THIS IS A NEW SPECIFICATION

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

Monday 7 June 2010
Morning

Duration: 1 hour 45 minutes

OCE/22979

Candidate Forename		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. Additional paper may be used if necessary but you must clearly show your Candidate Number, Centre Number and question number(s).

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 The alkanes are an homologous series of hydrocarbons.
The table shows information about some straight chain alkanes.

alkane	molecular formula	boiling point / °C
methane	CH_4	–164
ethane	C_2H_6	–89
propane	C_3H_8	–42
butane	C_4H_{10}	–1

(a) (i) What is meant by an *homologous series*?

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

(ii) Explain why the boiling points increase down the alkane homologous series.

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

(b) Alkynes are another homologous series of hydrocarbons.
The table gives the molecular formulae of the first five straight chain alkynes.

alkyne	molecular formula
ethyne	C_2H_2
propyne	C_3H_4
but-1-yne	C_4H_6
	C_5H_8
hex-1-yne	C_6H_{10}

(i) Suggest the name of a straight chain alkyne with the molecular formula C_5H_8.

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

(ii) Deduce the general formula for an alkyne.

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

(iii) The alkynes contain the C≡C functional group.

Suggest the displayed formula for propyne.

[1]

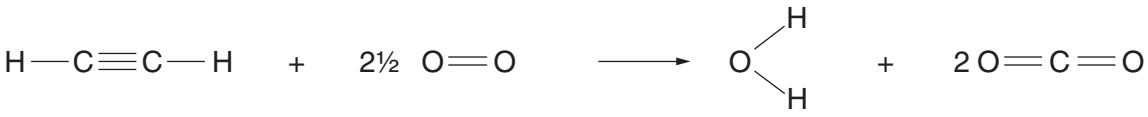
(iv) Hex-1-yne has many cyclic structural isomers.

Draw the skeletal structure of one of these cyclic structural isomers.

[1]

(c) Ethyne is commonly called acetylene.
It is used in an oxy-acetylene flame which is hot enough to cut through steel.

Ethyne completely combusts as shown in the equation below.



Calculate the enthalpy change of combustion of ethyne using the average bond enthalpies in the table below.

bond	average bond enthalpy / kJ mol^{-1}
C–H	+415
C≡C	+837
O=O	+498
C=O	+805
O–H	+464

enthalpy change of combustion = …… kJ mol^{-1} **[3]**

(d) Ethyne is formed when water reacts with calcium carbide, CaC_2.

$$CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(s) + C_2H_2(g)$$

The standard enthalpy change of this reaction can be determined indirectly using standard enthalpy changes of formation.

(i) What is meant by the term *standard enthalpy change of formation*, $\Delta H_f^{\ominus}$?
You should state the standard conditions in your answer.

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

(ii) Standard enthalpy changes of formation are shown in the table below.

substance	**standard enthalpy change of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}**
$CaC_2(s)$	−60
$H_2O(l)$	–286
$Ca(OH)_2(s)$	–987
$C_2H_2(g)$	+227

Calculate the standard enthalpy change of the reaction:

$$CaC_2(s) + 2H_2O(l) \longrightarrow Ca(OH)_2(s) + C_2H_2(g)$$

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

(e) A factory makes ethyne gas from calcium carbide, CaC_2.
One of the waste products is calcium hydroxide.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$$

Each day 1.00×10^6 grams of calcium carbide are used and 3.60×10^5 dm^3 of ethyne gas, measured at room temperature and pressure, is manufactured.

(i) Calculate the atom economy for this process using the relative formula masses in the table below.

compound	relative formula mass
CaC_2	64.1
H_2O	18.0
$Ca(OH)_2$	74.1
C_2H_2	26.0

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

(ii) Calculate the amount, in moles, of CaC_2 used each day.

amount of CaC_2 = ...mol **[1]**

(iii) Calculate the amount, in moles, of C_2H_2 made each day.

amount of C_2H_2 = ...mol **[1]**

(iv) Calculate the percentage yield of C_2H_2.

percentage yield = ... % **[1]**

(v) Comment on the percentage yield and the atom economy of this process in terms of sustainability.

