THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY A

F322

Chains, Energy and Resources

Scan the QR code or type in the URL below to access markschemes for these papers

goo.gl/K1hTTK

Thursday 14 January 2010
Morning

Duration: 1 hour 45 minutes

OCE/19234

Centre Number							Candidate Surname			
Centre Number							Candidate Number			

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

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 **20** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Kerosene is used as a fuel for aeroplane engines.

(a) Kerosene is obtained from crude oil.

Name the process used to obtain kerosene from crude oil **and** explain why the process works.

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

(b) Some of the hydrocarbons in kerosene have the formula $C_{10}H_{22}$.

(i) What is the name of the straight chain hydrocarbon with the formula $C_{10}H_{22}$?

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

(ii) Draw the skeletal formula of one branched chain isomer with the formula $C_{10}H_{22}$.

[1]

(iii) Explain why the straight chain isomer of $C_{10}H_{22}$ has a higher boiling point than any of its branched chain structural isomers.

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

(iv) Explain why the straight chain isomer of $C_{10}H_{22}$ is converted by the petroleum industry into its branched chain isomers.

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

(c) When kerosene burns in an aeroplane engine very little carbon monoxide, CO, is formed but a significant amount of nitrogen monoxide, NO, is formed.

(i) Construct the equation to show the **complete** combustion of $C_{10}H_{22}$.

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

(ii) Suggest, with the aid of an equation, how NO is formed within an aeroplane engine.

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

(d) NO is a radical and contributes towards ozone depletion in the stratosphere.

(i) What is a *radical*?

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

(ii) One of the processes leading to the breakdown of ozone in the stratosphere can be represented by the following two equations.

$$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$$

$$NO_2(g) + O(g) \rightarrow NO(g) + O_2(g)$$

What is the role of the NO in this process?

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

(iii) Ozone in the stratosphere is broken down to make O_2 and O.

Describe and explain how the concentration of ozone in the stratosphere is maintained.

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

(iv) Why is it important to life on the Earth's surface that the concentration of ozone in the stratosphere is maintained?

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

[Total: 15]

2 Dilute aqueous hydrogen peroxide, $H_2O_2(aq)$, is used to sterilise contact lenses.

(a) Dilute $H_2O_2(aq)$ slowly decomposes at room temperature to produce oxygen and water.

The decomposition of $H_2O_2(aq)$ can be made faster by:

- increasing the concentration of the $H_2O_2(aq)$,
- adding a small amount of manganese(IV) oxide catalyst,
- heating the solution to 60 °C.

(i) Construct the equation for the decomposition of H_2O_2.

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

(ii) Explain why increasing the concentration of $H_2O_2(aq)$ increases the rate of decomposition.

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

(iii) Explain how the catalyst can increase the rate of decomposition of $H_2O_2(aq)$.

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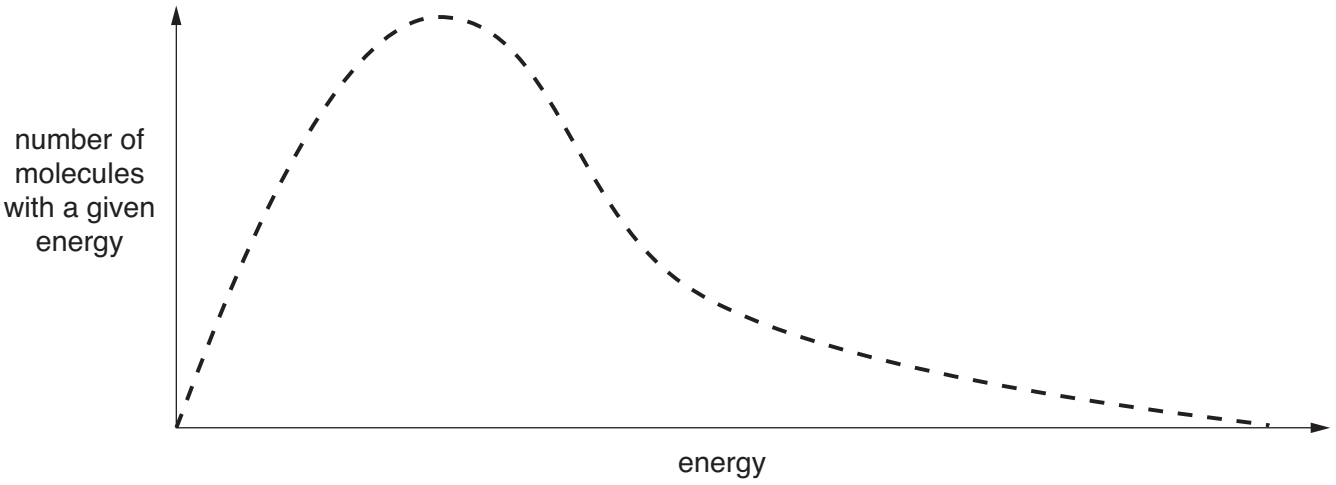
(iv) Explain why increasing the temperature of $H_2O_2(aq)$ increases the rate of decomposition.

As part of your answer, you should add a second curve and any necessary labels to the Boltzmann distribution of molecular kinetic energies shown below.



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

(b) (i) In the past, hydrogen peroxide was manufactured by reacting barium peroxide, BaO_2, with ice-cold dilute sulfuric acid.

$$BaO_2(s) + H_2SO_4(aq) \longrightarrow BaSO_4(s) + H_2O_2(aq)$$

This method required the disposal of poisonous barium compounds.

Calculate the atom economy for this manufacture of hydrogen peroxide from BaO_2. Use the table of relative formula masses given below.

compound	relative formula mass
BaO_2	169.3
H_2SO_4	98.1
$BaSO_4$	233.4
H_2O_2	34.0

atom economy = ... % **[2]**

(ii) Nowadays, hydrogen peroxide is manufactured using hydrogen gas, oxygen from the air and a substance called anthraquinone.

stage 1 H_2 + anthraquinone $\longrightarrow$ anthraquinol

stage 2 O_2 + anthraquinol $\longrightarrow$ H_2O_2 + anthraquinone

Compare the manufacture of H_2O_2 from hydrogen and oxygen with the manufacture from barium peroxide described in **b(i)**.

Explain the advantages of the manufacture of H_2O_2 from hydrogen and oxygen.

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

(c) Some reactions of H_2O_2 are exothermic.

Use ideas about the enthalpy changes that take place during bond breaking and bond making to explain why some reactions are exothermic.

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

[Total: 15]

3 Glucose, $C_6H_{12}O_6$, can be completely combusted to give carbon dioxide and water.

$$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(l)$$

(a) In the body, the conversion of glucose into carbon dioxide and water takes place in a number of stages catalysed by enzymes.

What name is given to this oxidation process in the body?

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

(b) A student carries out an experiment to determine the enthalpy change of combustion of glucose.

In the experiment, 0.831 g of glucose is burned. The energy released is used to heat 100 cm^3 of water from 23.7 °C to 41.0 °C.

(i) Calculate the energy released, in kJ, during combustion of 0.831 g glucose.

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

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

(ii) Calculate the amount, in moles, of glucose that is burned.

amount = ... mol **[2]**

(iii) Calculate the enthalpy change of combustion of glucose.
Give your answer to **three** significant figures.

ΔH_c = ... kJ mol^{-1} **[2]**

(c) The standard enthalpy change of combustion of glucose can also be determined indirectly.

Calculate the standard enthalpy change of combustion of glucose using the standard enthalpy changes of formation below.

substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$C_6H_{12}O_6(s)$	–1250
$CO_2(g)$	–394
$H_2O(l)$	–286

$$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(l)$$

–1

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

(d) Suggest **two** reasons why standard enthalpy changes of combustion determined experimentally are less exothermic than the calculated theoretical values.

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

[Total: 12]

4 A reaction mechanism shows the individual steps that take place during a reaction.

(a) Methane reacts with bromine in the presence of ultraviolet radiation to form several products. Two of these products are bromomethane and hydrogen bromide.

(i) Write an equation for the reaction between methane and bromine to make bromomethane and hydrogen bromide.

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

(ii) Name one other bromine-containing organic product which is formed when methane reacts with bromine.

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

(iii) The mechanism for this reaction is called radical substitution.

Describe the mechanism for the radical substitution of methane by bromine to make bromomethane.

Use the mechanism to suggest why a small amount of ethane is also formed.

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

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

(b) The 'curly arrows' model is used in reaction mechanisms to show the movement of electron pairs during chemical reactions.

Choose a reaction mechanism that you have studied involving the curly arrow model.

Name and describe your chosen reaction mechanism.

In your answer, include:

- an example of the reaction with the chosen mechanism,
- the type of bond fission that occurs,
- relevant dipoles.

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[6]

[Total: 15]

5 Alkenes are a very useful series of hydrocarbons used widely in synthesis. Alkenes are more reactive than alkanes.

(a) What is the name of the process used to convert long chain alkanes into more useful shorter chain alkenes?

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

(b) Ethene and steam can be converted into ethanol.
The equilibrium is shown below.

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -46 \text{ kJ mol}^{-1}$$

le Chatelier's principle can be used to predict the effect of changing conditions on the position of equilibrium.

(i) Name the catalyst used in this reaction.

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

(ii) State le Chatelier's principle.

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

(iii) Using le Chatelier's principle, predict and explain the conditions that would give the maximum equilibrium yield of ethanol from ethene and steam.

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

(iv) The actual conditions used are 60 atmospheres pressure at 300 °C in the presence of a catalyst. Compare these conditions with your answer to **(iii)** and comment on why these conditions are used.

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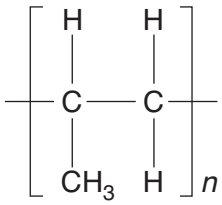
..... **[3]**

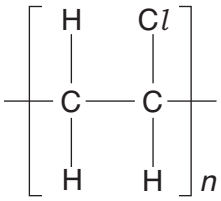
(c) Alkenes are used to make addition polymers.
The repeat unit for an addition polymer is shown below.



What is the name of the monomer used to make this polymer?

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

(d) Poly(chloroethene) has the repeat unit below.



This repeat unit can be written as —CH_2CHCl— .

One way to dispose of poly(chloroethene) is to react it with oxygen at high temperature. This is called incineration.

(i) Complete the following equation that shows the reaction taking place during incineration.

