OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY A

Chains, Energy and Resources

F322

OCE/23212

Candidates answer on the question paper.

OCR Supplied Materials:
- *Data Sheet for Chemistry A* (inserted)

Other Materials Required:
- Scientific calculator

Thursday 20 January 2011
Afternoon

Duration: 1 hour 45 minutes

F3222

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The insert will be found in the centre of this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- 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.
- Answer **all** the questions.
- 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 Crude oil is a source of alkanes.

(a) Fractional distillation is used to separate useful hydrocarbons found in crude oil.

Explain, in terms of intermolecular forces, how fractional distillation works.

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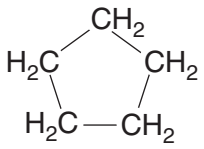
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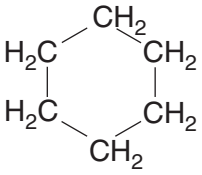
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..... **[2]**

(b) The petroleum industry processes straight-chained alkanes into cycloalkanes such as cyclopentane and cyclohexane.



cyclopentane



cyclohexane

(i) Deduce the general formula of a **cycloalkane**.

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

(ii) Construct the equation to show the formation of cyclohexane from hexane.

[1]

(iii) Suggest why the petroleum industry processes hexane into cyclohexane.

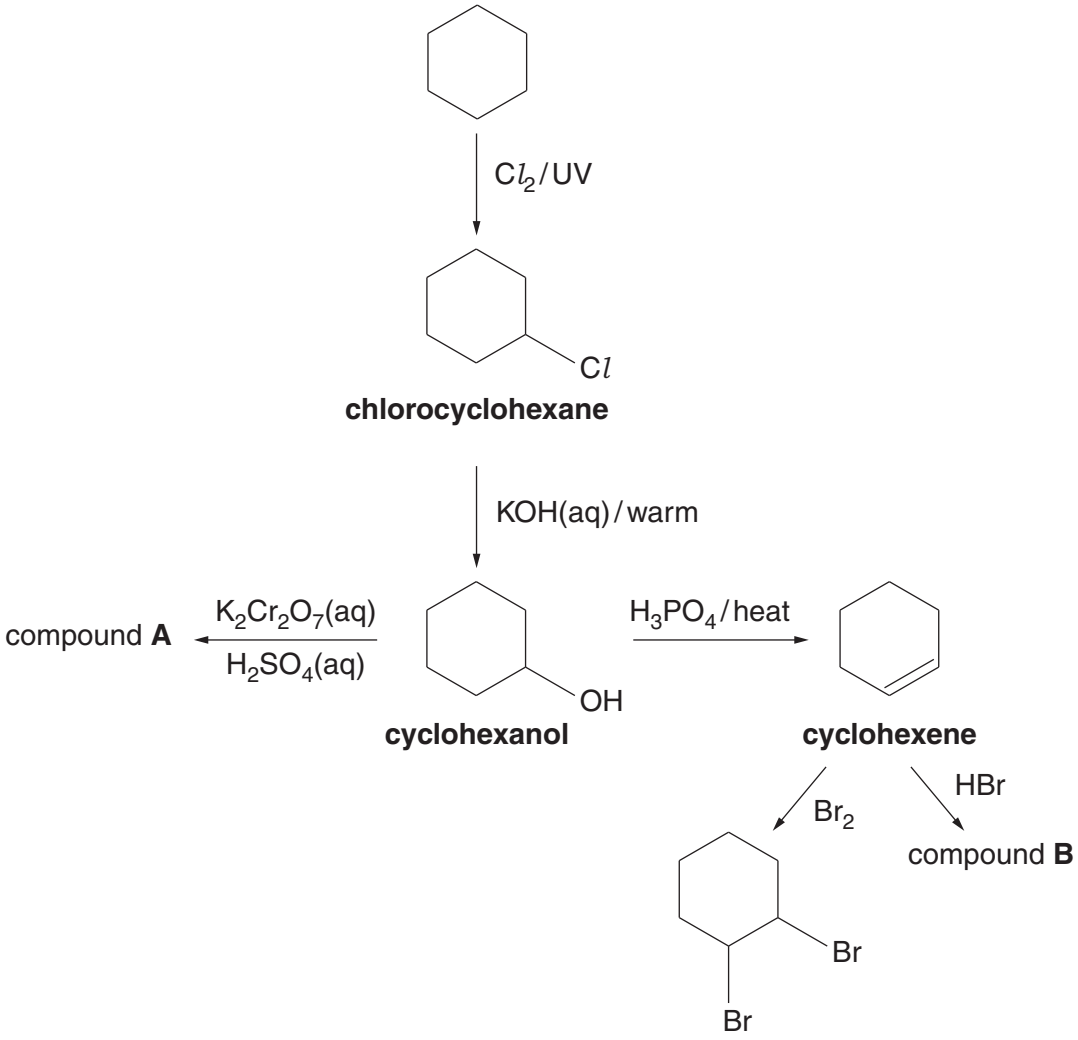
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..... **[1]**

