AQA

A-level
Chemistry (7405/2)

Paper 2: Organic and Physical Chemistry

Specimen 2014 Session 2 hours

Materials
For this paper you must have:
- the Data Booklet, provided as an insert
- a ruler
- a calculator.

Instructions
- Answer **all** questions.
- Show **all** your working.

Information
- The maximum mark for this paper is 105.

Please write clearly, in block capitals, to allow character computer recognition.

Centre number ☐☐☐☐☐ Candidate number ☐☐☐☐

Surname

Forename(s)

Candidate signature _____

Answer **all** questions.

1 This question involves the use of kinetic data to deduce the order of a reaction and calculate a value for a rate constant.

The data in **Table 1** were obtained in a series of experiments on the rate of the reaction between compounds **A** and **B** at a constant temperature.

Table 1

Experiment	Initial concentration of A / mol dm^{-3}	Initial concentration of B / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	0.12	0.26	0.21×10^{-3}
2	0.36	0.26	1.89×10^{-3}
3	0.72	0.13	3.78×10^{-3}

0 1 . 1 Deduce the order of reaction with respect to **A**.

[1 mark]

0 1 . 2 Deduce the order of reaction with respect to **B**.

[1 mark]

The data in **Table 2** were obtained in two experiments on the rate of the reaction between compounds **C** and **D** at a constant temperature.

Table 2

Experiment	Initial concentration of C / mol dm^{-3}	Initial concentration of D / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
4	1.9×10^{-2}	3.5×10^{-2}	7.2×10^{-4}
5	3.6×10^{-2}	5.4×10^{-2}	To be calculated

The rate equation for this reaction is

$$rate = k[\mathbf{C}]^2[\mathbf{D}]$$

0 1 . 3 Use the data from experiment **4** to calculate a value for the rate constant, *k*, at this temperature. Deduce the units of *k*.

[3 marks]

k = _____ Units = _____

0 1 . 4 Calculate a value for the initial rate in experiment **5**.

[1 mark]

Initial rate = _____ mol dm^{-3} s^{-1}

Question 1 continues on the next page

0 1 . 5 The rate equation for a reaction is

$$rate = k[\mathbf{E}]$$

Explain qualitatively why raising the temperature by 10 °C has a much greater effect on the rate of the reaction than doubling the concentration of **E**.

[3 marks]