—CH_2CHCl— + ... O_2 → ..... CO_2 + ... H_2O + ... HCl **[1]**

(ii) Research chemists have reduced the environmental impact of incineration by removing the HCl formed from the waste gases.

Suggest a type of reactant that could be used to remove the HCl.

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

(e) The disposal of polymers causes environmental damage.
Research chemists are developing polymers that will reduce this environmental damage and increase sustainability.

Describe **two** ways in which chemists can reduce this environmental damage.

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

[Total: 14]

6 This question is about the six alcohols below.

butan-2-ol	**ethane-1,2-diol**
2-methylpentan-3-ol	**2-methylpropan-2-ol**
propan-1-ol	**propan-2-ol**

(a) Which alcohol is an example of a tertiary alcohol?

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

(b) Draw the skeletal formula for 2-methylpentan-3-ol.

[1]

(c) Butan-2-ol and 2-methylpropan-2-ol are structural isomers.

(i) What is meant by the term *structural isomer*?

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

(ii) Draw another structural isomer of these two alcohols.

[1]

(d) Ethane-1,2-diol can be dissolved in water to act as an anti-freeze in car radiators.

Explain why ethane-1,2-diol is very soluble in water.

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

(e) Ethane-1,2-diol is heated under reflux with ethanoic acid and a small amount of H_2SO_4 catalyst. Compound **A** is formed with molecular formula $C_6H_{10}O_4$.

Draw the structure of compound **A**.

[2]

(f) Butan-2-ol is heated with H_2SO_4 catalyst.

- A mixture of **three** alkenes forms, **B**, **C** and **D**.
- The alkenes **B** and **C** are stereoisomers.

(i) Draw the structures of the two stereoisomers **B** and **C**.

[2]

(ii) What type of stereoisomerism is shown by **B** and **C**?

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

(iii) Draw the structure of the other alkene, **D**, that is formed in this reaction.

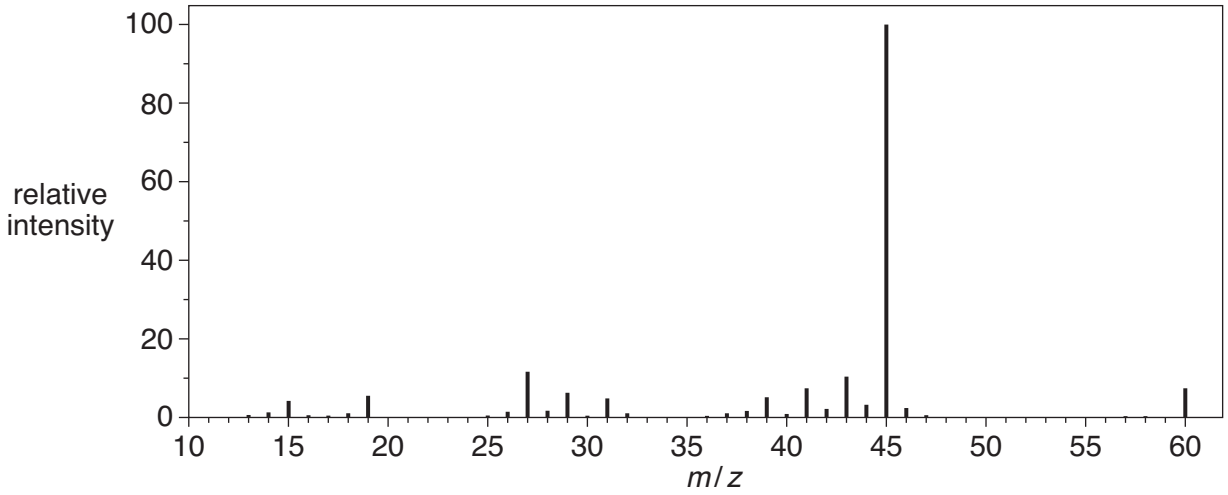
[1]

(g) Alcohol **E** is one of the following alcohols.

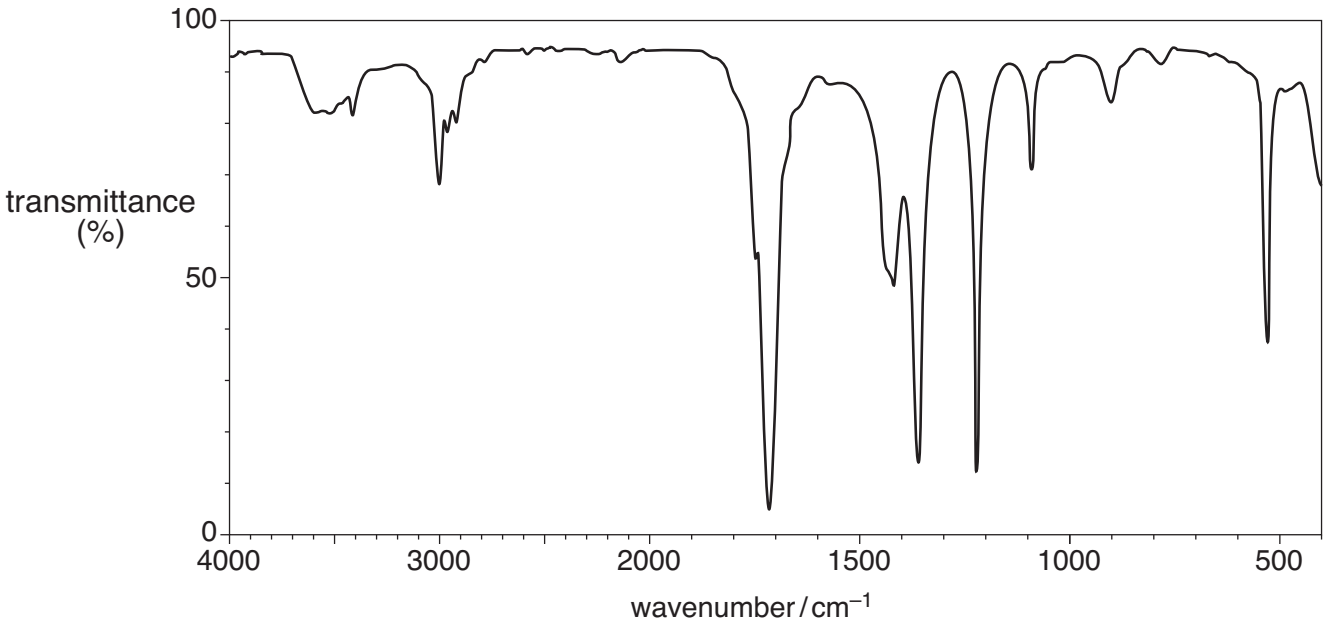
butan-2-ol	**ethane-1,2-diol**
2-methylpentan-3-ol	**2-methylpropan-2-ol**
propan-1-ol	**propan-2-ol**

A student oxidises alcohol **E** by heating under reflux with excess acidified potassium dichromate(VI). An organic product **F** is isolated.

The mass spectrum of the alcohol **E** is shown below.



The infrared spectrum of the organic product **F** is shown below.



- Name **or** draw the structures of the alcohol **E** and the organic product **F**.
- Write an equation for the reaction of alcohol **E** with acidified potassium dichromate(VI).

Use [O] to represent the oxidising agent, acidified potassium dichromate(VI).

In your answer, you should make clear how each structure fits with the information given above.

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

[Total: 19]

7 There is much international concern that an increase in atmospheric concentrations of carbon dioxide and methane may lead to global warming and climate change.

(a) Carbon dioxide and methane are both greenhouse gases.

(i) What type of radiation is absorbed by methane molecules and what effect does this radiation have on these molecules?

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

(ii) Some scientists are more concerned about carbon dioxide as a greenhouse gas than methane.

Suggest why.

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

(b) Describe ways that research chemists are trying to minimise climate change resulting from global warming caused by the release of greenhouse gases.

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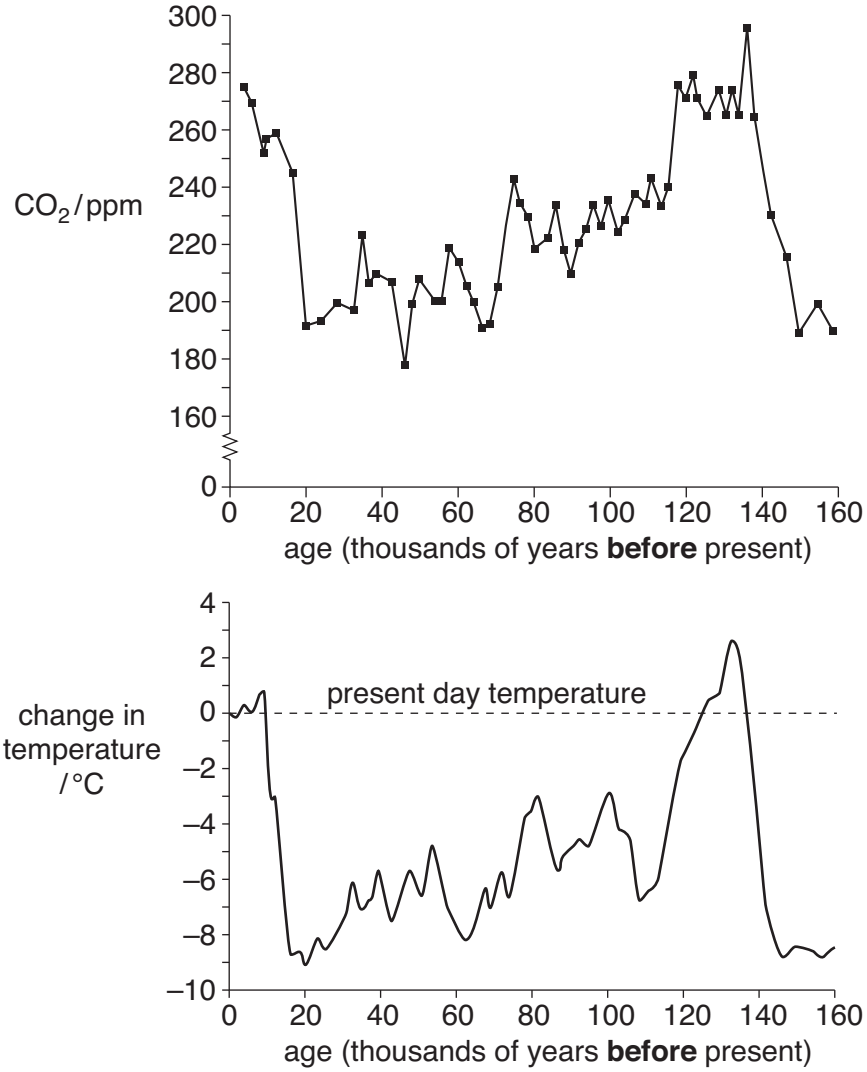
..... **[5]**

(c) Research scientists working in the Antarctic have measured the concentration of carbon dioxide in the ice. This study has allowed the scientists to estimate the atmospheric concentration of carbon dioxide over many thousands of years.