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(c) The flowchart below shows some of the organic compounds that could be made starting from cyclohexane.



(i) Explain why cyclohexene is described as *unsaturated* and as a *hydrocarbon*.

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

(ii) The reaction between chlorine and cyclohexane is an example of radical substitution.

State **one** problem of using this reaction to prepare a sample of chlorocyclohexane.

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

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(iii) The formation of cyclohexanol from chlorocyclohexane involves the reaction of a nucleophile, the hydroxide ion.

Suggest what feature of the hydroxide ion makes it able to act as a nucleophile.

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

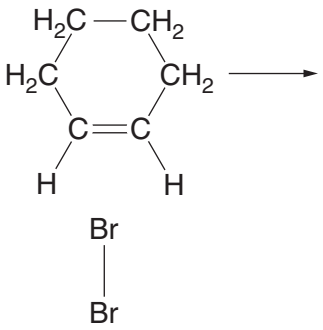
(iv) Using the flowchart, draw the structures of compound **A** and compound **B**.

compound **A**	compound **B**

[2]

(v) Describe, using the 'curly arrow model', the mechanism for the reaction between Br_2 and cyclohexene.

Show relevant dipoles and charges.



[4]

[Total: 15]

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2 Butyl ethanoate is an ester used as a flavouring.
This ester can be synthesised from butan-1-ol by two different processes.

Process 1 is a one-step process that involves a reversible reaction.

$$CH_3CH_2CH_2CH_2OH + CH_3COOH \rightleftharpoons CH_3COOCH_2CH_2CH_2CH_3 + H_2O$$

The percentage yield for **process 1** is 67.1%.
The atom economy for **process 1** is 86.6%.

Process 2 is a two-step process.

$$CH_3COOH + SOCl_2 \longrightarrow CH_3COCl + SO_2 + HCl$$

$$CH_3CH_2CH_2CH_2OH + CH_3COCl \longrightarrow CH_3COOCH_2CH_2CH_2CH_3 + HCl$$

The overall percentage yield for **process 2** is 93.3%.
The overall atom economy for **process 2** is 45.8%.

(a) Draw the skeletal formula for the ester butyl ethanoate.

[1]

(b) Show that the atom economy for **process 1** is 86.6%.

[2]

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(c) A research chemist investigates **process 1**.
She finds that 6.25 g of butan-1-ol forms 6.57 g of butyl ethanoate.

(i) Suggest the conditions needed for this reaction.

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

(ii) Show that the percentage yield of **process 1** is 67.1%.

[2]

(d) Explain why **process 2** has a high percentage yield but a low atom economy.

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

(e) Suggest **two** reasons why butyl ethanoate is manufactured by **process 1** rather than by **process 2**.

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

[Total: 11]

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3 Enthalpy changes of reaction can be determined by experiment or by using bond enthalpies.

(a) What is meant by the term *enthalpy change of reaction*?