Turn over for the next question

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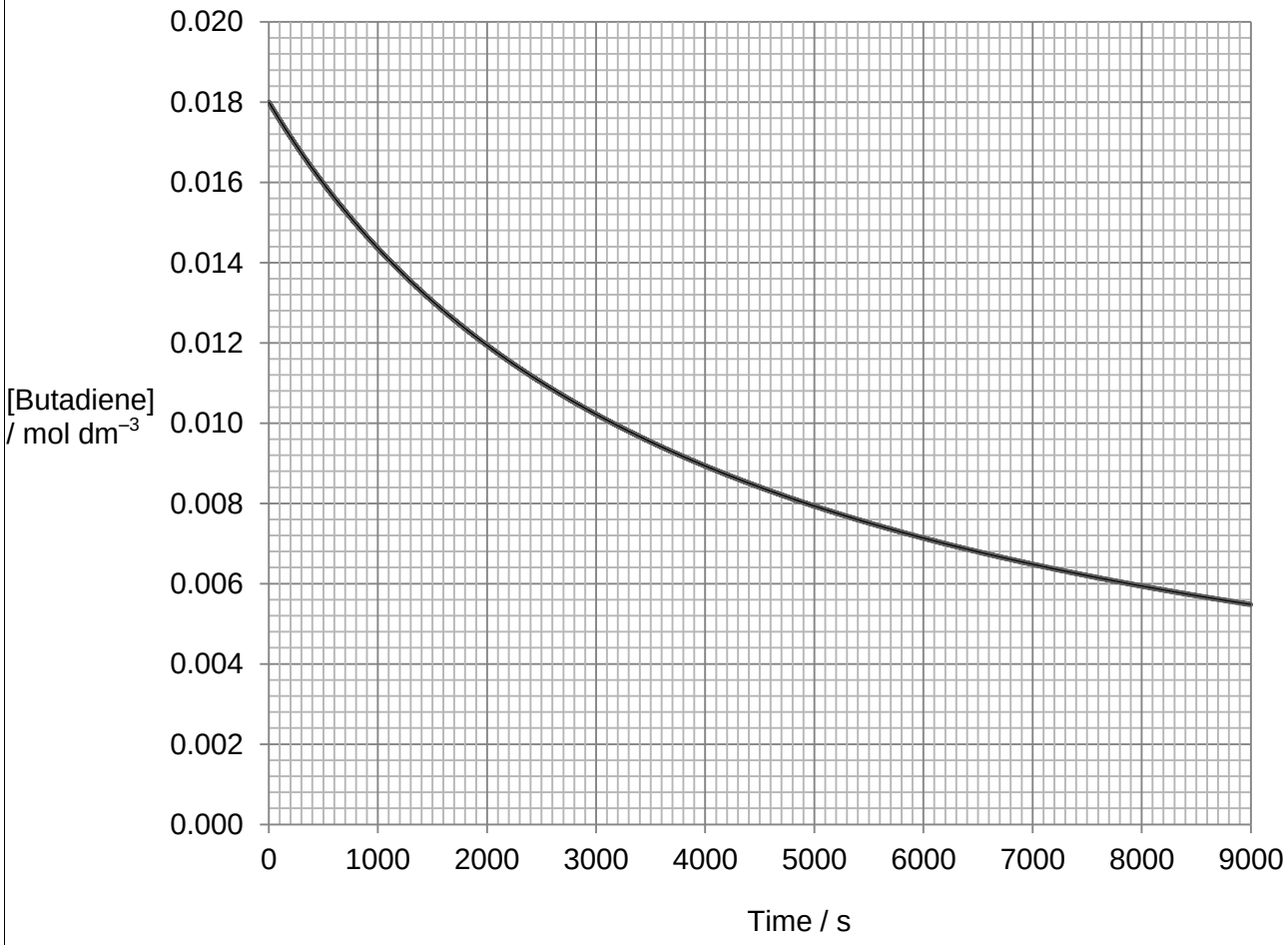
ANSWER IN THE SPACES PROVIDED

2 Butadiene dimerises according to the equation

$$2C_4H_6 \longrightarrow C_8H_{12}$$

The kinetics of the dimerisation are studied and the graph of the concentration of a sample of butadiene is plotted against time. The graph is shown in **Figure 1**.

Figure 1



0 2 . 1 Draw a tangent to the curve when the concentration of butadiene is 0.0090 mol dm^{-3}.

[1 mark]

0 2 . 2 Use this tangent to deduce the rate of the reaction, in mol dm^{-3} s^{-1}, at this concentration of butadiene.

[2 marks]

Rate of reaction = _____ mol dm^{-3} s^{-1}

0 2 . 3 The initial rate of reaction in this experiment has the value 4.57×10^{-6} mol dm^{-3} s^{-1}.

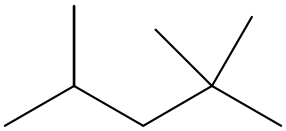
Use this value, together with your answer from Question **2.2**, to deduce the order of the reaction with respect to butadiene.

[3 marks]

Turn over for the next question

3 Isooctane (C_8H_{18}) is the common name for the branched-chain hydrocarbon that burns smoothly in car engines. The skeletal formula of isooctane is shown in **Figure 2**.

Figure 2



0 3 . 1 Give the IUPAC name for isooctane.

[1 mark]

0 3 . 2 Using its molecular formula, write an equation for the complete combustion of isooctane.

[1 mark]

0 3 . 3 Deduce the number of peaks in the ^{13}C NMR spectrum of isooctane.

[1 mark]

Only **one** answer is allowed.

Completely fill in the circle alongside the appropriate answer.

CORRECT METHOD WRONG METHODS

If you want to change your answer you must cross out your original answer as shown.

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown.

5

6

7

8

0 3 . 4 Isooctane can be formed, together with propene and ethene, in a reaction in which one molecule of an alkane that contains 20 carbon atoms is cracked.