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

[Total: 23]

2 Petrol and diesel are both complex mixtures of hydrocarbons used as fuels in transport.

(a) Petrol contains some branched chain alkanes.
The number of carbon atoms per molecule varies between five and nine.

Name one branched chain alkane with between five and nine carbon atoms.

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

(b) When petrol burns in an internal combustion engine the exhaust gases contain CO_2, CO, NO, N_2, O_2, H_2O and unburnt hydrocarbons.

(i) What effect does the absorption of infrared radiation have on the bonds in CO_2 molecules in the atmosphere?

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

(ii) Why is CO present in the exhaust gases?

.....

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

(iii) Both NO and CO are atmospheric pollutants.

For each pollutant, describe one environmental problem.

NO .....

.....

CO .....

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

(c) Most cars are fitted with a catalytic converter which catalyses the exothermic reaction between NO and CO to form two less harmful gases.

(i) Name the two gases formed and write an equation for this reaction.

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

(ii) NO and CO react very slowly without a catalyst.
The catalyst in a catalytic converter increases the rate of reaction.

Explain, using an enthalpy profile diagram and the Boltzmann distribution model, how the use of a catalyst increases the rate of reaction.

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

(d) Many lorries and some cars use diesel powered engines.
Biodiesel is being developed as a substitute for diesel from crude oil.

Biodiesel is a methyl ester of a long chain carboxylic acid.
The flow chart shows how it is produced.

plants $\rightarrow$ plant oil $\rightarrow$ long chain carboxylic acids $\rightarrow$ biodiesel

Describe the benefits and disadvantages of changing from diesel to biodiesel.

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

[Total: 17]

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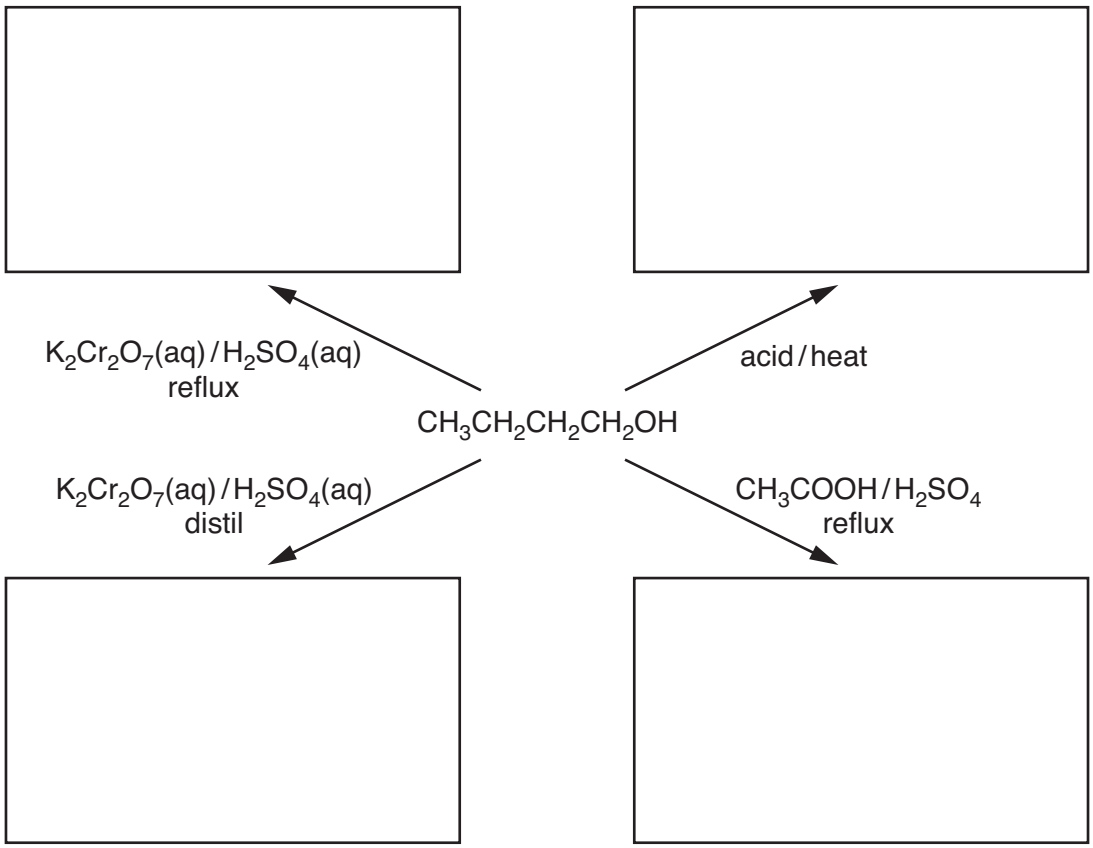
3 Alcohols are used in the industrial production of many organic compounds.