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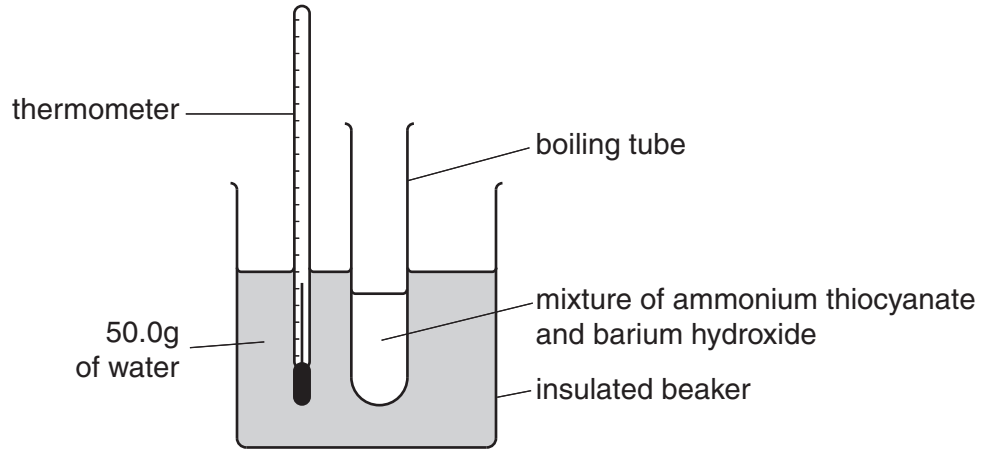
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..... **[2]**

(b) Solid ammonium thiocyanate, NH_4SCN, reacts with solid barium hydroxide, $Ba(OH)_2$, as shown in the equation below.

$$2NH_4SCN(s) + Ba(OH)_2(s) \longrightarrow Ba(SCN)_2(s) + 2H_2O(l) + 2NH_3(g)$$

A research chemist carries out an experiment to determine the enthalpy change of this reaction.



In the experiment, 15.22 g of NH_4SCN is reacted with a slight excess of $Ba(OH)_2$. The reaction absorbs energy, cooling the 50.0 g of water from 21.9 °C to 10.9 °C.

(i) Calculate the energy absorbed, in kJ, during this reaction.

The specific heat capacity of water = $4.2\,J\,g^{-1}\,K^{-1}$.

energy = ...kJ **[2]**

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(ii) Calculate the amount, in moles, of NH_4SCN used by the research chemist.

amount = ... mol **[1]**

(iii) Calculate the enthalpy change of reaction.

Include the sign in your answer.

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

ΔH_r = ...kJ mol^{-1} **[3]**

PART (c) CONTINUES ON PAGE 10

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(c) Standard enthalpy changes of reaction can also be determined using average bond enthalpies.

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

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

Table 3.1 below shows some average bond enthalpies.

bond	average bond enthalpy / kJ mol^{-1}
C–H	+415
C–C	+345
C=C	+611

Table 3.1

(ii) Explain the bonding in a C=C double bond. Use the orbital overlap model.

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

(iii) Suggest why the average bond enthalpy of a C=C bond is **not** twice the bond enthalpy of a C–C bond.

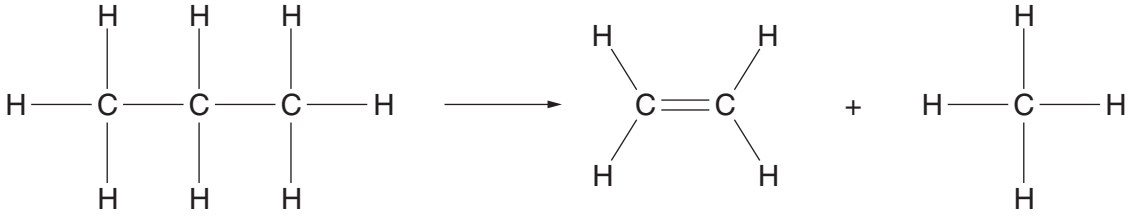
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..... **[1]**

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(iv) Propane can be cracked to make ethene.



Using the average bond enthalpies in **Table 3.1**, calculate the enthalpy change of this reaction.

ΔH_r = ...kJ mol^{-1} **[2]**

(v) The actual value for the enthalpy change of this reaction is +81 kJ mol^{-1}.

Suggest a reason why the actual value for the enthalpy change of this reaction is different from the calculated value.

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

[Total: 16]

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4 Catalysts speed up the rate of a reaction without being consumed by the overall reaction.

(a) Chlorine radicals in the stratosphere act as a catalyst for ozone depletion.

(i) Research chemists have proposed possible reaction mechanisms for ozone depletion. The equations below represent part of such a mechanism.

Complete the equations.

$Cl + O_3 \longrightarrow$ ..... + ...

ClO + ... $\longrightarrow$ ..... + O_2 **[2]**

(ii) Write an equation for the overall reaction in **(i)**.

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

(b) One of the catalysed reactions that takes place in a catalytic converter is shown below.

$$2CO(g) + 2NO(g) \longrightarrow N_2(g) + 2CO_2(g)$$

The catalyst used is platinum/rhodium attached to a ceramic surface.