The graphs below show these atmospheric concentrations and the corresponding average surface temperature.



Do the graphs provide reliable evidence that an increase in atmospheric carbon dioxide concentration will result in global warming?

Explain your answer.

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

[Total: 10]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY A

Chains, Energy and Resources

F322

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

OCE/23212

F322

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.
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- 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.

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

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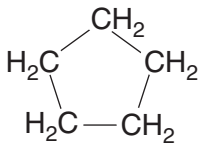
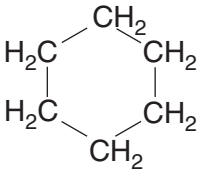
..... **[2]**

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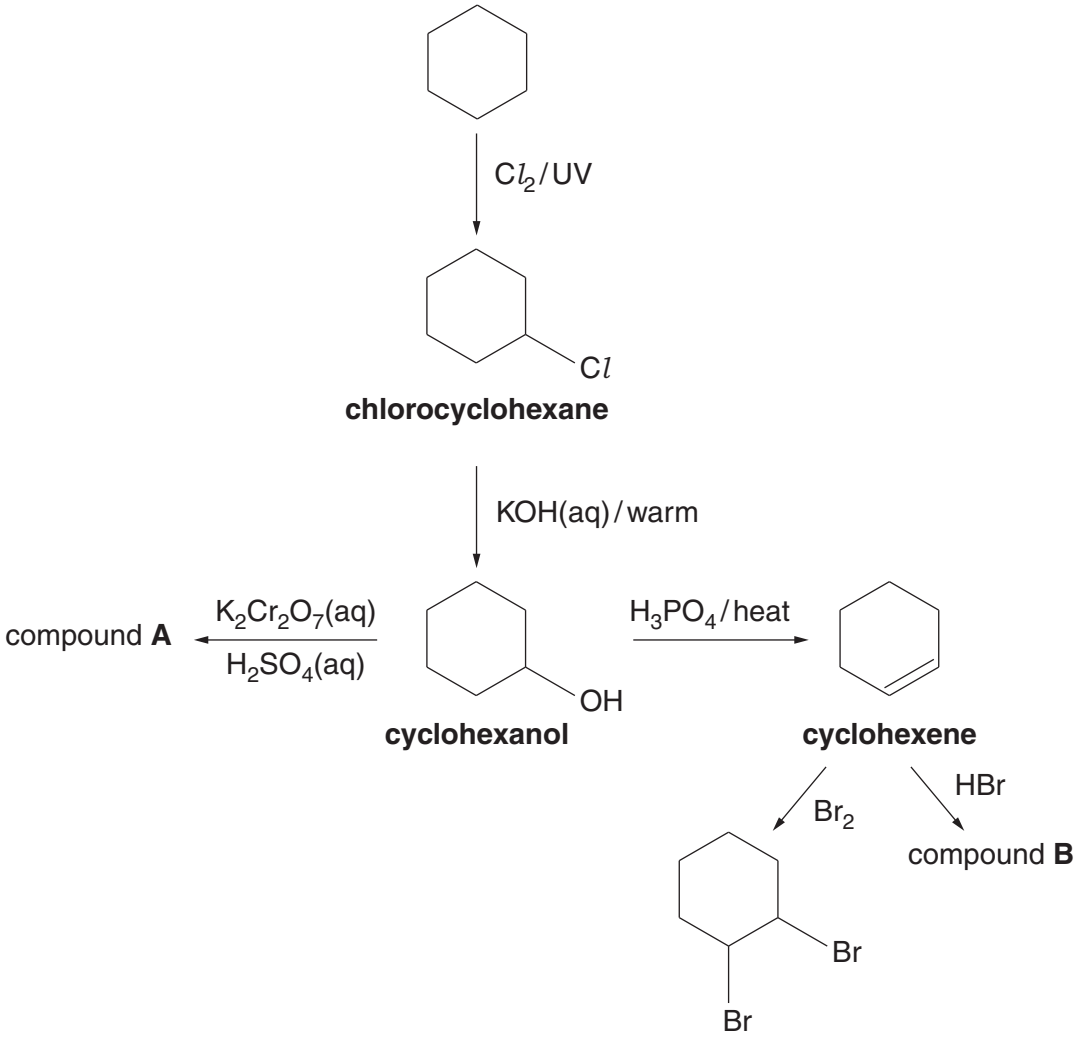
..... **[1]**

(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]**

(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]**

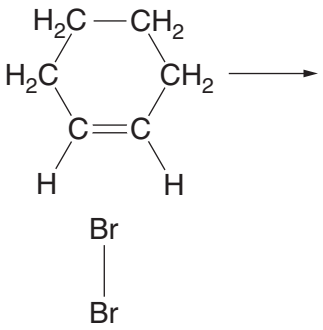
(iv) Using the flowchart, draw the structures of compound **A** and compound **B**.

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]

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]

(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]

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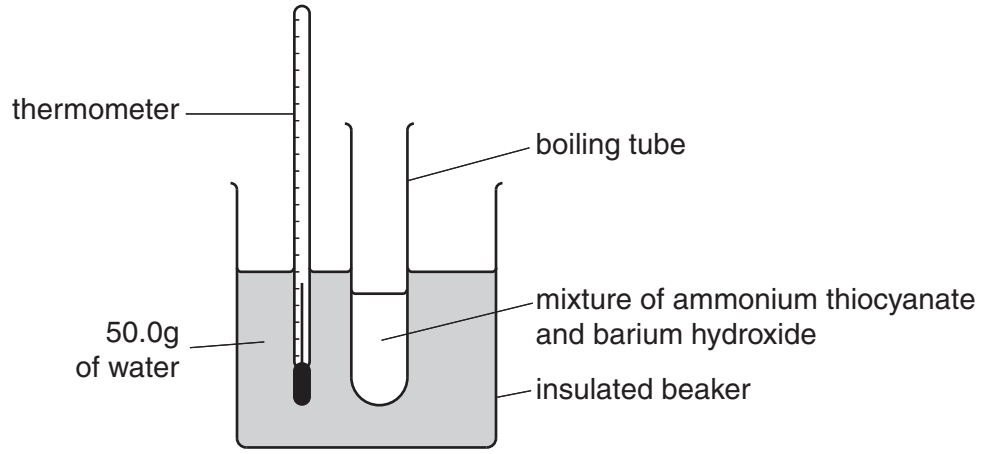
..... **[2]**

(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]**

(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

(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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(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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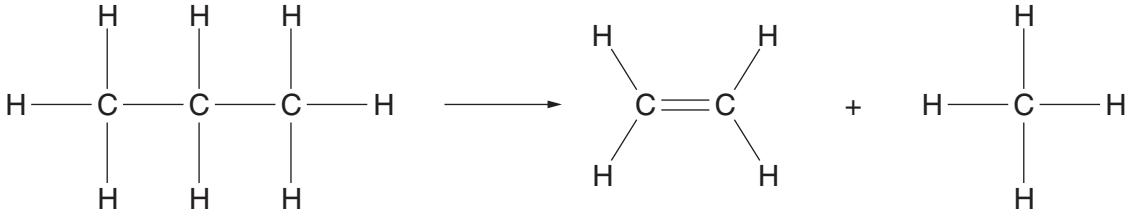
(iv) Propane can be cracked to make ethene.



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]

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]**

(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.

.... **[7]**

(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]

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, $CH_3CH_2CH_2NH_2$.

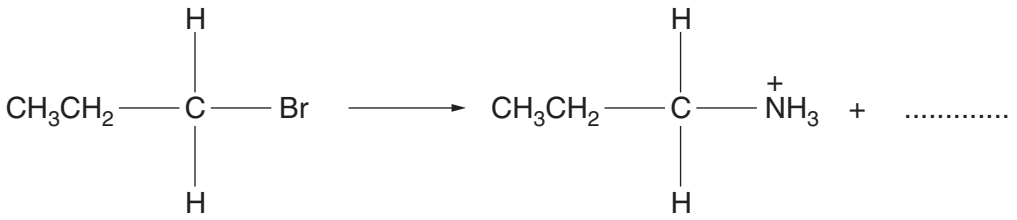
$$CH_3CH_2CH_2Br + 2NH_3 \longrightarrow CH_3CH_2CH_2NH_2 + NH_4Br$$

(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]**

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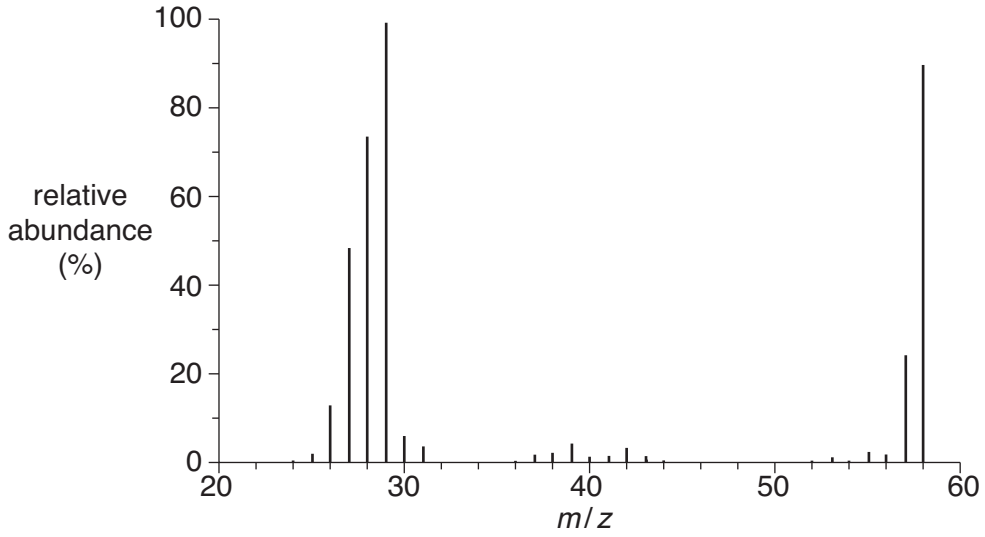
..... **[1]**

[Total: 16]

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.