(a) Complete the flowchart below to show the organic product formed in each of the reactions of butan-1-ol.



[4]

(b) Butan-1-ol can be prepared by the alkaline hydrolysis of 1-iodobutane.

$$CH_3CH_2CH_2CH_2I + OH^- \longrightarrow CH_3CH_2CH_2CH_2OH + I^-$$

The reaction mixture is gently heated for 20 minutes.

(i) The curly arrow model is used in reaction mechanisms to show the movement of electron pairs.

Use the curly arrow model to outline the mechanism for the alkaline hydrolysis of 1-iodobutane.

In your answer, include the name of the mechanism, the type of bond fission and relevant dipoles.

name of mechanism .....

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

(ii) A student decides to prepare butan-1-ol by the alkaline hydrolysis of 1-chlorobutane.

Suggest, with reasons, any change in the conditions from those used in the alkaline hydrolysis of 1-iodobutane.

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

[Total: 11]

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4 Infrared spectroscopy and mass spectrometry are used to identify substances.

(a) Police use breathalysers to detect ethanol in the breath of drivers.

(i) Some modern breathalysers use infrared spectroscopy.

Suggest **two** characteristic infrared absorptions that could be used to identify the presence of ethanol vapour.

1 ……. cm^{-1}

2 ……. cm^{-1} **[2]**

(ii) Some older breathalysers used the redox reaction between acidified dichromate(VI) ions and ethanol. A colour change was seen which indicated the presence of ethanol in the breath.

What is the colour change that would be seen in this breathalyser if ethanol was present in the breath?

…….. to …….. **[1]**

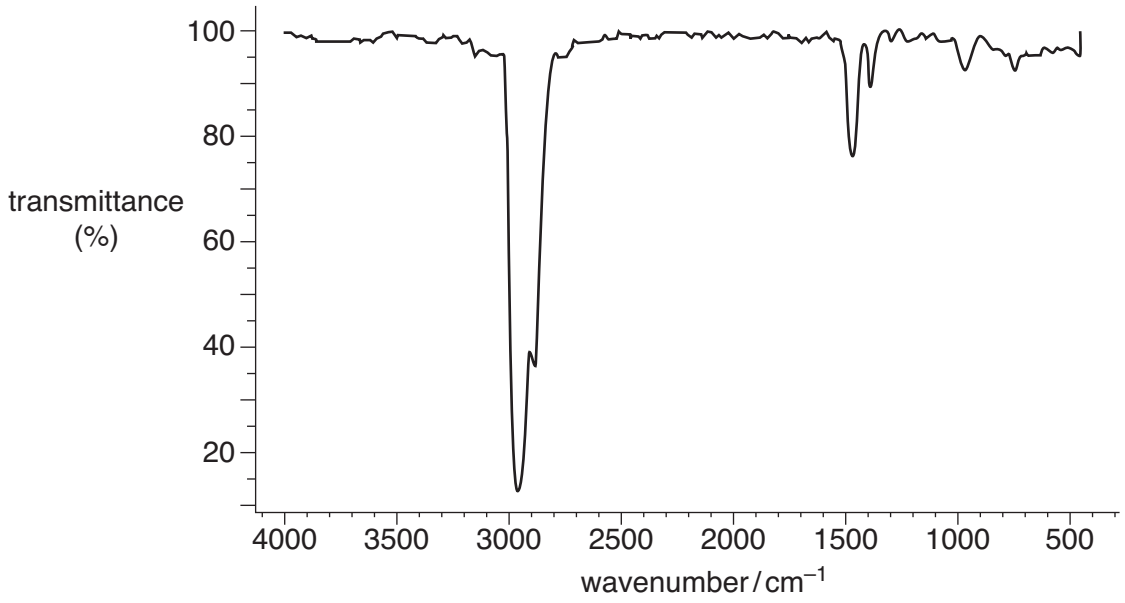
(iii) Give an equation to show the reaction between acidified dichromate(VI) ions and ethanol.