Outline the stages that take place in a catalytic converter to allow CO to react with NO.

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

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(c) Explain, using an enthalpy profile diagram and a Boltzmann distribution, how the presence of a catalyst increases the rate of reaction.



In your answer you should organise your answer and use the correct technical terms.

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(d) Explain why many industrial manufacturing processes use catalysts.

Include in your answer ideas about sustainability, economics and pollution control.

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

[Total: 18]

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5 This question is about halogenated hydrocarbons.

(a) Halogenoalkanes undergo nucleophilic substitution reactions with ammonia to form amines. Amines contain the $-NH_2$ functional group.

For example, 1-bromopropane reacts with ammonia to form propylamine, $CH_3CH_2CH_2NH_2$.

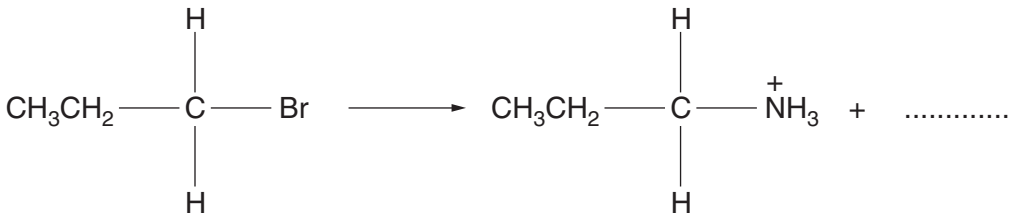
$$CH_3CH_2CH_2Br + 2NH_3 \longrightarrow CH_3CH_2CH_2NH_2 + NH_4Br$$

(i) Iodoethane is reacted with ammonia.

Write an equation for this reaction.

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

(ii) The first step in the mechanism of the reaction between $CH_3CH_2CH_2Br$ and NH_3 is shown below. It is incomplete.



Complete the mechanism.

Include relevant dipoles, lone pairs, curly arrows and the missing product. **[3]**

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(b) A student investigates the rate of hydrolysis of six halogenoalkanes.

The student mixes 5 cm^3 of ethanol with five drops of halogenoalkane. This mixture is warmed to 50 °C in a water bath. The student adds 5 cm^3 of aqueous silver nitrate, also heated to 50 °C, to the halogenoalkane. The time taken for a precipitate to form is recorded in a results table.

The student repeats the whole experiment at 60 °C instead of 50 °C.

halogenoalkane	**time taken for a precipitate to form / s**	
	at 50 °C	**at 60 °C**
$CH_3CH_2CH_2CH_2Cl$	243	121
$CH_3CH_2CH_2CH_2Br$	121	63
$CH_3CH_2CH_2CH_2I$	40	19
$CH_3CH_2CHBrCH_3$	89	42
$(CH_3)_2CHCH_2Br$	110	55
$(CH_3)_3CBr$	44	21

Describe and explain the factors that affect the rate of hydrolysis of halogenoalkanes.

Include ideas about
- the halogen in the halogenoalkanes
- the groups attached to the carbon of the carbon–halogen bond (the type of halogenoalkane)
- the temperature of the hydrolysis.

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

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..... **[7]**

(c) Poly(tetrafluoroethene), PTFE, and poly(chloroethene), PVC, are halogenated plastics.

(i) Write an equation, using displayed formulae, for the reaction to form PTFE from its monomer.

[3]

(ii) The combustion of waste polymers can be used for energy production.

What problem is caused by disposing of PTFE and PVC in this way?

