as a reagent to test for sulfate ions.

(c) (i) State why sulfuric acid should **not** be used to acidify the barium chloride.

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(1 mark)

(c) (ii) Write the **simplest ionic** equation for the reaction that occurs when acidified barium chloride solution is added to a solution containing sulfate ions.

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(1 mark)

5 It is possible to convert but-1-ene into its structural isomer but-2-ene.

(a) State the type of structural isomerism shown by but-1-ene and but-2-ene.

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(1 mark)

(b) The first stage in this conversion involves the reaction of hydrogen bromide with but-1-ene.



Outline a mechanism for this reaction.

(4 marks)

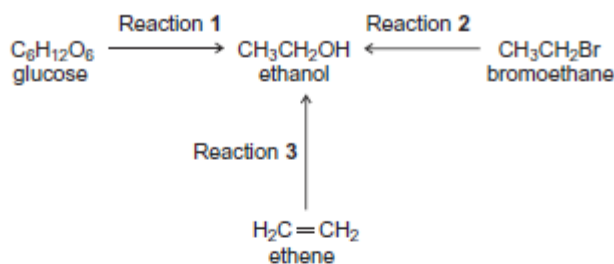
(c) The second stage is to convert 2-bromobutane into but-2-ene.



Outline a mechanism for this reaction.

(3 marks)

6 Three different ways of producing ethanol are shown below.



(a) Reaction 1 produces a 15% aqueous solution of ethanol. It is claimed that the ethanol produced in this way is a carbon-neutral biofuel.

Write an equation for Reaction 1 and name the process.

Write an equation for the complete combustion of ethanol.

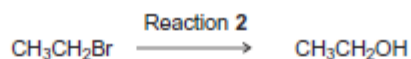
Explain why the ethanol produced by this process may **not** be a *carbon-neutral* biofuel.

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(5 marks)

(Extra space)

(b) Give a reagent and conditions for Reaction 2.



Name and outline a mechanism for Reaction 2.

Suggest **one** reason, other than safety, why this method is **not** used in industry to make ethanol.

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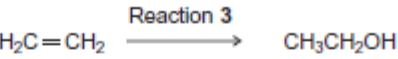
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(6 marks)

(c) Reaction 3 is used in industry.



Identify a suitable catalyst for Reaction 3.

Identify the type of reaction.

Give **two** conditions, in addition to the presence of a catalyst, necessary for Reaction 3 to produce a high yield of ethanol.

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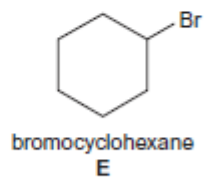
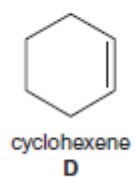
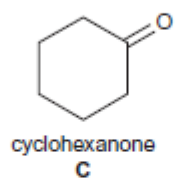
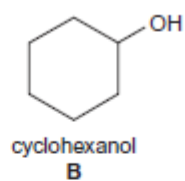
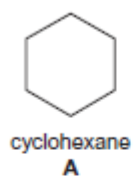
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(4 marks)