Using molecular formulas, write an equation for this reaction.

[1 mark]

0 3 . 5 State why the reaction in Question **3.4** is an example of thermal cracking.

[1 mark]

0 3 . 6 Using molecular formulas, write equations to show the mechanism for the reaction of isooctane (C_8H_{18}) with chlorine.
Include a termination step in which an organic compound is formed.

[4 marks]

0 3 . 7 Give an essential condition for the reaction of isooctane with chlorine.

[1 mark]

Question 3 continues on the next page

0 3 . 8 Deduce the number of monochloro isomers formed by isooctane.
Draw the structure of the monochloro isomer that exists as a pair of optical isomers.

[2 marks]

Number of monochloro isomers _____

Structure

0 3 . 9 An isomer of isooctane reacts with chlorine to form only one monochloro compound.

Draw the **skeletal formula** of this monochloro compound.

[1 mark]

Turn over for the next question

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4 Alcohol **A** $(CH_3)_2CHCH(OH)CH_3$ undergoes reactions separately with acidified potassium dichromate(VI) and with concentrated sulfuric acid.

0 4 . 1 Give the IUPAC name for alcohol **A**.

[1 mark]

0 4 . 2 Give the structure of the organic product, **B**, formed when **A** is oxidised in the reaction with acidified potassium dichromate(VI).

[1 mark]

0 4 . 3 Two isomeric alkenes, **C** and **D**, are formed when **A** is dehydrated in the reaction with concentrated sulfuric acid.

Name the mechanism for this dehydration reaction.

[1 mark]

0 4 . 4 Draw the structure of each isomer.

[2 marks]

Isomer **C**

Isomer **D**

0 4 . 5 Name the type of structural isomerism **C** and **D** show.

[1 mark]

0 4 . 6 List alcohol **A**, product **B** and isomer **C** in order of increasing boiling point. Explain your answer.

[4 marks]

Order of increasing boiling point _____

Explanation _____

_____

_____

_____

_____

0 4 . 7 Draw the structure of the isomer of **A** which is **not** oxidised by acidified potassium dichromate(VI).

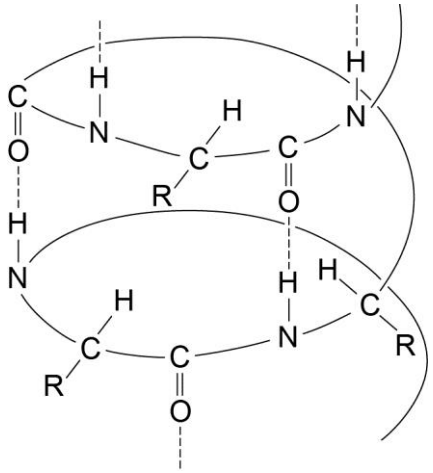
[1 mark]

0 4 . 8 Draw the structure of the isomer of **A** which **cannot** be dehydrated to form an alkene by reaction with concentrated sulfuric acid.

[1 mark]

5 **Figure 3** shows a simplified representation of the arrangement of some amino acids in a portion of a protein structure in the form of an α-helix.

Figure 3



0 5 . 1 Name the type of protein structure in **Figure 3**.

[1 mark]

0 5 . 2 Name the interaction represented by the dotted lines in **Figure 3** and explain how the interaction arises.

[4 marks]

Name _____

Explanation _____

_____

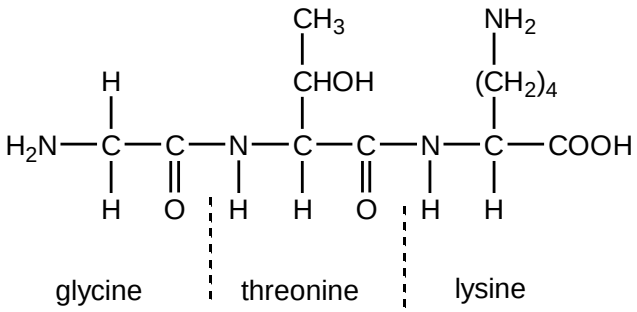
_____

_____

_____

6 The tripeptide shown in **Figure 4** is formed from the amino acids glycine, threonine and lysine.

Figure 4



0 6 . 1 Draw a separate circle around **each** of the asymmetric carbon atoms in the tripeptide in **Figure 4**.

