OCR
Oxford Cambridge and RSA

Friday 10 June 2016 – Afternoon

AS GCE CHEMISTRY A

F322/01 Chains, Energy and Resources

Candidates answer on the Question Paper.

OCR supplied materials:
- *Data Sheet for Chemistry A* (inserted)

Other materials required:
- Scientific calculator

Duration: 1 hour 45 minutes

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5878514104

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.

Where you see this icon you will be awarded marks for the quality of written communication in your answer.

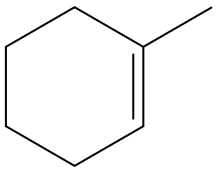
This means for example you should:
- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- organise information clearly and coherently, using specialist vocabulary when appropriate.

- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **100**.
- This document consists of **24** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Compound **A** is an unsaturated hydrocarbon that can be used as the starting material for the production of organic compounds.



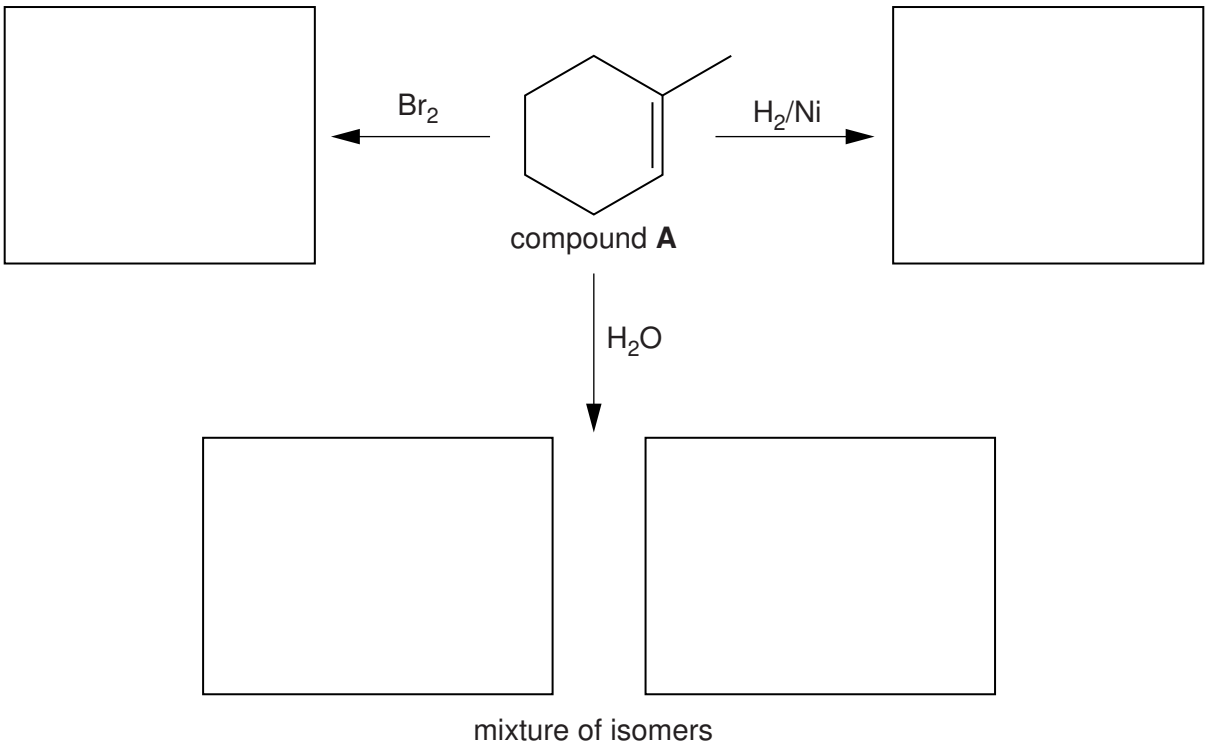
compound **A**

(a) What is the molecular formula of compound **A**?