.....

.....

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

(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.

.....

.....

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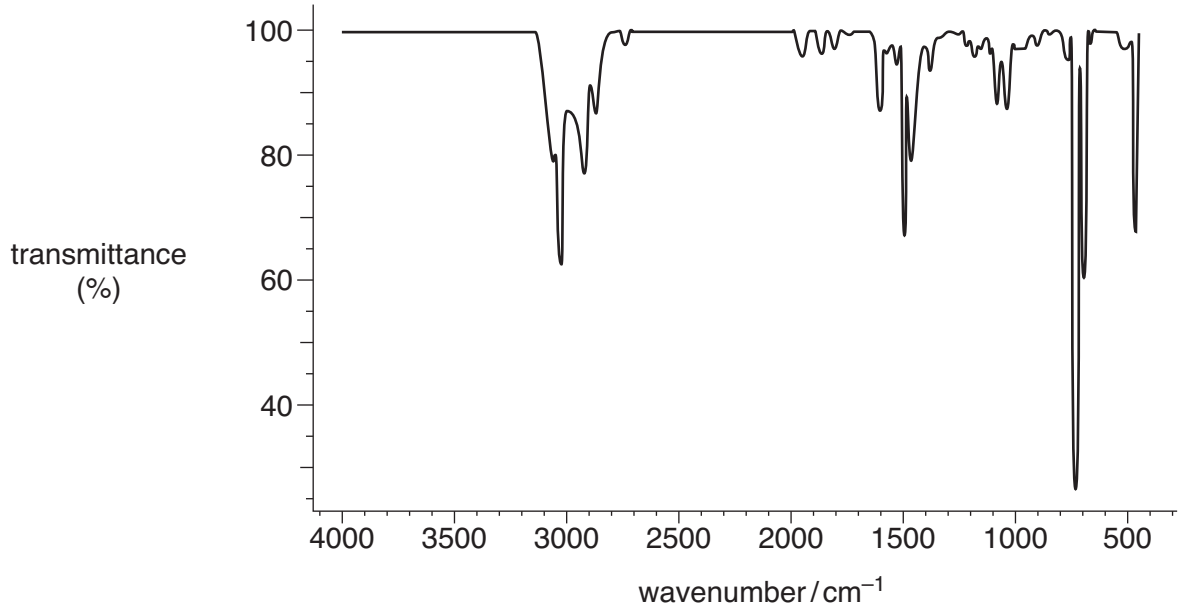
..... **[1]**

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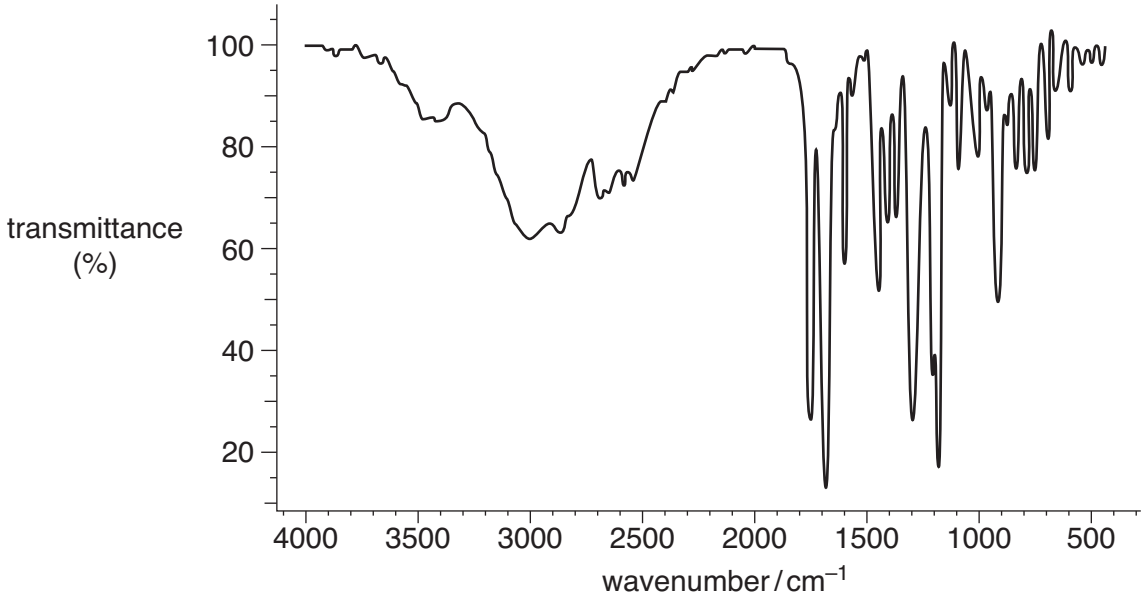
..... **[1]**

(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]

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.

.....

.....

..... **[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]**

(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

OCR
RECOGNISING ACHIEVEMENT

Thursday 19 January 2012 – Afternoon

AS GCE CHEMISTRY A

F322 Chains, Energy and Resources

F3144401122

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

F322

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. 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.

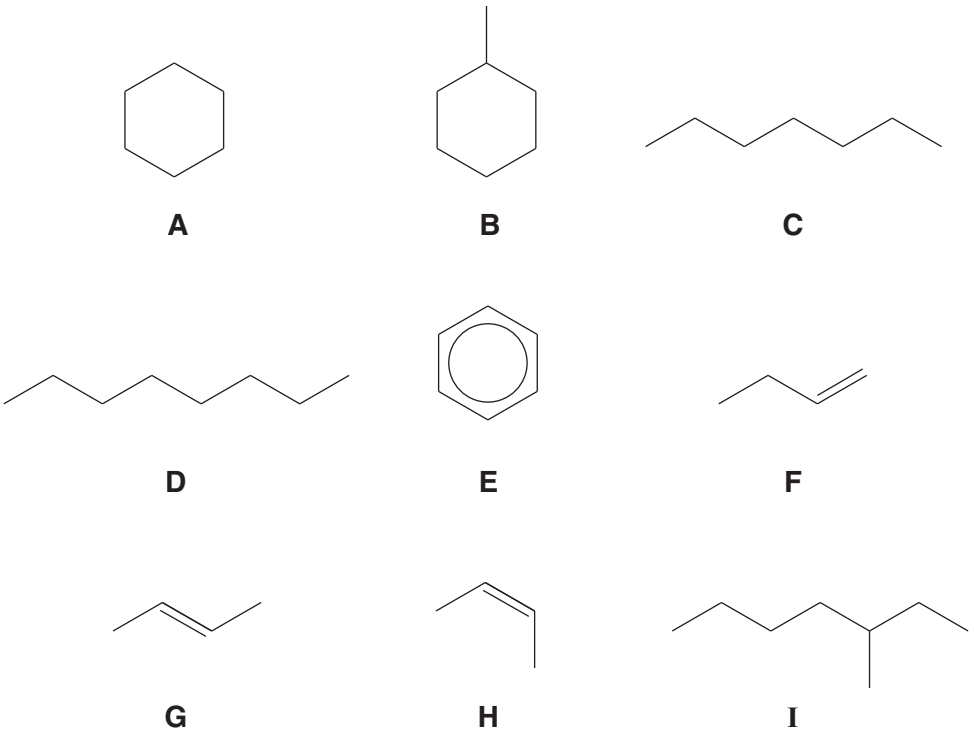
This means for example you should:
- ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
- organise information clearly and coherently, using specialist vocabulary when appropriate.

- 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.

Answer **all** the questions.

1 Crude oil is a source of many hydrocarbons.

The skeletal formulae of some of these hydrocarbons are shown below.



(a) Explain why compound **A** is both *saturated* and a *hydrocarbon*.

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

(b) What is the empirical formula for compound **A**?

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

(c) Give the letters, **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** or **I**, of two hydrocarbons that are structural isomers of each other.

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

(d) The petroleum industry processes straight chain alkanes into cyclic hydrocarbons such as **A**, **B** and **E**.

(i) Explain why the petroleum industry processes straight chain alkanes into cyclic hydrocarbons.

.....

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

(ii) Hydrocarbon **C** can be processed into the cyclic hydrocarbon **B**.

Construct an equation for this reaction.

[1]

(e) Explain why hydrocarbon **D** has a higher boiling point than hydrocarbon **C**.

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

(f) Hydrocarbons **G** and **H** are stereoisomers of each other.

Explain what is meant by the term *stereoisomerism*.

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

(g) Construct the equation for the **complete** combustion of hydrocarbon **C**.

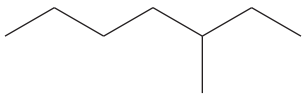
..... **[2]**

(h) A hydrocarbon molecule, $C_{16}H_{34}$, is cracked to form an octane molecule and two molecules of but-2-ene.

Construct the equation for this reaction.

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

(i) Compound **I** is 3-methylheptane. It does not contain a functional group.



I

(i) What is meant by the term *functional group*?

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

(ii) Compound **I** reacts with chlorine in the presence of ultraviolet radiation to give several structural isomers of $C_8H_{17}Cl$.

How many **structural** isomers could be formed in this reaction?

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

(iii) The mechanism of the reaction involves radicals.

What is meant by the term *radical*?

.....

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

[Total: 16]

2 Ethanoic acid, CH_3COOH, is used to make esters.

Some information about two of the processes used to make ethanoic acid is given below.

Process 1

This is a one-step process that involves the reaction of methanol with carbon monoxide.

$$CH_3OH + CO \rightarrow CH_3COOH$$

The conditions used are 180 °C and 30 atmospheres pressure. A rhodium/iodine catalyst is used.

The percentage yield for this process is 99%.

Process 2

This involves the oxidation of naphtha, a fraction obtained from crude oil.

Liquid naphtha is oxidised using air at a temperature of 180 °C and 50 atmospheres pressure. No catalyst is needed.

A large variety of other products are also formed in this oxidation.

(a) Suggest **three** advantages of making ethanoic acid using **Process 1** rather than **Process 2**.