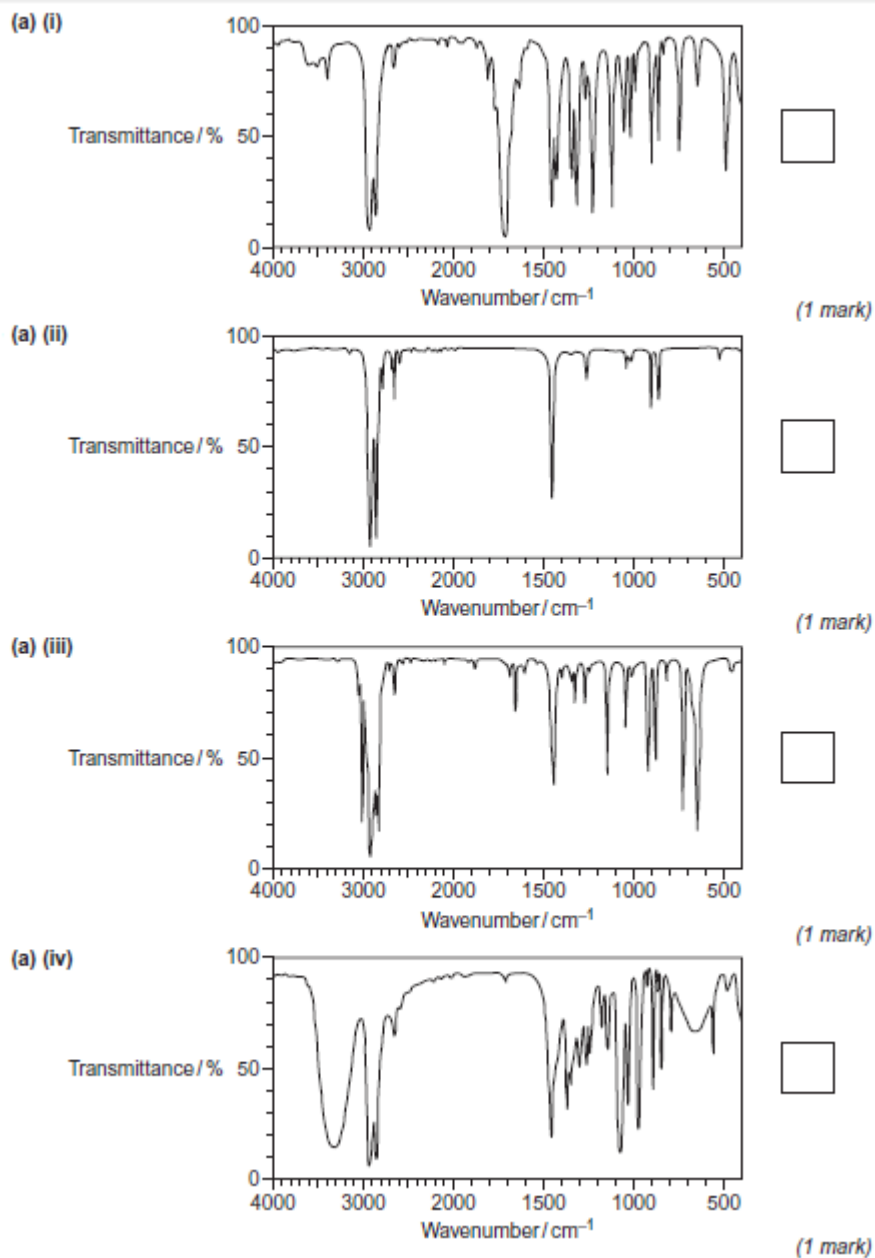


7 Consider the five cyclic compounds, **A**, **B**, **C**, **D** and **E**.



(a) The infrared spectra of compounds **A**, **B**, **C** and **D** are shown opposite.

Write the correct letter, **A**, **B**, **C** or **D**, in the box next to each spectrum. You may find it helpful to refer to **Table 1** on the Data Sheet.



- (b) A simple chemical test can be used to distinguish between cyclohexane (A) and cyclohexene (D).  
Give a reagent for this test and state what you would observe with each compound.

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(3 marks)

(Extra space) .....

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- (c) Cyclohexanol (B) can be converted into cyclohexanone (C).

Give a reagent or combination of reagents that can be used for this reaction and state the type of reaction.

State the class of alcohols to which cyclohexanol belongs.

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(3 marks)

- (d) Cyclohexane (A) can be converted into bromocyclohexane (E) by a reaction that is similar to the reaction of methane either with chlorine or with bromine.

Name and outline a mechanism for the reaction of methane (CH<sub>4</sub>) with bromine to form bromomethane (CH<sub>3</sub>Br). Give **one** condition for this reaction to occur.  
Write an equation for each step in your mechanism.

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(5 marks)