..... **[1]**

(b) The flowchart shows three **addition** reactions of compound **A**.

(i) In the boxes below, show the structures of the organic products formed in the reactions.



[4]

(ii) What are the essential conditions for the reaction of compound **A** with H_2O?

..... **[2]**

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(iii) Using curly arrows, outline the mechanism for the reaction of compound **A** with Br_2.

[3]

(iv) Name the mechanism in part **(iii)**.

..... **[1]**

[Total: 11]

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2 This question is about the homologous series of alcohols.

(a) What is meant by the term *homologous series*?

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..... **[2]**

(b) Ethanol is used more than any other alcohol. One method of preparing ethanol uses yeast.

Write the equation for this preparation and state the essential conditions.

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..... **[2]**

(c) At room temperature and pressure, the first four members of the alkanes are all gases but the first four alcohols are all liquids.

Explain this difference in terms of intermolecular forces.

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..... **[2]**

(d) The boiling points of 2-methylpropan-1-ol and butan-1-ol are shown below.

Alcohol	**Boiling point / °C**
2-methylpropan-1-ol	108
butan-1-ol	117

Explain why the boiling points are different.

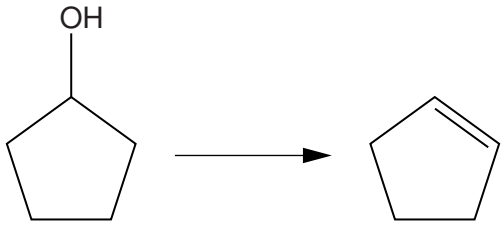
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..... **[2]**

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(e) Alkenes can be prepared from alcohols. Cyclopentene can be prepared from cyclopentanol as shown in the equation below.



A student plans to prepare 5.00 g of cyclopentene from cyclopentanol. The percentage yield of this reaction is 45.0%.

(i) What is the name of this type of reaction?

..... **[1]**

(ii) Calculate the mass of cyclopentanol that the student should use.

Show your working.

mass of cyclopentanol = ... g **[3]**

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(f) Alcohols can be prepared from halogenoalkanes. 2,2-dimethylpropan-1-ol can be prepared by hydrolysis of a chloroalkane with aqueous sodium hydroxide.

(i) Write the equation for this reaction.

Use structures for the organic compounds.

[1]

(ii) Outline the mechanism for this reaction.

Show curly arrows and relevant dipoles.

[2]

[Total: 15]

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3 This question is about different ways of determining enthalpy changes.

(a) A student carries out an experiment to determine directly the enthalpy change of reaction, ΔH_r, shown below.

$$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$$

- The student measures the initial temperature of 25.0 cm^3 of 0.500 $mol\,dm^{-3}$ $CuSO_4(aq)$.
- The student adds an excess of magnesium powder and stirs the mixture.
- The student measures the maximum temperature of the solution.

Results

Initial temperature of solution = 21.5 °C
Maximum temperature of solution = 63.0 °C

Density of the solution = 1.00 $g\,cm^{-3}$; specific heat capacity of the solution = 4.18 $J\,g^{-1}\,K^{-1}$.

(i) Calculate the enthalpy change of reaction, ΔH_r, in $kJ\,mol^{-1}$.

Give your answer to **three** significant figures.

ΔH_r = ... kJ mol^{-1} **[4]**

(ii) The student weighed out enough magnesium so that it would be in excess by **at least** 25%. The student had access to a two decimal-place balance.

Calculate the minimum mass of magnesium that the student would need to weigh out on this balance.

mass = ... g **[1]**

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(b) Enthalpy changes of formation can be determined indirectly from standard enthalpy changes of combustion, $\Delta H_c^{\ominus}$.

Three enthalpy changes of combustion are shown below.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	–394
$H_2(g)$	–286
$C_9H_{20}(l)$	–6125

(i) Define *standard enthalpy change of combustion*.