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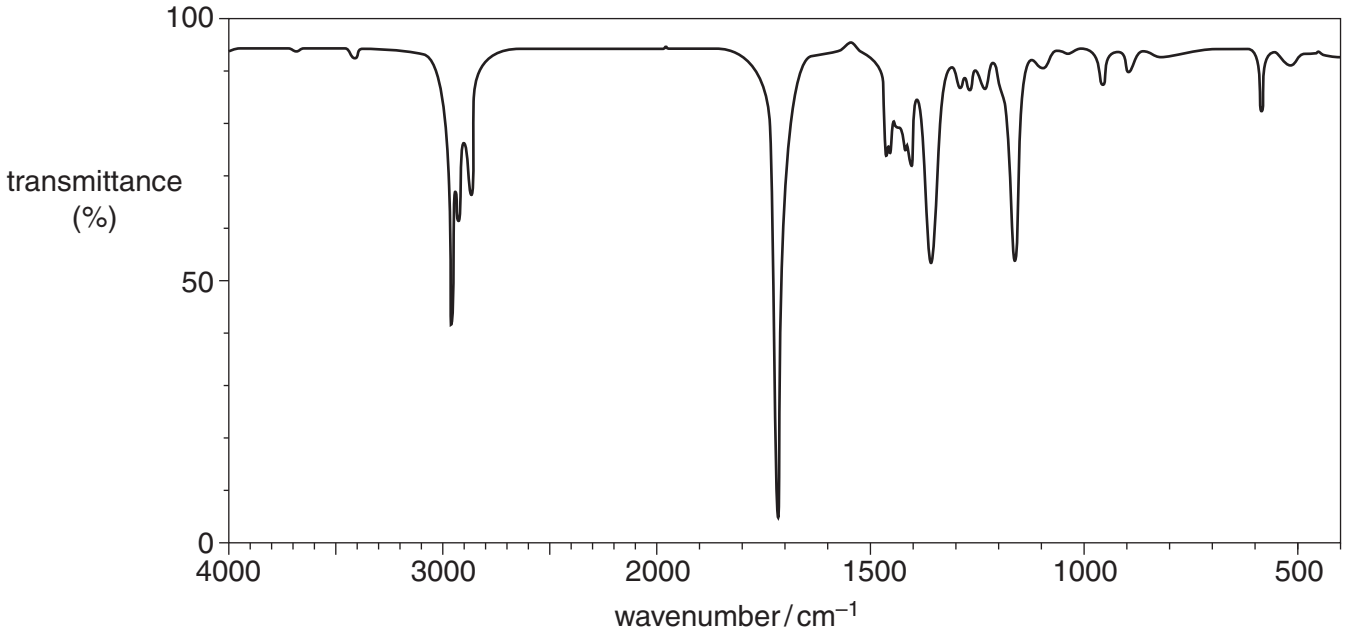
..... **[3]**

(b) The other products formed in **Process 2** are carboxylic acids, aldehydes and ketones.

A research chemist investigates some of these other products of **Process 2**.

(i) The research chemist isolates product, **J**.

The infrared spectrum of **J** is shown below.



The chemist also finds that 0.172 g of a pure sample of **J** contains 2.00×10^{-3} mol of **J**.

Suggest, with reasons, **one** possible structure for **J**.

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

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..... **[5]**

(ii) The chemist isolates another product, the carboxylic acid, **K**.

K has the molecular formula $C_4H_8O_2$.

Suggest a possible structure and name for **K**.

structure

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

(c) Ethanoic acid is used in the manufacture of the ester, propyl ethanoate.

Describe how ethanoic acid is converted into propyl ethanoate.
Include an equation in your answer.

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

[Total: 14]

3 Enthalpy changes can be determined directly or indirectly.

(a) A student investigates the reaction between magnesium and dilute hydrochloric acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

The student determines the enthalpy change for this reaction.

In her experiment, she reacts 0.486 g of magnesium with 50.0 cm^3 of 2.00 mol dm^{-3} HCl(aq). The HCl(aq) is in excess.

The temperature of the solution changes from 19.2 °C to 32.0 °C.

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

The specific heat capacity of the solution = 4.18 J g^{-1} K^{-1}.

The density of the solution is 1.00 g cm^{-3}.

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

(ii) Calculate the amount, in moles, of magnesium used by the student.

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

(iii) Calculate the enthalpy change of reaction.

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

enthalpy change of reaction = ...kJ mol^{-1} **[3]**

(b) The student wants to determine the enthalpy change of formation of calcium carbonate, $CaCO_3(s)$.

$$Ca(s) + C(s) + 1\tfrac{1}{2}O_2(g) \rightarrow CaCO_3(s)$$

(i) What is meant by the term *standard enthalpy change of formation*?
You should state the standard conditions in your answer.

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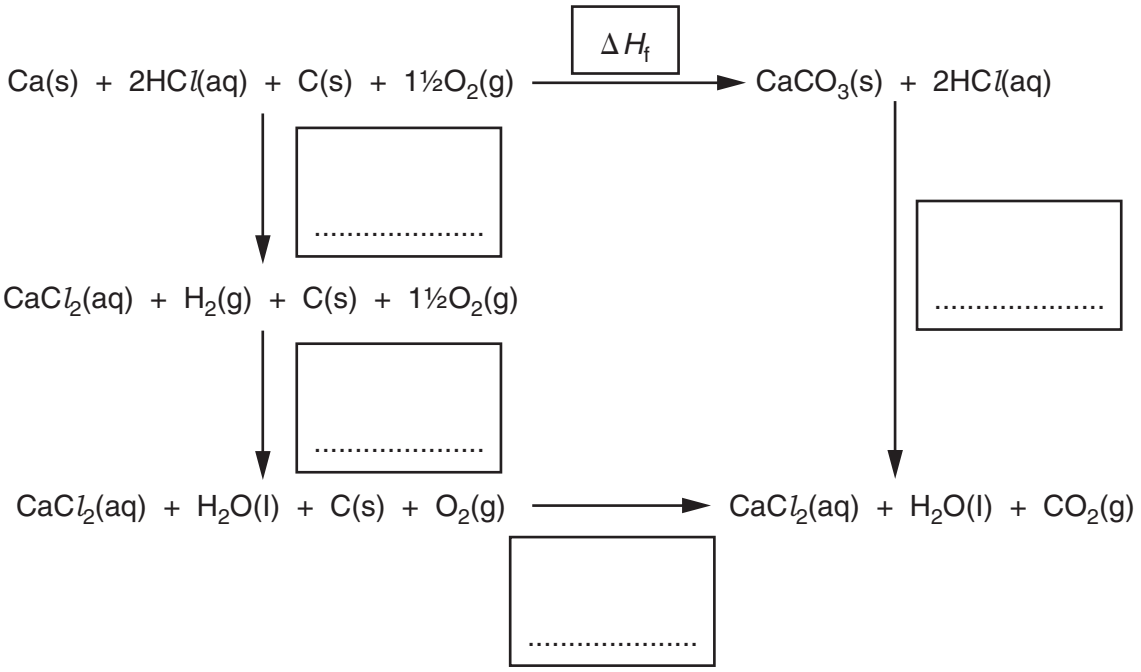
..... **[3]**

(ii) Using the following data and enthalpy cycle,

- fill in the boxes on the enthalpy cycle with the correct enthalpy change values
- calculate the enthalpy change of formation, ΔH_f, of $CaCO_3(s)$.

reaction	enthalpy change, ΔH / kJ mol^{-1}
$C(s) + O_2(g) \rightarrow CO_2(g)$	–393
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	–285
$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$	–54
$Ca(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2(g)$	–168



ΔH_f = ... kJ mol^{-1} **[3]**

[Total: 12]

4 Hydrogen and chlorine are reacted together to form hydrogen chloride.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g) \qquad \Delta H = -184 \text{ kJ mol}^{-1}$$

(a) Calculate the bond enthalpy for the H–C*l* bond using the information in the table below.

bond	bond enthalpy / kJ mol^{-1}
H–H	+436
C*l*–C*l*	+243

bond enthalpy = ... kJ mol^{-1} **[2]**

(b) The reaction is repeated at a **higher** pressure.

Describe and explain what happens to the rate of the reaction between $H_2(g)$ and $Cl_2(g)$.

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

(c) The reaction is repeated again. This time the temperature is **decreased**.

Describe and explain, by drawing appropriately labelled Boltzmann distributions, what happens to the rate of reaction between $H_2(g)$ and $Cl_2(g)$.

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..... **[5]**

(d) The mechanism of the reaction between $H_2(g)$ and $Cl_2(g)$ involves initiation, propagation and termination.

(i) The initiation step is the homolytic fission of the covalent bond in a chlorine molecule.

Write an equation to show this homolytic fission.

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

(ii) Complete the following equations which show the propagation steps.

$Cl + H_2 \rightarrow$ ..... + ...

$H + Cl_2 \rightarrow$ ..... + ... **[2]**

(iii) Suggest equations for **two** termination steps.

.....

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

[Total: 14]

5 Sulfuric acid is made from sulfur, oxygen and water in a three-stage process.
This can be represented by the following overall equation.

$$2S(s) + 3O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(l)$$

(a) Explain why the overall process to make sulfuric acid has an atom economy of 100%.

.....

.....

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

(b) A factory uses 51.4 tonnes of sulfur to manufacture 147 tonnes of H_2SO_4.

What is the percentage yield of H_2SO_4?

Give your answer to **two** significant figures. (1 tonne = 1×10^6 g)

percentage yield = ... % **[3]**

(c) One of the reactions involved in making sulfuric acid converts sulfur dioxide, SO_2, into sulfur trioxide, SO_3.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -197 \text{ kJ mol}^{-1}$$

This reaction can be carried out at 450 °C and 3 atmospheres pressure in the presence of a V_2O_5 catalyst.

Under these conditions the position of equilibrium is almost completely on the right-hand side.

(i) A research chemist investigates this reaction.
He uses a temperature of 450 °C and 3 atmospheres pressure.
The research chemist does **not** use the catalyst.

Predict the changes, if any, on each of the following.

position of equilibrium .....

rate of backward reaction ..... **[2]**

(ii) The temperature of the reaction mixture is **increased** to 600 °C.

State and explain what will happen to the position of equilibrium.

.....

.....

.....

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

(iii) The pressure of the reaction mixture is **decreased** to 2 atmospheres.

State and explain what will happen to the position of equilibrium.

.....

.....

.....