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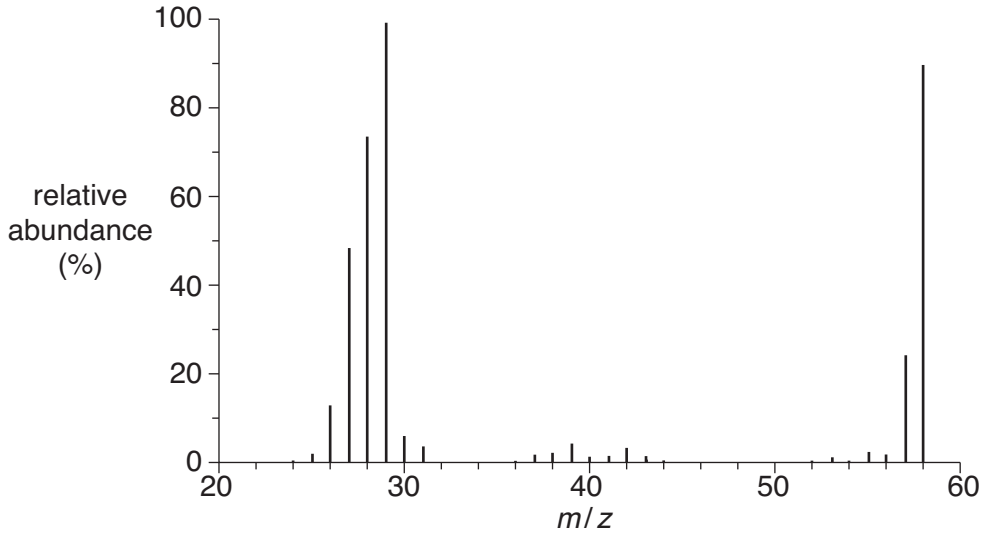
..... **[1]**

[Total: 16]

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6 Mass spectrometry and infrared spectroscopy are used in analysis.

(a) The mass spectrum of compound **Z** is shown below.



Compound **Z** has the molecular formula $C_3H_6O_x$.

(i) Using the mass spectrum, deduce the value of x in $C_3H_6O_x$.

Explain your answer.

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

(ii) Suggest a possible structure for **Z**.

[1]

(iii) Suggest the formula of an ion that gives rise to the peak at $m/z = 29$ in this spectrum.

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

(b) A space probe has detected the presence of the element iron on the surface of the planet Mars.

Outline how a mass spectrum would show the presence of iron.

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

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(c) The space probe also detected different isotopes of sulfur on Mars.

(i) Outline how the mass spectrum would show how many different isotopes of sulfur were present on Mars.

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

(ii) The relative atomic mass of the sulfur found by the space probe was different from the relative atomic mass of sulfur on Earth.

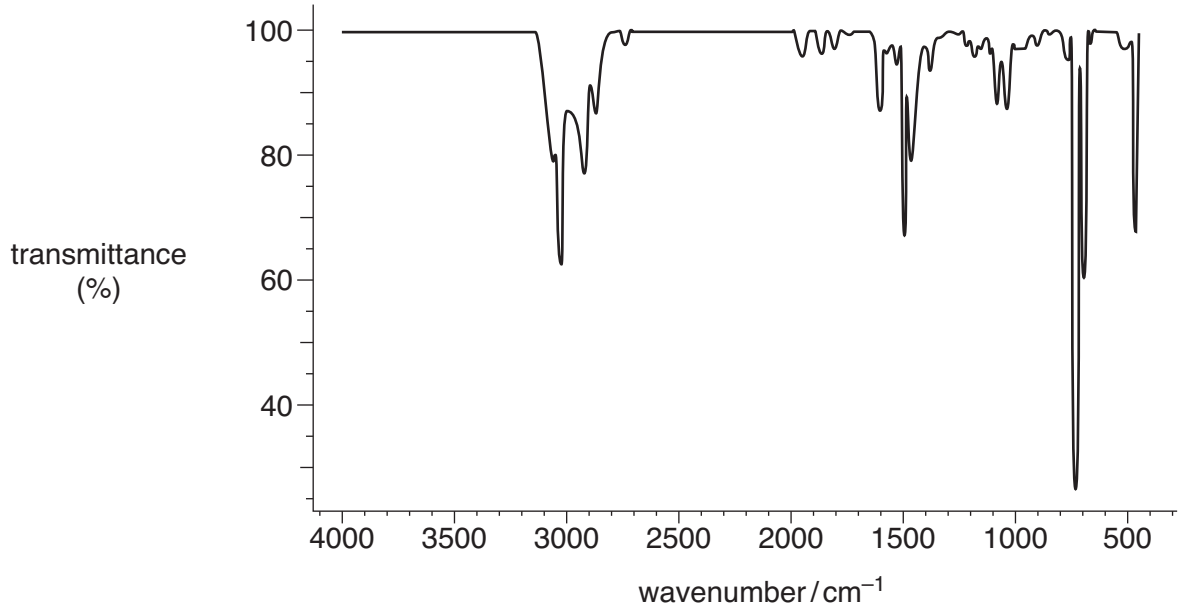
Suggest why.