Include the standard conditions that are used.

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..... **[3]**

(ii) The equation that represents the enthalpy change of formation, ΔH_f, of nonane is shown below.

Calculate the standard enthalpy change of formation of nonane.

$$9C(s) + 10H_2(g) \rightarrow C_9H_{20}(l)$$

ΔH_f = ... kJ mol^{-1} **[2]**

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(c) The bond enthalpy for the bond in carbon monoxide can be calculated from the information below.

$$CH_4(g) + H_2O(g) \longrightarrow CO(g) + 3H_2(g) \qquad \Delta H = +210\,kJ\,mol^{-1}$$

Bond	Average bond enthalpy / kJ mol^{-1}
C–H	413
O–H	464
H–H	436

(i) What is meant by the term *average bond enthalpy*?

.....

.....

..... **[2]**

(ii) Calculate the bond enthalpy for the bond in carbon monoxide.

Show your working.

bond enthalpy = ... kJ mol^{-1} **[3]**

[Total: 15]

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4 This question is about equilibrium and catalysts.

(a) The equilibrium between NO_2 and N_2O_4 gases is set up in a gas syringe at room temperature. The two gases are different in appearance.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H = -58\,\text{kJ mol}^{-1}$$

Using le Chatelier's principle, predict and explain how the following changes would affect the appearance of the equilibrium mixture.

(i) The gas mixture is compressed by pushing in the plunger of the gas syringe.

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..... **[2]**

(ii) The gas syringe is placed in a warm water bath.

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..... **[2]**

(b) When potassium chromate(VI), K_2CrO_4, is dissolved in water an equilibrium is set up. The position of equilibrium is well to the left and the solution is a yellow colour.

$$\underset{\text{yellow}}{2CrO_4^{2-}(aq)} + 2H^+(aq) \rightleftharpoons \underset{\text{orange}}{Cr_2O_7^{2-}(aq)} + H_2O(l)$$

The addition of aqueous acid turns the solution an orange colour.
Aqueous alkali is then added and the solution turns a yellow colour.

Explain these observations in terms of le Chatelier's principle.

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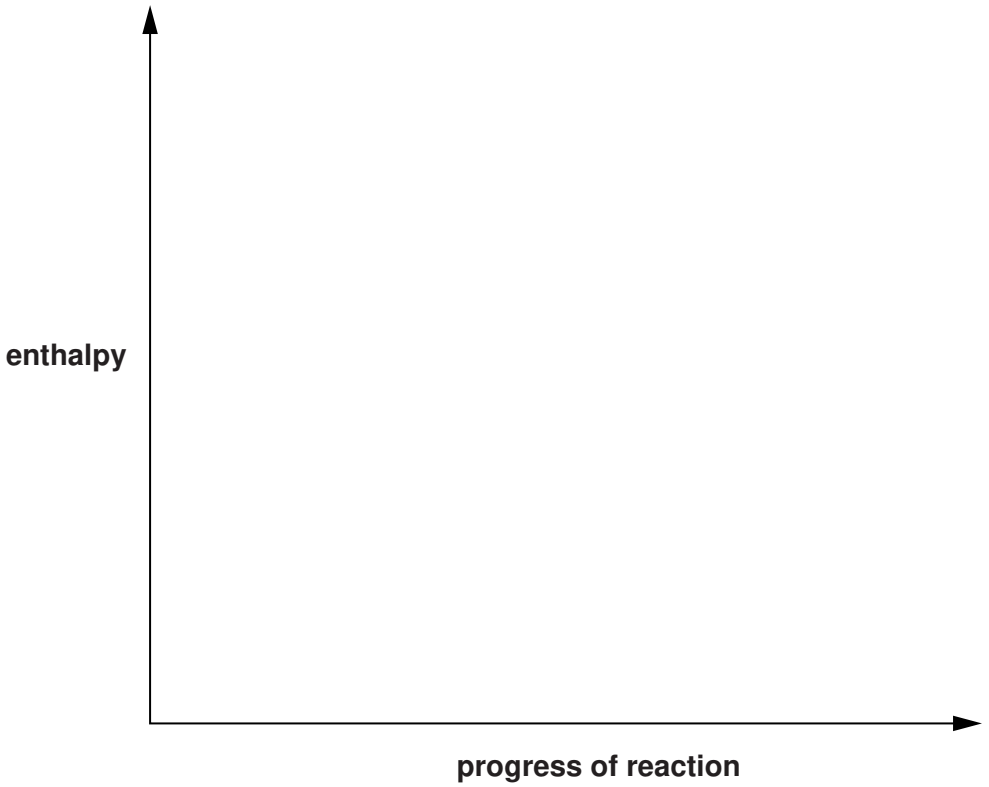
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(c) Catalysts can be used to change the rate of some chemical reactions.