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

(d) Concentrated H_2SO_4 is used as an acid catalyst in the elimination of water from alcohols.

There are several alcohols that are structural isomers with the formula $C_5H_{11}OH$. When these alcohols are heated with H_2SO_4 they form alkenes.

$$C_5H_{11}OH \rightarrow C_5H_{10} + H_2O$$

(i) Pentan-1-ol is a structural isomer of $C_5H_{11}OH$ that is a primary alcohol.

Draw the structure of another structural isomer of $C_5H_{11}OH$ that is a primary alcohol.

[1]

(ii) Pentan-2-ol is a structural isomer of $C_5H_{11}OH$ that is a secondary alcohol.
Pentan-2-ol is heated with H_2SO_4.

Three alkenes are formed, **L**, **M** and **N**.

- **L** and **M** are stereoisomers.
- **N** is a structural isomer of the stereoisomers **L** and **M**.

Draw the structures for alkenes **L**, **M** and **N**.

alkene **L**

alkene **M**

alkene **N**

[3]

(iii) One structural isomer of $C_5H_{11}OH$ is an alcohol that **cannot** be oxidised by heating with acidified potassium dichromate(VI).

Draw the structure of this alcohol.

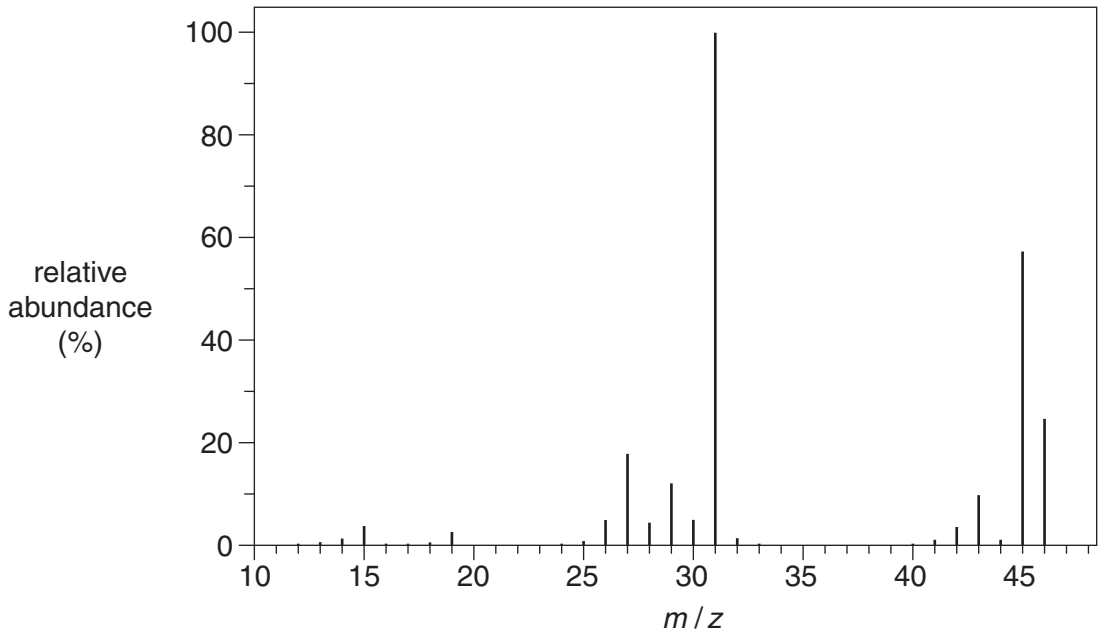
[1]

[Total: 13]

6 Mass spectrometry is used in analysis.

(a) Compound **O** contains carbon, hydrogen and oxygen.

The mass spectrum of compound **O** is shown below.



(i) Identify the *m*/*z* value that corresponds to the molecular ion.

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

(ii) Write the formula of the ion that gives rise to the peak at *m*/*z* = 31.

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

(iii) Suggest the molecular formula for **O**.

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

(b) A scientist analyses a sample of Moon rock. She uses mass spectrometry to find out which metal the sample contains.

The mass spectrum of the sample shows *m*/*z* peaks as shown in the table.

***m*/*z* value**	**percentage abundance (%)**
63	72.2
65	27.8

Positive ions, $\mathbf{X}^+$, of the metal were responsible for the two *m*/*z* peaks.

Identify the metal **X** by calculating its relative atomic mass to **one decimal place**.

relative atomic mass of **X** = ...

metal **X** = ... **[3]**

[Total: 6]

7 Chlorofluorocarbons, CFCs, were once used as propellants in aerosols. CFCs contribute to ozone depletion in the upper atmosphere.

(a) A CFC has the formula CF_2Cl_2.

State the three-dimensional shape of a CF_2Cl_2 molecule and the F–C–C*l* bond angle.

shape .....

bond angle ..... **[2]**

(b) Two reasons that CF_2Cl_2 was used as an aerosol propellant are that it has low reactivity and will not hydrolyse in water.

(i) State **one** other reason why CF_2Cl_2 was developed for use as an aerosol.

.....

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

(ii) Suggest why CF_2Cl_2 does **not** hydrolyse in water.

.....

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

(c) Explain, with the aid of equations, how the presence of CFCs in the upper atmosphere leads to ozone depletion.

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

(d) Why are scientists concerned about ozone depletion?

.....

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

(e) International agreements have reduced the use of CFCs. However the concentration of atmospheric CFCs has hardly changed.

Suggest **two** reasons why.

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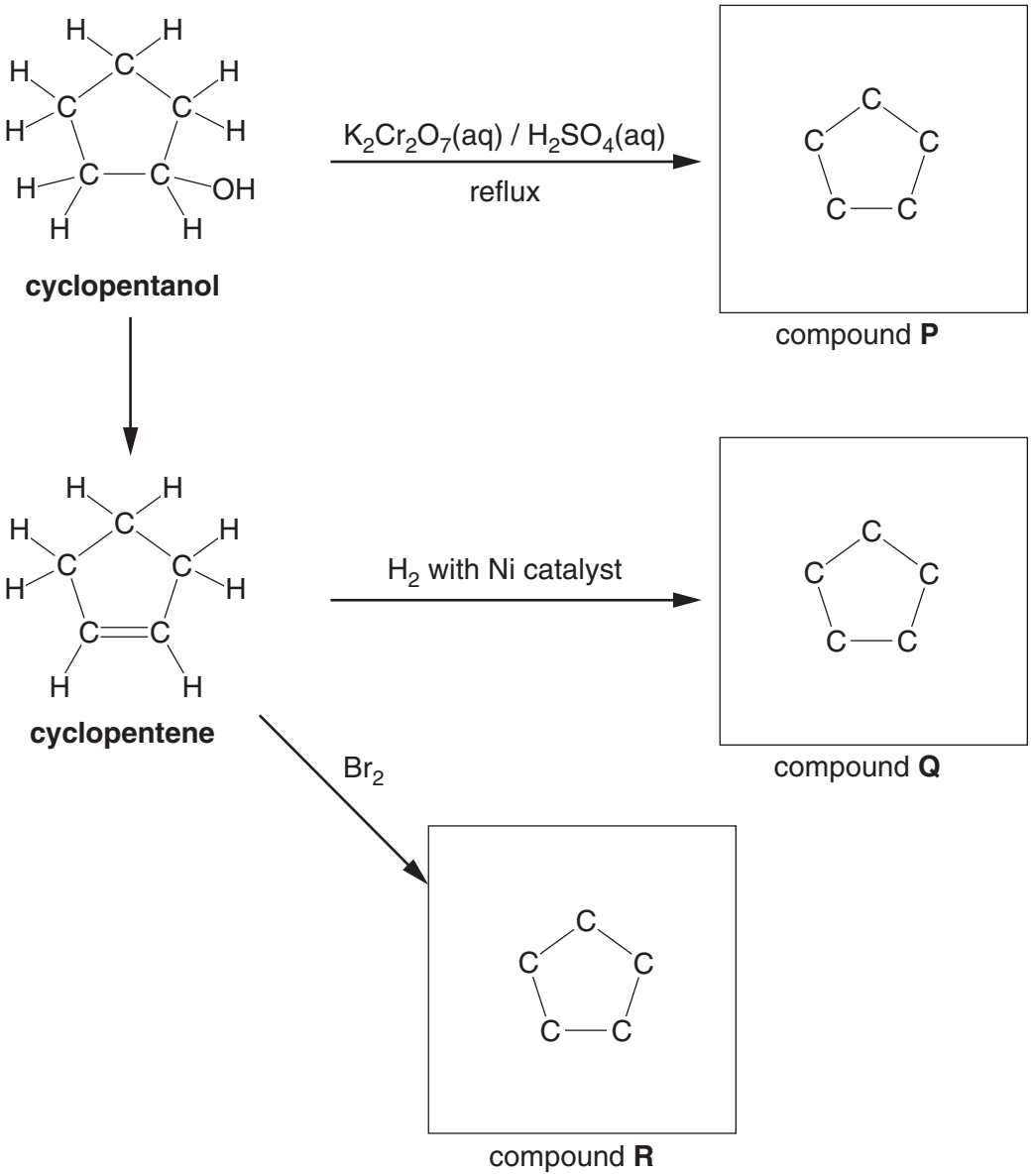
..... **[2]**

[Total: 10]

8 Cyclopentene is a cyclic alkene.

(a) The flowchart shows some reactions involving cyclopentene and cyclopentanol.

Complete the partial structures in the boxes to show compounds **P**, **Q** and **R**, the main organic products of the reactions.



[3]

(b) What would be the colour change in the reaction between cyclopentene and bromine?

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

(c) Cyclopentene can be polymerised to give poly(cyclopentene).

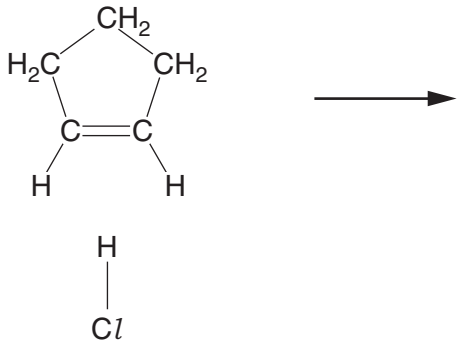
Draw a section of poly(cyclopentene) to show **two** repeat units.

[1]

(d) Cyclopentene reacts with HC*l* by electrophilic addition.