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

(d) An environmental chemist used infrared spectroscopy to monitor air pollution outside a petrol station. The infrared spectrum below was obtained from one of these pollutants.



What evidence is there in the spectrum that the pollutant may be a hydrocarbon rather than an alcohol or a carbonyl compound?

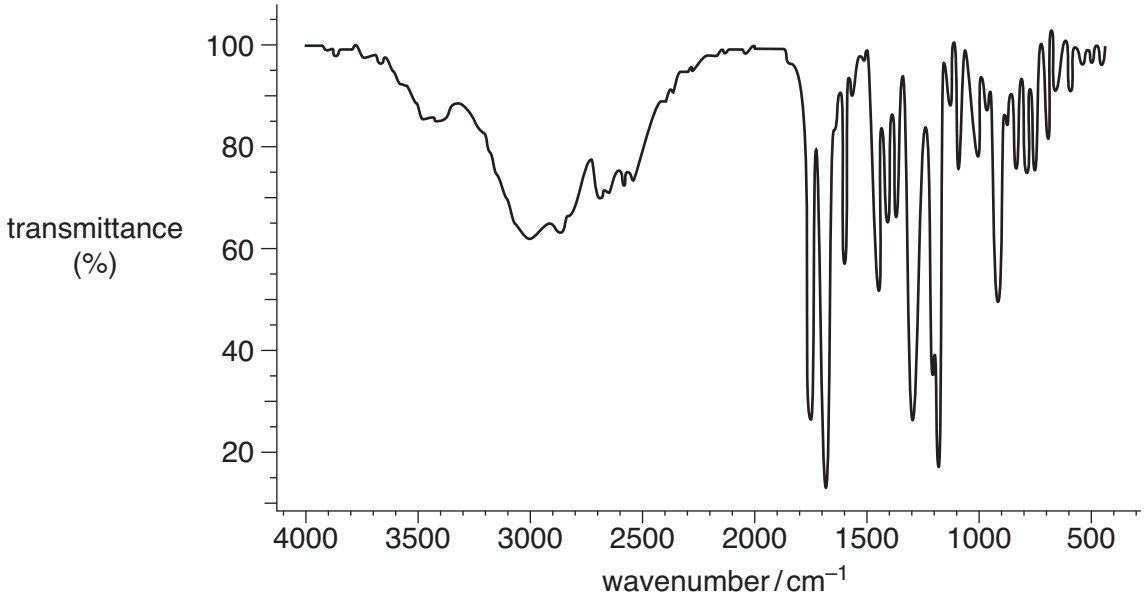
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(e) The infrared spectrum of a drug is shown below.



Suggest, with reasons, possible functional group(s) present in the drug.

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

[Total: 10]

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7 Biofuels such as bioethanol and biodiesel are increasingly being used as an alternative to fossil fuels to provide energy.

(a) Describe, with the aid of an equation, how bioethanol is manufactured by fermentation.

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

(b) Biodiesel is obtained from plant oils. The manufacture involves several stages, all of which have a high energy requirement.

Biodiesel is often described as being 'carbon-neutral' because:

- plants convert atmospheric carbon dioxide into carbon compounds
- on burning biodiesel this carbon dioxide is returned to the atmosphere.

(i) Construct an equation to show the complete combustion of biodiesel.

Assume that the molecular formula of the biodiesel is $C_{15}H_{30}O_2$.

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

(ii) Suggest why biodiesel is **not** completely carbon-neutral.

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

(c) Many scientists suggest that society should use more biofuels rather than fossil fuels to provide energy. Other scientists are worried that biofuels will need large areas of land to grow suitable crops.

Suggest **disadvantages** or **advantages**, other than being carbon-neutral, of using more biofuels.

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

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(d) Unsaturated compounds in plant oils can also be used to make margarine.

Describe how.

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

(e) Part of the structure of an unsaturated compound in plant oils is shown below:

$$-CH_2CH_2CH=CHCH_2CH_2-$$

(i) Draw the displayed formula of the *Z* isomer of this part of the structure.

[1]

(ii) Explain why this part of the structure can have an *E* and a *Z* isomer.

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

[Total: 14]

END OF QUESTION PAPER

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ADDITIONAL PAGE

If additional space is required, you should use the lined pages below. The question number(s) must be clearly shown.

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ADDITIONAL PAGE

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