(i) Zinc and sulfuric acid react together to form a solution of zinc sulfate, $ZnSO_4$, and hydrogen gas. The reaction is exothermic.

The rate of the reaction increases when a catalyst is added.

- Complete the enthalpy profile diagram for this reaction using the formulae of the reactants and products.
- Label activation energies, $\boldsymbol{E_a}$ (without catalyst) and $\boldsymbol{E_c}$ (with catalyst).
- Label the enthalpy change of reaction, $\Delta \boldsymbol{H}$.



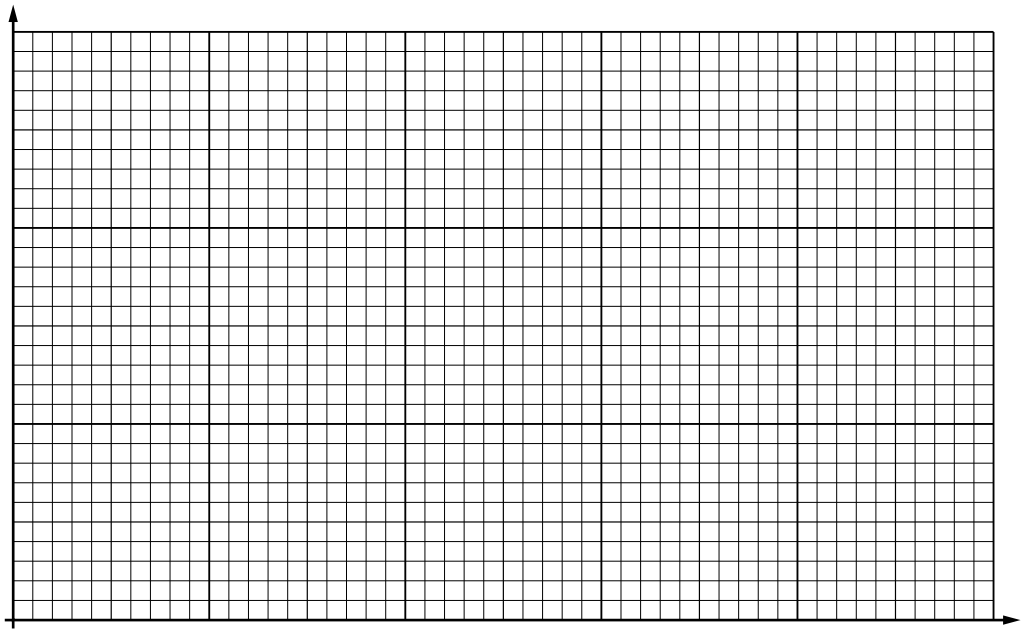
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(ii) Using a Boltzmann distribution, explain how a catalyst increases the rate of a chemical reaction.

Include a labelled sketch of your Boltzmann distribution on the grid below. Label the axes and any other important features.

Your answer needs to be clear and well organised using the correct terminology.