[1 mark]

0 6 . 2 Draw the zwitterion of glycine.

[1 mark]

0 6 . 3 Draw the structure of the species formed when glycine reacts with an excess of bromomethane.

[1 mark]

0 6 . 4 Give the IUPAC name of threonine.

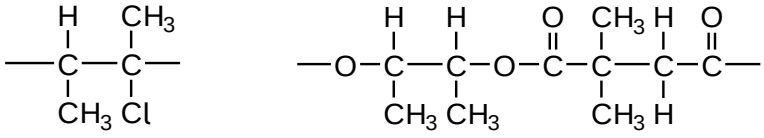
[1 mark]

0 6 . 5 Draw the structure of the species formed by lysine at low pH.

[1 mark]

7 Repeating units of two polymers, **P** and **Q**, are shown in **Figure 5**.

Figure 5



P **Q**

0 7 . 1 Draw the structure of the monomer used to form polymer **P**.
Name the type of polymerisation involved.

[2 marks]

Monomer

Type of polymerisation _____

0 7 . 2 Draw the structures of **two** compounds that react together to form polymer **Q**.

[2 marks]

Structure of compound 1

Structure of compound 2

0 7 . 3 Suggest an environmental advantage of polymer **Q** over polymer **P** and explain your answer.

[3 marks]

Advantage _____

Explanation _____

_____

_____

_____

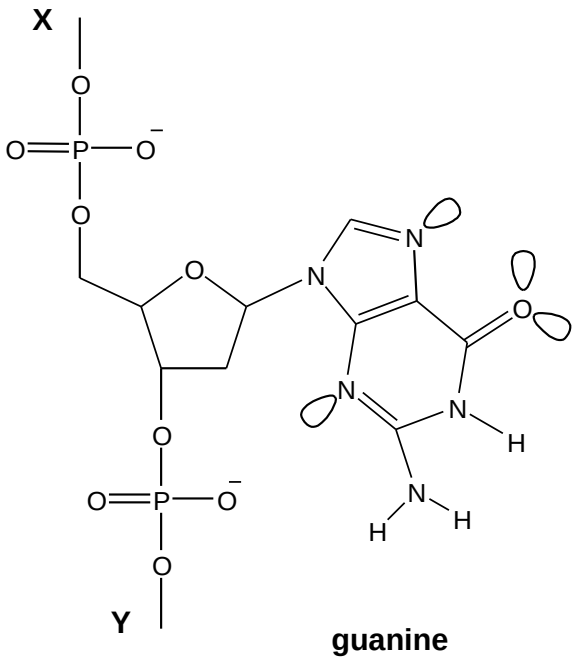
_____

Turn over for the next question

8 The anticancer drug cisplatin operates by reacting with the guanine in DNA.

Figure 6 shows a small part of a single strand of DNA. Some lone pairs are shown.

Figure 6



guanine

0 8 . 1 The DNA chain continues with bonds at **X** and **Y**.

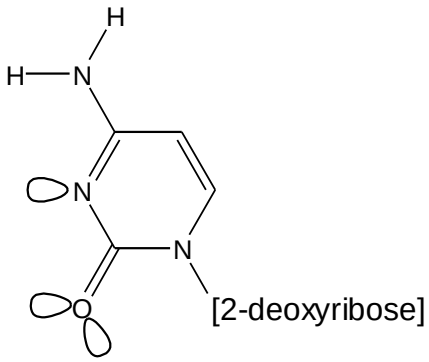
State the name of the sugar molecule that is attached to the bond at **X**.

[1 mark]

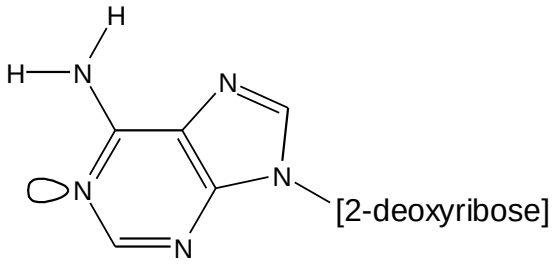
_____

0 8 . 2 **Figure 7** shows two more bases found in DNA.

