

**Q1.** Sulfuric acid is manufactured by the Contact Process.

- (a) In this process, sulfur dioxide reacts with oxygen.  
The equation for the equilibrium that is established is



- (i) State and explain the effect of a **decrease** in temperature on the equilibrium yield of  $\text{SO}_3$ .

Effect of a decrease in temperature on yield .....

Explanation .....

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(Extra space) .....

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(3)

- (ii) Give **two** features of a reaction at equilibrium.

Feature 1 .....

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Feature 2 .....

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(2)

- (b) Write an equation for the reaction of concentrated sulfuric acid with potassium bromide to form potassium hydrogensulfate and hydrogen bromide.

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(1)

- (c) Bromine is one of the products formed when concentrated sulfuric acid reacts with hydrogen bromide.

Write an equation for this reaction.  
State the role of sulfuric acid in this reaction.

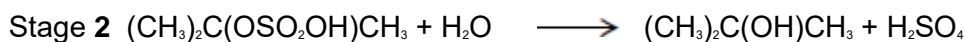
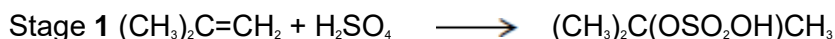
Equation

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Role of sulfuric acid .....

(3)

- (d) Concentrated sulfuric acid is used in a two-stage process to convert 2-methylpropene into 2-methylpropan-2-ol.



- (i) Name and outline a mechanism for Stage 1 of this conversion.

Name of mechanism .....

Mechanism

(5)

- (ii) Deduce the type of reaction in Stage 2 of this conversion.

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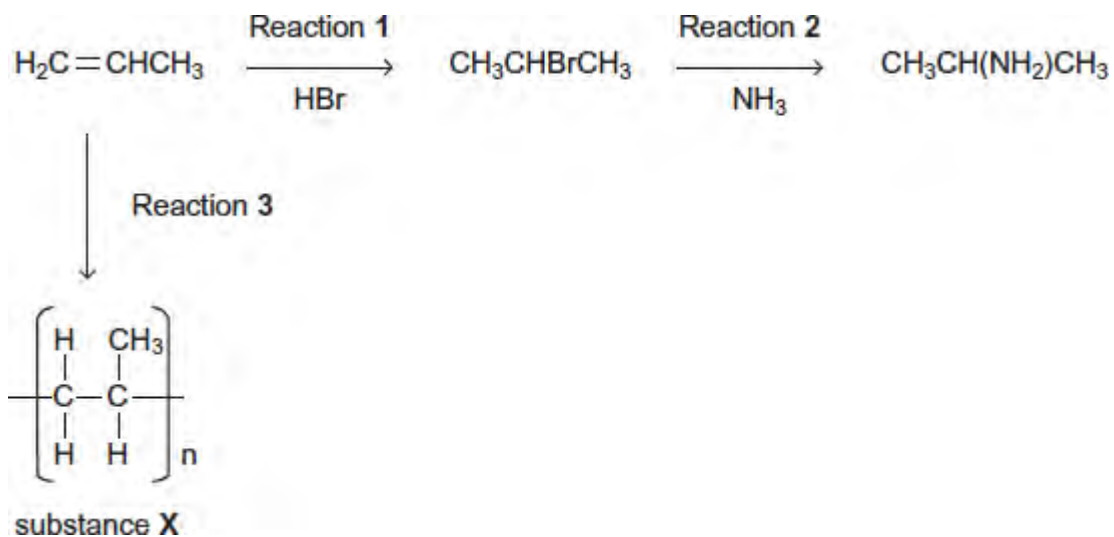
(1)

(iii) State the overall role of sulfuric acid in this conversion.

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(1)  
(Total 16 marks)

**Q2.** Consider the following reactions.



(a) Name and outline a mechanism for Reaction 1.

Name of mechanism

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Mechanism

(5)

(b) Name and outline a mechanism for Reaction 2.

Name of mechanism

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Mechanism

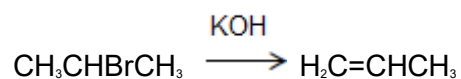
(5)

- (c) State the type of reaction in Reaction 3.  
Give the name of substance X.

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(2)


- (d) The haloalkane produced in Reaction 1 can be converted back into propene in an elimination reaction using ethanolic potassium hydroxide.



Outline a mechanism for this conversion.

(3)  
(Total 15 marks)

**Q3.** The following table gives the names and structures of some structural isomers with the molecular formula  $C_5H_{10}$ .

	Name of isomer	Structure
Isomer 1	pent-2-ene	$CH_3CH = CHCH_2CH_3$
Isomer 2	cyclopentane	
Isomer 3	3-methylbut-1-ene	$(CH_3)_2CHCH = CH_2$
Isomer 4	2-methylbut-2-ene	$(CH_3)_2C = CHCH_3$
Isomer 5	2-methylbut-1-ene	$H_2C = C(CH_3)CH_2CH_3$

(a) Isomer 1 exists as E and Z stereoisomers.

(i) State the meaning of the term **stereoisomers**.

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(2)

(ii) Draw the structure of the E stereoisomer of Isomer 1.