Use the curly arrow model to complete the mechanism for this reaction.

In your answer include any relevant dipoles, the intermediate and the product.



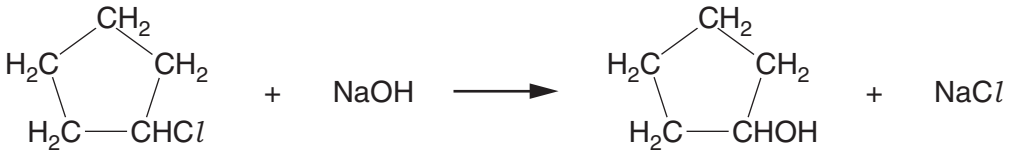
intermediate

product

[5]

TURN OVER FOR QUESTION 8(e)

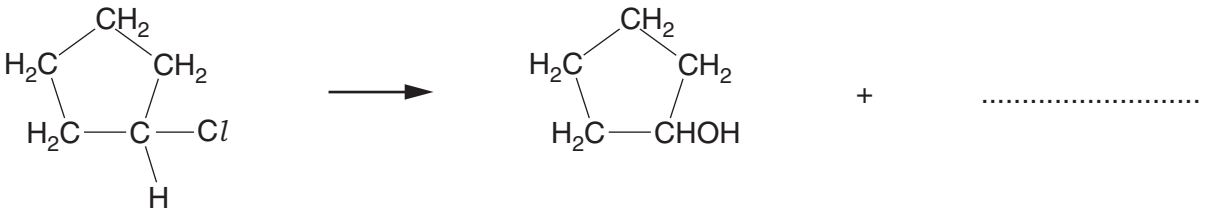
(e) Chlorocyclopentane can be hydrolysed by heating with aqueous sodium hydroxide.



Use the curly arrow model to complete the mechanism for this hydrolysis reaction.

Include in your answer, relevant dipoles, the name of the mechanism and the type of bond fission.

*In your answer you should use the correct technical terms, spelled correctly***.**



HO^- **products**

name of mechanism .....

type of bond fission ..... **[5]**

[Total: 15]

END OF QUESTION PAPER

OCR
RECOGNISING ACHIEVEMENT

Wednesday 16 January 2013 – Morning

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

* F 3 2 2 0 1 *

* F 3 1 4 4 4 0 1 1 3 *

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. 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.

Answer **all** the questions.

1 Crude oil contains many hydrocarbons.

The table shows information about some of these hydrocarbons.

Hydrocarbon	Molecular formula	Boiling point/°C
Hexane	C_6H_{14}	69
3-Methylpentane	C_6H_{14}	63
2,2-Dimethylbutane	C_6H_{14}	50

(a) What is the empirical formula of hexane?

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

(b) Explain why hexane is both *saturated* and a *hydrocarbon*.

saturated

.....

.....

hydrocarbon

.....

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

(c) Draw the skeletal formula for 2,2-dimethylbutane.

[1]

(d) Describe and explain the trend shown by the boiling points of the hydrocarbons in the table.

.....

.....

.....

.....

.....

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

(e) Decane, $C_{10}H_{22}$, can be cracked to form hexane and **one** other product.

Write an equation for this reaction.

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

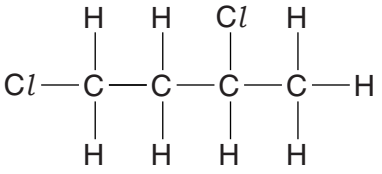
(f) In the presence of ultraviolet radiation, butane, C_4H_{10}, reacts with chlorine to form a large number of organic products.

Several of these products are structural isomers of $C_4H_8Cl_2$.

(i) Write an equation, using molecular formulae, for the formation of $C_4H_8Cl_2$ from butane.

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

(ii) Complete the table below about two of the structural isomers of $C_4H_8Cl_2$.

	Isomer 1	**Isomer 2**
Name	1,4-Dichlorobutane	.....
Displayed formula		

[2]

(g) The reaction between butane and chlorine is an example of radical substitution.

Initially, chlorobutane, C_4H_9Cl, is formed, which then reacts with more chlorine to form $C_4H_8Cl_2$.

(i) The first step of the reaction of C_4H_9Cl with chlorine is the homolytic fission of a chlorine molecule.

What is meant by the term *homolytic fission*?

.....

.....

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

(ii) Complete the missing species in the propagation steps below.

$$Cl \quad + \quad C_4H_9Cl \quad \rightarrow \quad \text{.....} \; + \; \text{.....}$$

$$\text{.....} \; + \; \text{.....} \quad \rightarrow \quad C_4H_8Cl_2 \; + \; \text{.....}$$

[2]

(h) Butane, C_4H_{10}, undergoes incomplete combustion when there is a shortage of oxygen.

Write an equation for the incomplete combustion of butane.

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

[Total: 16]

2 Phosphoric acid, H_3PO_4, can be manufactured by a two step process involving the reaction of phosphorus with oxygen, followed by a reaction with water.

$$P_4(s) + 5O_2(g) \longrightarrow P_4O_{10}(s) \qquad \Delta H_1 = -2984\,kJ\,mol^{-1}$$

$$P_4O_{10}(s) + 6H_2O(l) \longrightarrow 4H_3PO_4(l) \qquad \Delta H_2$$

(a) Explain why ΔH_1 represents the enthalpy change of formation of P_4O_{10}.

.....

.....

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

(b) Enthalpy changes of formation are shown in the table below.

Substance	Enthalpy change of formation, ΔH_f / kJ mol^{-1}
$P_4O_{10}(s)$	–2984
$H_2O(l)$	–286
$H_3PO_4(l)$	–1267

Calculate the enthalpy change of reaction, ΔH_2.

ΔH_2 = ... kJ mol^{-1} **[3]**

(c) Write the overall equation for the manufacture of H_3PO_4 from P_4.

Use this equation to explain why this process has a 100% atom economy.

.....

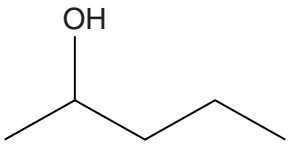
.....

.....

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

[Total: 7]

3 Pentan-2-ol, shown below, is a secondary alcohol.



(a) Pentan-2-ol can be converted into three alkenes, **A**, **B** and **C**, by the elimination of water.

- Two of the alkenes, **A** and **B**, are stereoisomers.
- The third alkene, **C**, is a structural isomer of both **A** and **B**.

This elimination often uses a catalyst.

(i) What is a suitable catalyst for this reaction?

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

(ii) Construct an equation, using molecular formulae, for the elimination of water from pentan-2-ol.

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

(iii) Explain what is meant by the terms *structural isomers* and *stereoisomers*.

structural isomers

.....

.....

.....

stereoisomers

.....

.....

.....

[4]

(iv) In the boxes below:

- draw the structures of stereoisomers **A** and **B**
- draw the structure of isomer **C**.

stereoisomer A

stereoisomer B

isomer C

[3]

(v) Stereoisomers **A** and **B** show *E*/*Z* isomerism.

State **two** features of these molecules that enable them to show *E*/*Z* isomerism.

.....

.....

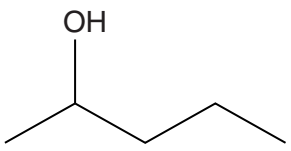
..... **[2]**

(b) Pentan-2-ol can be oxidised by heating under reflux with acidified aqueous potassium dichromate(VI).

Complete the equation for this oxidation.

Use a skeletal formula for the organic product.

Use [O] to represent the oxidising agent.

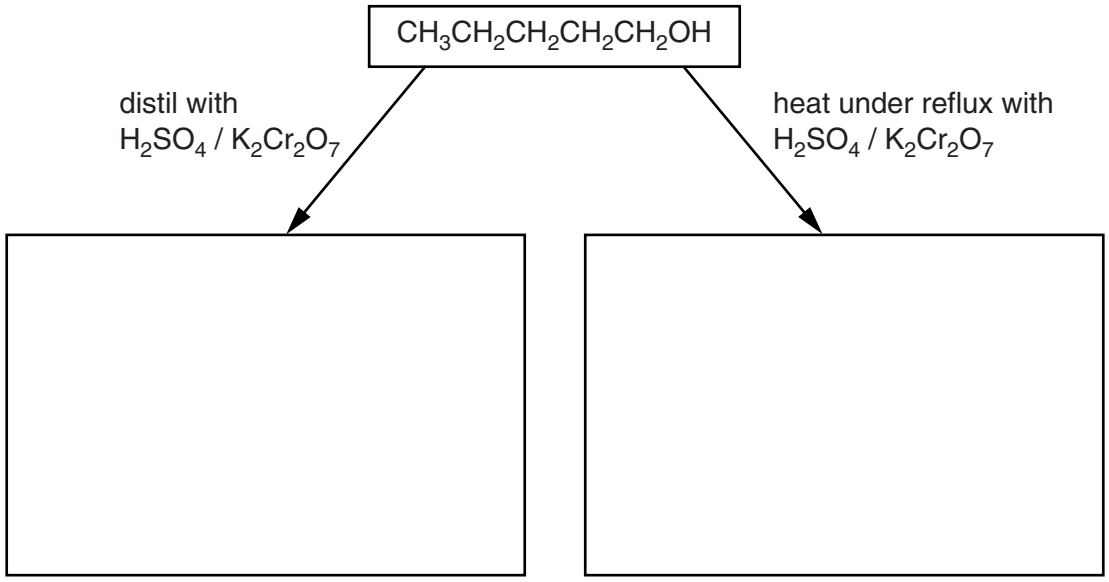


$\rightarrow$

[2]

(c) Pentan-1-ol can also be oxidised but it gives two different products.

Complete the flowchart below to show the structures of the two organic products formed.



[2]

[Total: 15]

4 Methanol can be manufactured by the reaction of carbon dioxide with hydrogen.

$$3H_2(g) + CO_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g) \quad \textbf{equation 4.1}$$

In this reaction, 49.0 kJ of energy are released when 3 moles of H_2 react completely. This enthalpy change is called the enthalpy change of reaction, ΔH_r.