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..... **[4]**

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(d) The chemical industry uses catalysts for many of its reactions.

(i) State an example of a catalyst used by the chemical industry and write the equation for the reaction that is catalysed.

catalyst .....

equation .....

[1]

(ii) State **two** ways that the use of catalysts helps chemical companies to make their processes more sustainable and less harmful to the environment.

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..... **[2]**

(e) In the stratosphere, nitrogen oxides can catalyse the breakdown of ozone.

(i) State **two** sources of nitrogen oxides in the stratosphere.

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..... **[1]**

(ii) Write equations to show how nitrogen monoxide catalyses the breakdown of ozone.

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..... **[2]**

[Total: 19]

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5 The hydrocarbons present in crude oil are processed to obtain useful materials, including many fuels.

Alkanes with 6–10 carbon atoms are used in petrol.

(a) What is the general formula of an alkane?

..... **[1]**

(b) Carbon monoxide and nitrogen monoxide are pollutants formed in internal combustion engines, using petrol as their fuel.

- Explain how carbon monoxide and nitrogen monoxide are formed in internal combustion engines.
- Describe the stages that allow a catalytic converter to reduce carbon monoxide and nitrogen monoxide emissions.
- Include equations for any reactions and use octane to represent the alkanes present in petrol.

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..... **[6]**

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(c) Oil companies process alkanes into branched and cyclic hydrocarbons to promote efficient combustion in petrol.

- Draw the structure of one branched and one cyclic saturated hydrocarbon that contains **8** carbon atoms.
- Name each hydrocarbon.

Branched	**Cyclic**
name: ……	*name:* ……

[3]

(d) The greenhouse effect of a gas in the atmosphere is dependent on two factors.

State these **two** factors.

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..... **[2]**

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(e) By 2020, the EU has regulated that a car must emit less CO_2 per kilometre than in 2015. A typical car will need to emit 5.6×10^5 g less CO_2 in 2020 compared with 2015.

Calculate how much less petrol would be consumed by a typical car in 2020 to meet this regulation.

Give your answer in litres of petrol (1 litre of petrol has a mass of 700 g).

Assume that petrol is liquid octane and that complete combustion takes place, as in the equation below.

$$C_8H_{18}\,(l) + 12.5\,O_2\,(g) \longrightarrow 8CO_2\,(g) + 9H_2O\,(l)$$

volume of petrol = ... litres **[4]**

[Total: 16]