Figure 7



cytosine



adenine

State which of these two bases pairs with the guanine in **Figure 7** when two separate strands of DNA form a double helix.
Explain how the base that you have chosen forms a base pair with guanine.

[4 marks]

Question 8 continues on the next page

0 8 . 3 Cisplatin works because one of the atoms on guanine can form a co-ordinate bond with platinum, replacing one of the ammonia or chloride ligands. Another atom on another guanine can also form a co-ordinate bond with the same platinum by replacing another ligand.

Explain how the action of cisplatin is able to stop the growth of cancer cells.

[3 marks]

Turn over for the next question

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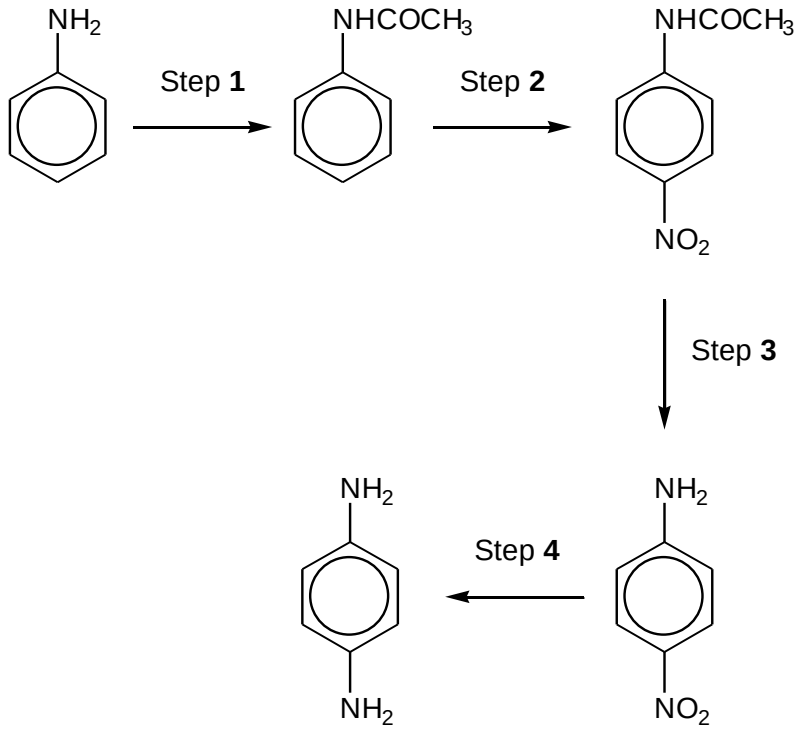
9 A possible synthesis of 1,4-diaminobenzene is shown in **Figure 8**.

Figure 8



0 9 . 1 A suitable reagent for step **1** is CH_3COCl

Name and draw a mechanism for the reaction in step **1**.

[5 marks]

Name of mechanism _____

Mechanism

0 9 . 2 The product of step **1** is purified by recrystallisation.

Outline how you would carry out this purification technique and confirm that the dried product was pure.

[6 marks]

0 9 . 3 In an experiment starting with 5.05 g of phenylamine (M_r = 93.0), 4.82 g of purified product were obtained in step **1**.

Calculate the percentage yield in this reaction.