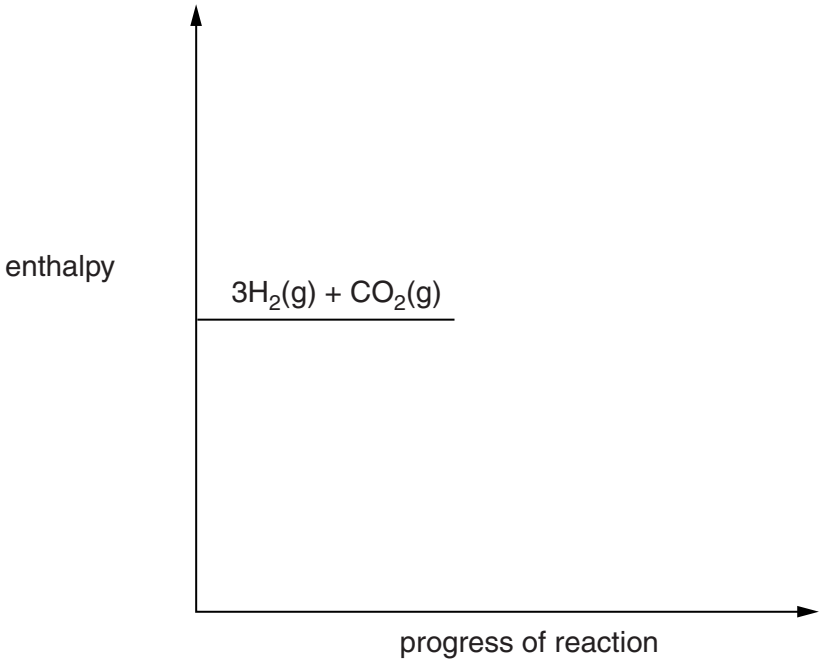
(a) Calculate the energy released when 1000 dm^3 of hydrogen, measured at room temperature and pressure, react completely with carbon dioxide.

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

energy released = ... kJ **[3]**

(b) Complete the enthalpy profile diagram for the forward reaction.

Label the activation energy, E_a, and the enthalpy change, ΔH_r.



[3]

(c) What is the enthalpy change of reaction for the **reverse** reaction?

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

(d) A scientist estimates the activation energy for the forward reaction as +225 kJ mol^{-1}.

Using this information, estimate the activation energy of the **reverse** reaction.

activation energy = ... kJ mol^{-1} **[1]**

(e) The temperature of the equilibrium mixture in **equation 4.1** is **increased**.

Describe and explain what happens to the position of equilibrium.

.....

.....

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

(f) The total pressure of the equilibrium mixture in **equation 4.1** is **decreased**.

Describe and explain what happens to the position of equilibrium.

.....

.....

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

(g) The reaction uses a solid catalyst. This catalyst functions in a similar way to the catalyst used in catalytic converters.

Outline the stages that allow H_2 to react with CO_2 in the presence of a solid catalyst.

.....

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.....

.....

.....

.....

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

[Total: 15]

5 Chloroethene, CH_2CHCl, is made from 1,2-dichloroethane, CH_2ClCH_2Cl.

$$CH_2ClCH_2Cl \longrightarrow CH_2CHCl + HCl \quad \textbf{equation 5.1}$$

(a) A chemical plant uses 19.80 tonnes of 1,2-dichloroethane to make 11.25 tonnes of chloroethene.

Calculate the percentage yield of chloroethene.

(1 tonne = 1.00×10^6 g)

percentage yield = ... % **[3]**

(b) The table below shows some average bond enthalpies.

Bond	Average bond enthalpy /kJ mol^{-1}
C–H	+413
C–C	+347
C=C	+612
C–Cl	+346
H–Cl	+432

Using the average bond enthalpies in the table above, calculate the enthalpy change of reaction, ΔH_r, for **equation 5.1**.

ΔH_r = ... kJ mol^{-1} **[3]**

(c) Chloroethene is used to make poly(chloroethene), PVC.

Write an equation, using **displayed formulae**, for the reaction to form poly(chloroethene) from its monomer.

[3]

(d) Waste polymers are often disposed of by combustion. The heat released can be used to generate electricity.

(i) Hydrogen chloride, HC*l*, is a toxic waste product formed by combustion of PVC.

Suggest how the HC*l* can be removed from the gases produced during the combustion of PVC.

.....

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

(ii) Some waste polymers are put into landfill sites. This uses up a valuable resource.

State **two** ways, other than landfill and combustion, of processing waste polymers.

1 .....

.....

2 .....

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

(iii) Chemists are trying to minimise the environmental damage caused by the disposal of waste polymers by developing new types of polymers.

Give an example of a type of polymer being developed to minimise environmental damage.

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

[Total: 13]

6 Many reactions are catalysed by biological catalysts called enzymes.

Ethanol is manufactured by the enzyme-catalysed fermentation of glucose.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

(a) Fermentation is an **exothermic** reaction.

Explain why. Use ideas about the enthalpy changes associated with bond breaking and bond making in your answer.

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.....

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

(b) Carbon dioxide is a greenhouse gas that has been linked to climate change.

(i) What happens within a carbon dioxide molecule when it absorbs infrared radiation?

.....

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

(ii) Chemists are developing methods for carbon capture and storage to minimise climate change.

Give **two** examples of carbon capture and storage.

1 .....

.....

2 .....

.....

[2]

(c) One benefit of using an enzyme to catalyse a reaction is that there is a large increase in the rate of reaction without the enzyme being used up.

State **two** other benefits, other than cost, of using enzymes to catalyse reactions.

1 .....

.....

2 .....

.....

[2]

(d) Catalysts, such as enzymes, increase the rate of a reaction.

Explain why. Use a labelled Boltzmann distribution of molecular energies in your answer.

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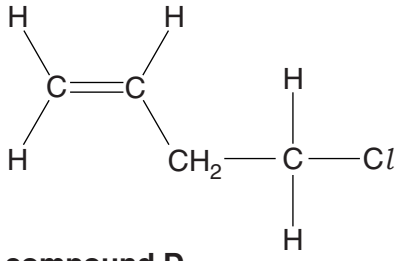
..... **[5]**

[Total: 12]

7 Compound **D** reacts by nucleophilic substitution and electrophilic addition.



compound D

Compound **D** reacts with KOH(aq) and with HBr(g).

The reaction with KOH(aq) is an example of a nucleophilic substitution and the reaction with HBr(g) is an example of electrophilic addition.

Describe these two reactions. For each reaction, include:

- an equation
- the structure of each organic product
- the mechanism, using the curly arrow model, showing any relevant dipole
- the type of bond fission that occurs.

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.....[12]

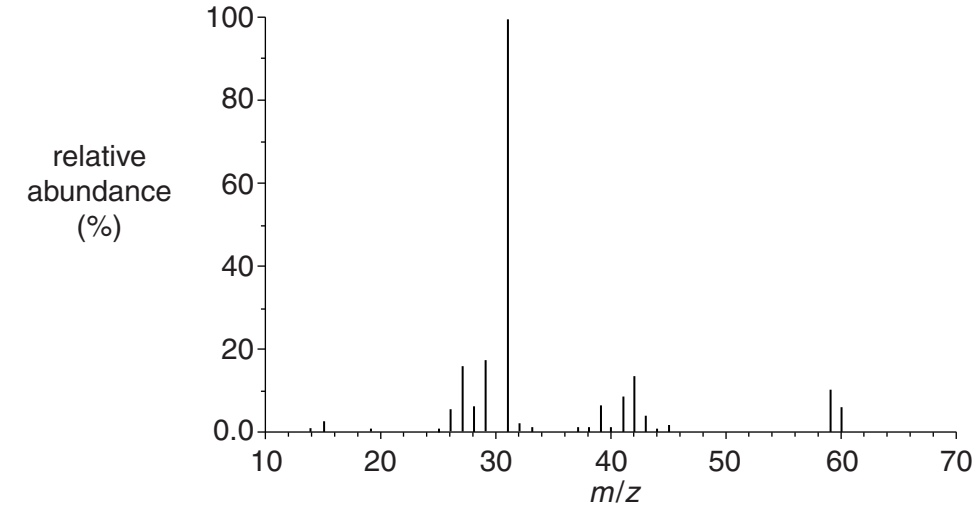
[Total: 12]

8 Compound **X** is a saturated compound that contains carbon, hydrogen and oxygen only.

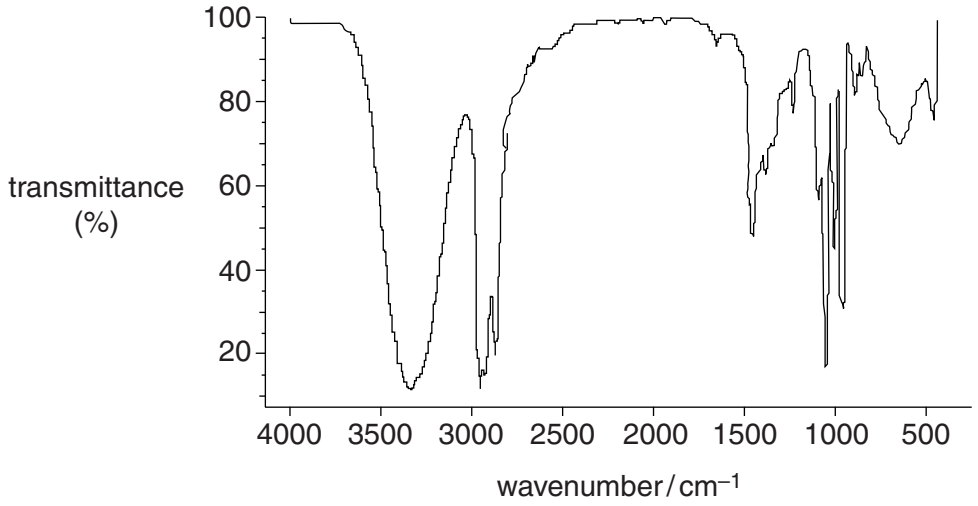
A scientist analyses a 1.00 g sample of compound **X** and finds it contains 0.133 g of hydrogen and 0.600 g of carbon.

The scientist also analyses compound **X** using mass spectrometry and infrared spectroscopy.

mass spectrum of X



IR spectrum of X



The scientist finds that compound **X** reacts with ethanoic acid in the presence of a concentrated sulfuric acid catalyst to make compound **Y**.

Compound **Y** has the molecular formula $C_5H_{10}O_2$.

Using all the information, show the structures of compounds **X** and **Y**.
Include an equation for the reaction of compound **X** with ethanoic acid to make compound **Y**.

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

[10]

[Total: 10]

END OF QUESTION PAPER