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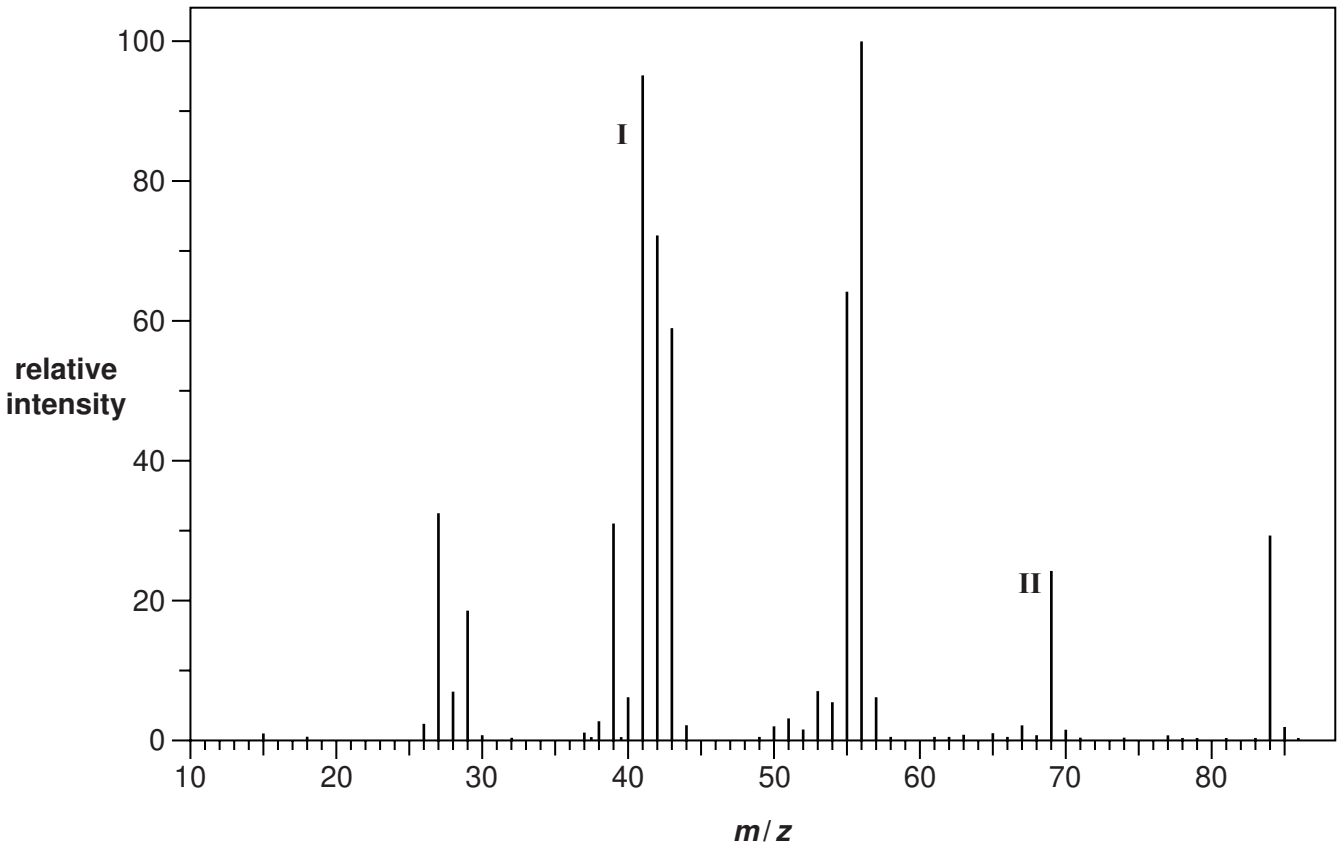
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Turn over for the next question

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6 This question is about several unsaturated hydrocarbons.

(a) The mass spectrum of an alkene is shown below.



(i) The empirical formula of the alkene is CH_2.

Use the empirical formula and the mass spectrum to confirm the molecular formula as C_6H_{12}.

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..... **[1]**

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(ii) Further analysis showed that the alkene was hex-2-ene.

Suggest possible structures for the species responsible for the labelled peaks **I** and **II** in the mass spectrum of hex-2-ene shown opposite.

peak I	**peak II**

[3]

(b) Hex-2-ene shows *E*/*Z* isomerism.

(i) Draw the skeletal formulae of *E*-hex-2-ene and *Z*-hex-2-ene.

E-hex-2-ene	*Z*-hex-2-ene

[2]

(ii) State and explain the features of a hex-2-ene molecule that lead to *E* and *Z* isomers.

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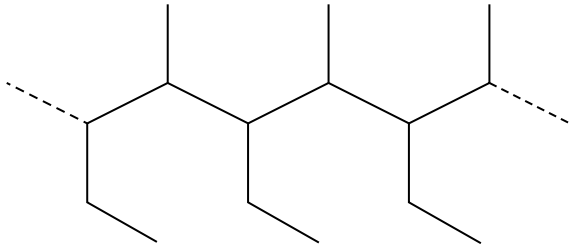
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(c) A section of a polymer that can be made from an unsaturated hydrocarbon **B** is shown below.



(i) Add brackets to the section of the polymer to show **one** repeat unit. **[1]**

(ii) Draw the structure of hydrocarbon **B**.