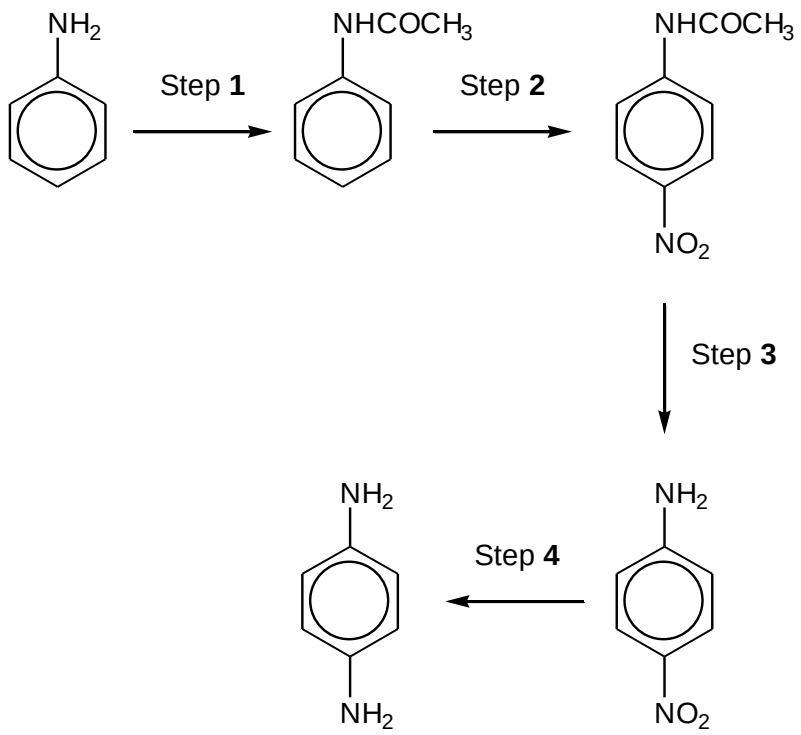
[3 marks]

Percentage yield = _____ %

Question 9 continues on the next page

Figure 8 is repeated here to help you answer the following questions.

Figure 8



0 9 . 4 Identify the reagents used in step **2**.

[2 marks]

0 9 . 5 Name a mechanism for the reaction in step **2**.

[1 mark]

0 9 . 6 Suggest the type of reaction occurring in step **3**.

[1 mark]

0 9 . 7 Identify the reagents used in step **4**.

[1 mark]

_____

Turn over for the next question

10 The infrared spectrum (**Figure 9**) and the ^{1}H NMR spectrum (**Figure 10**) of compound **R** with molecular formula $C_6H_{14}O$ are shown.