(1)

(b) A chemical test can be used to distinguish between separate samples of Isomer 1 and Isomer 2.

Identify a suitable reagent for the test.  
State what you would observe with Isomer 1 and with Isomer 2.

Reagent.....

Observation with Isomer 1.....

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Observation with Isomer 2.....

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(3)

(c) Use **Table A** on the Data Sheet when answering this question.  
Isomer 3 and Isomer 4 have similar structures.

(i) State the infrared absorption range that shows that Isomer 3 and Isomer 4 contain the same functional group.

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(1)

(ii) State **one** way that the infrared spectrum of Isomer 3 is different from the infrared spectrum of Isomer 4.

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(1)

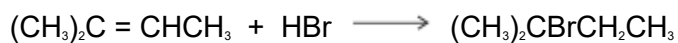
(d) Two alcohols are formed by the hydration of Isomer 4.

Draw the **displayed formula** for the alcohol formed that is oxidised readily by acidified potassium dichromate(VI).

(1)

(e) Isomer **4** reacts with hydrogen bromide to give two structurally isomeric bromoalkanes.

(i) Name and outline a mechanism for the reaction of Isomer **4** with hydrogen bromide to give 2-bromo-2-methylbutane as the major product.



Name of mechanism.....

Mechanism

(5)

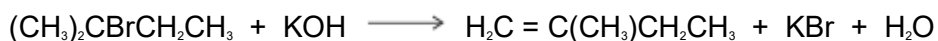
(ii) The minor product in this reaction mixture is 2-bromo-3-methylbutane.

Explain why this bromoalkane is formed as a minor product.

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(2)

(f) Name and outline a mechanism for the following reaction to form Isomer **5**. State the role of the hydroxide ion in this reaction.



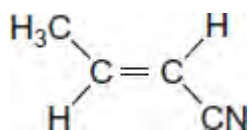
Name of mechanism .....

Mechanism

Role of hydroxide ion .....

(5)  
(Total 21 marks)

**Q4.** The alkene (*E*)-but-2-enitrile is used to make acrylic plastics.  
The structure of (*E*)-but-2-enitrile is



(a) (i) Draw the structure of (*Z*)-but-2-enitrile.

(1)

(ii) Identify the feature of the double bond in the *E* and *Z* isomers that causes them to be stereoisomers.

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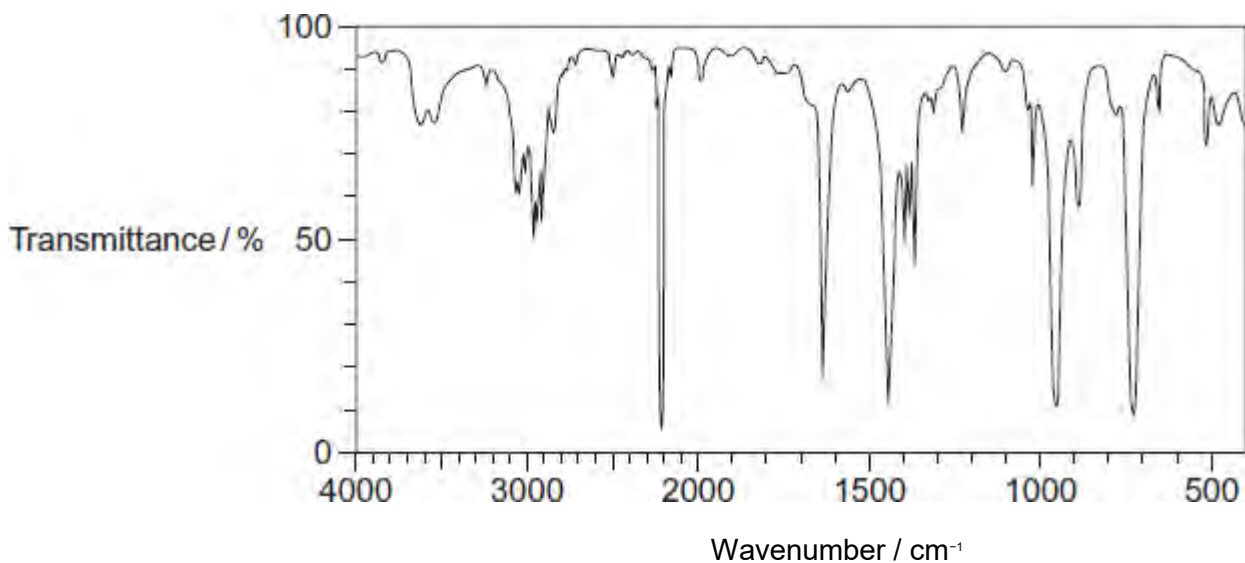
(1)

(b) Draw the repeating unit of the polyalkene formed by addition polymerisation of (*E*)-but-2-enitrile.

(1)



(c) Consider the infrared spectrum of (*E*)-but-2-enitrile.



Identify **two** features of the infrared spectrum that support the fact that this is the infrared spectrum for but-2-enitrile.

You may find it helpful to refer to **Table 1** on the Data Sheet.

Feature 1 .....

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Feature 2 .....

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(2)  
(Total 5 marks)