[1]

(iii) The polymer has a relative molecular mass of 50,000.

Calculate the number of monomer molecules required to make one molecule of the polymer.

number of monomer molecules = ... **[1]**

[Total: 11]

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7 A student was provided with a mixture of two structural isomers. Each isomer has the percentage composition by mass C, 29.29%; H, 5.70%; Br, 65.01%. The relative molecular mass of each isomer is less than 150.

(a) Determine the structures of the two structural isomers.

Show your working.



In your answer you should link the evidence with your explanation.

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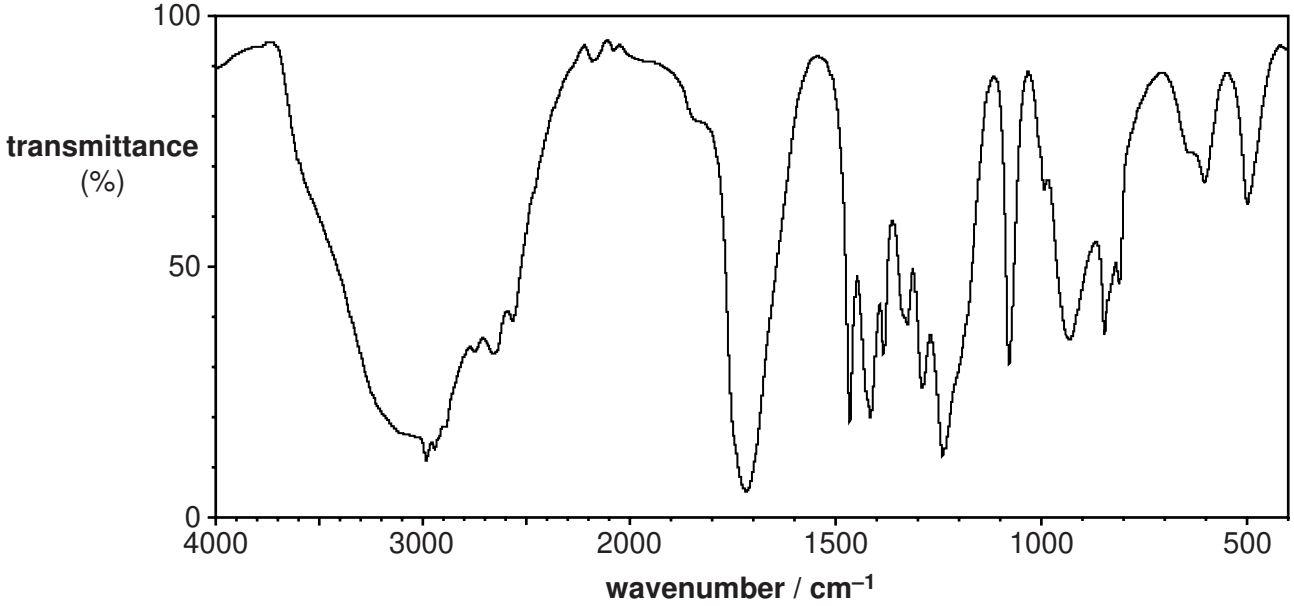
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[5]

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(b) The student heats the mixture of the two structural isomers from **(a)** under reflux with aqueous sodium hydroxide to form two compounds, **E** and **F**. The student separates the two compounds.

Compound **E** is heated under reflux with acidified potassium dichromate(VI) to form compound **G**, which gives the infrared spectrum below.



(i) Analyse the information and spectrum to determine the structures of **E**, **F** and **G**.

Include an equation for the formation of **G** from **E**.

In your answer you should link the evidence with your explanation.

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..... **[6]**

(ii) Compound **G** is heated with compound **F** in the presence of a small amount of concentrated sulfuric acid to form organic compound **H**.

Draw the structure of the organic compound **H**.

[2]

[Total: 13]

END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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