

Q1.The following pairs of compounds can be distinguished by simple test-tube reactions.

For each pair of compounds, give a reagent (or combination of reagents) that, when added separately to each compound, could be used to distinguish between them. State what is observed in each case.

(a) Butan-2-ol and 2-methylpropan-2-ol

Reagent

Observation with butan-2-ol

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Observation with 2-methylpropan-2-ol

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(3)

(b) Propane and propene

Reagent

Observation with propane

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Observation with propene

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(3)

(c) Aqueous silver nitrate and aqueous sodium nitrate

Reagent

Observation with aqueous silver nitrate

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Observation with aqueous sodium nitrate

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(3)

(d) Aqueous magnesium chloride and aqueous barium chloride

Reagent

Observation with aqueous magnesium chloride

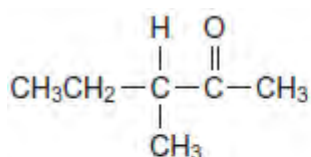
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Observation with aqueous barium chloride

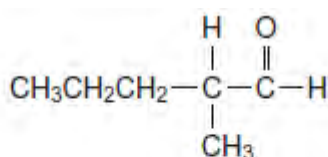
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(3)
(Total 12 marks)

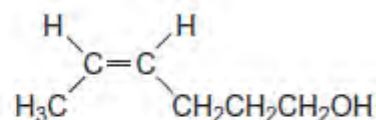
Q2. The following five isomers, **P**, **Q**, **R**, **S** and **T**, were investigated using test-tube reactions and also using n.m.r. spectroscopy.



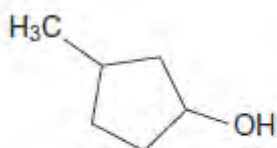
P



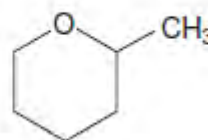
Q



R



S



T

(a) A simple test-tube reaction can be used to distinguish between isomers **P** and **S**.

Identify a reagent (or combination of reagents) you could use.

State what you would observe when both isomers are tested separately with this reagent or combination of reagents.

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(3)

- (b) A simple test-tube reaction can be used to distinguish between isomer **Q** and all the other isomers.

Identify a reagent (or combination of reagents) you could use.
State what you would observe when **Q** is tested with this reagent or combination of reagents.

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(2)

- (c) State which **one** of the isomers, **P**, **Q**, **R**, **S** and **T**, has the least number of peaks in its ^1H n.m.r. spectrum.
Give the number of peaks for this isomer.

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(2)

- (d) Write the **molecular** formula of the standard used in ^{13}C n.m.r. spectroscopy.
Give **two** reasons why this compound is used.

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(3)

(e) **Figure 1** and **Figure 2** show the ^{13}C n.m.r. spectra of two of the five isomers.

Figure 1

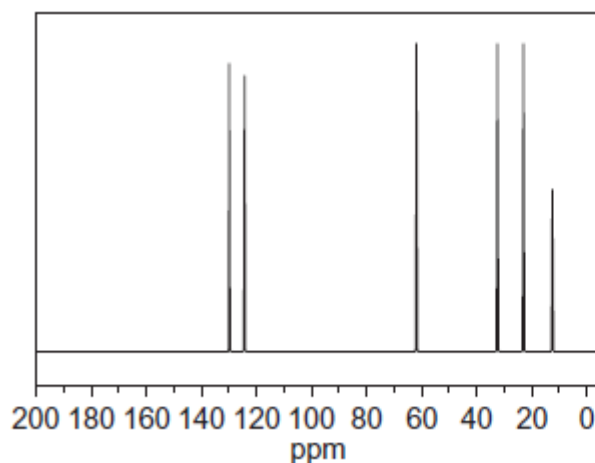
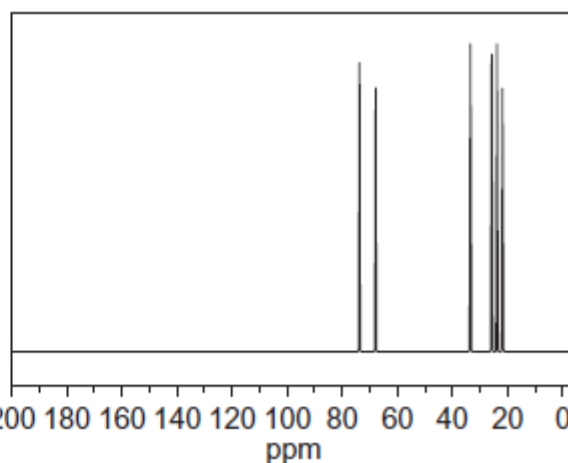
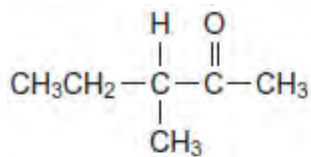


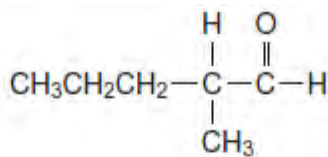
Figure 2



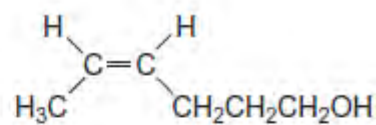
The structures of the five isomers are repeated to help you answer this question.



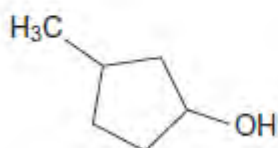
P



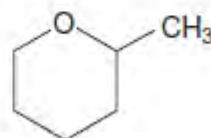
Q



R



S



T

State which isomer produces the spectrum in **Figure 1** and which isomer produces

the spectrum in **Figure 2**.

Explain your answer.

You do not need to identify every peak in each spectrum.
Use **Table C** on the Data Sheet to answer the question.

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(5)

- (f) **U** and **V** are other isomers of **P**, **Q**, **R**, **S** and **T**.
The ¹H n.m.r. spectrum of **U** consists of two singlets.
V is a cyclic alcohol that exists as optical isomers.

Draw the structure of **U** and the structure of **V**.


U

V

(2)
(Total 17 marks)

Q3. The following table gives the names and structures of some structural isomers with the molecular formula C₅H₁₀.

	Name of isomer	Structure
Isomer 1	pent-2-ene	CH ₃ CH = CHCH ₂ CH ₃

Isomer 2	cyclopentane	
Isomer 3	3-methylbut-1-ene	$(\text{CH}_3)_2\text{CHCH} = \text{CH}_2$
Isomer 4	2-methylbut-2-ene	$(\text{CH}_3)_2\text{C} = \text{CHCH}_3$
Isomer 5	2-methylbut-1-ene	$\text{H}_2\text{C} = \text{C}(\text{CH}_3)\text{CH}_2\text{CH}_3$

(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**.....
.....

(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**.

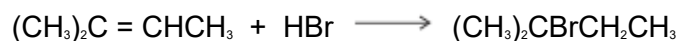
Draw the **displayed formula** for the alcohol formed that is oxidised readily by acidified potassium dichromate(VI).

(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)

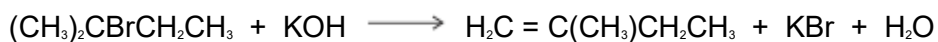
(ii) The minor product in this reaction mixture is 2-bromo-3-methylbutane.

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)