Figure 9

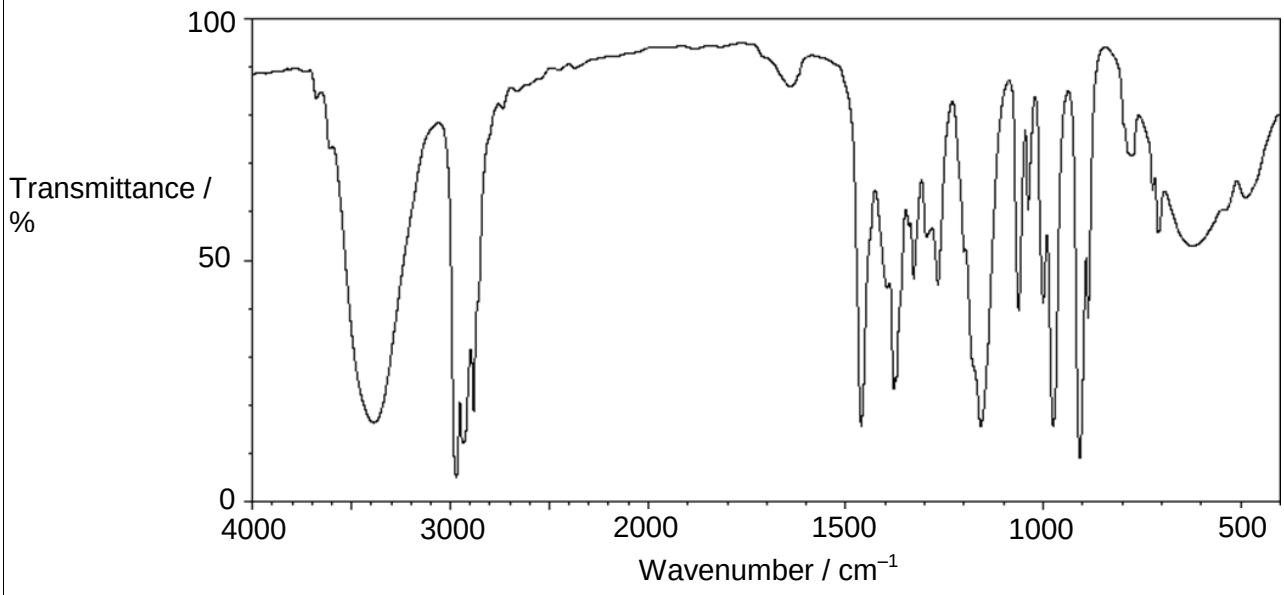
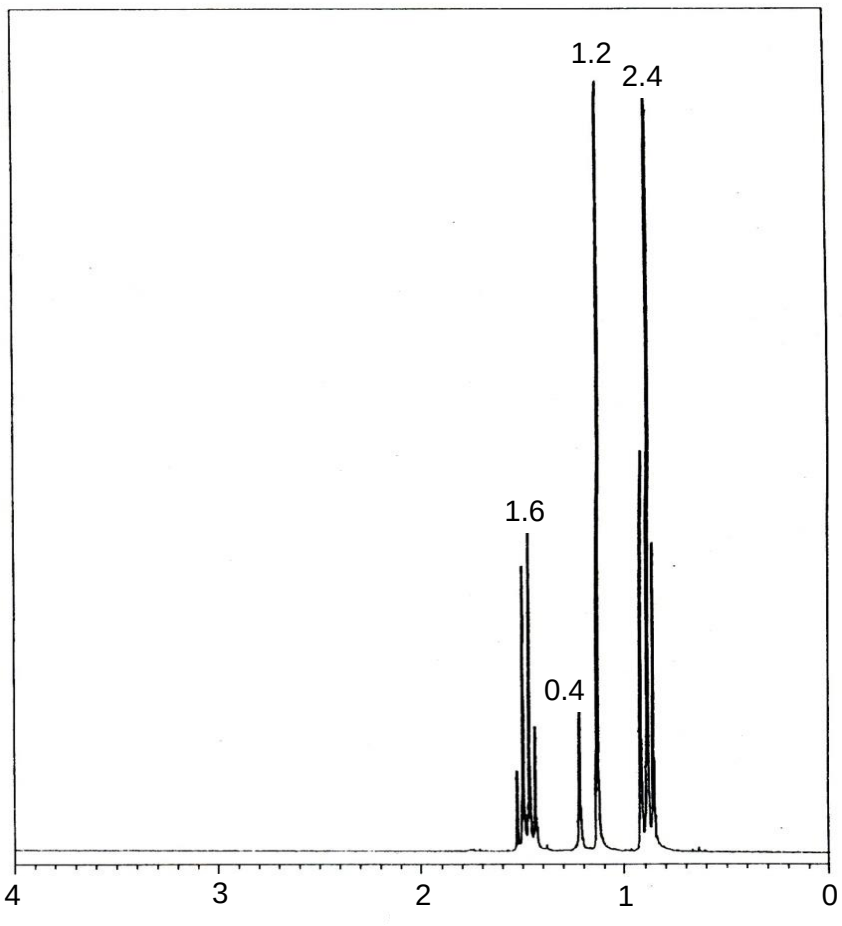


Figure 10



1 0 The relative integration values for the NMR peaks are shown on **Figure 10**.

Deduce the structure of compound **R** by analysing **Figure 9** and **Figure 10**. Explain each stage in your deductions.

Use **Table A** and **Table B** on the Data Sheet.

[8 marks]

Turn over for the next question

11 The unsaturated compounds butanone and but-1-ene both react with compounds of the form HY (where Y is an atom or group of atoms) to form saturated products.

1 1 . 1 Suggest a reagent of the form HY that reacts with butanone.

[1 mark]

1 1 . 2 Write an equation for the reaction in Question **11.1**.

[1 mark]

1 1 . 3 Explain why the product obtained is optically inactive.

[3 marks]

1 1 . 4 Suggest a reagent of the form HY which reacts with but-1-ene.

[1 mark]

1 1 . 5 Draw a mechanism for the reaction in Question **11.4**.

[4 marks]

1 1 . 6 Explain why the product obtained contains three isomers.

[3 marks]

END OF QUESTIONS

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