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

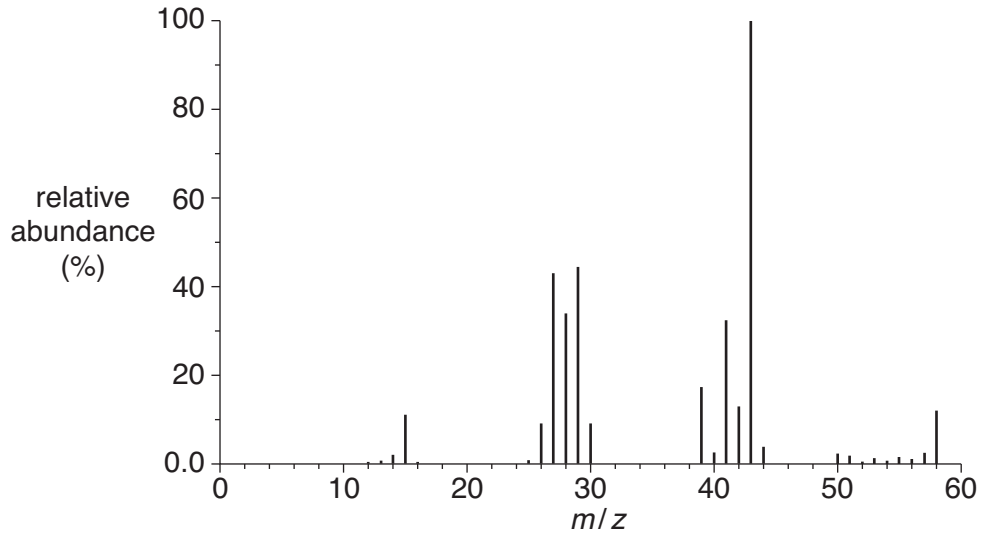
..... **[2]**

(b) Infrared spectroscopy and mass spectrometry are used in the search for organic molecules in outer space.

Compound **A** has been analysed by infrared spectroscopy.



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



(i) A research chemist concludes that compound **A** is a hydrocarbon.

What evidence is there to support this conclusion?

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

(ii) How does the mass spectrum confirm that compound **A** has a molecular formula of C_4H_{10}?

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

(iii) Draw the structural isomers of C_4H_{10}.

[1]

(iv) Identify the fragment ions that give rise to the following peaks in the mass spectrum.

m/z 15 is …….

m/z 29 is …….

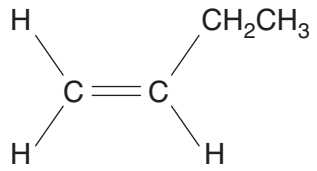
m/z 43 is ……. **[3]**

(v) Use your answer to part **(iv)** to identify which of the isomers in part **(iii)** is compound **A**. Explain your reasoning.

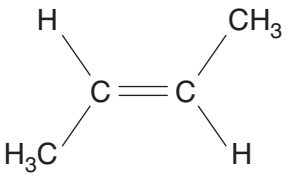
[1]

[Total: 13]

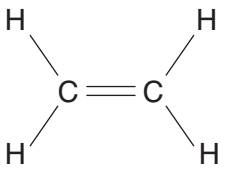
5 Alkenes **B**, **C**, **D**, **E** and **F** are shown below.



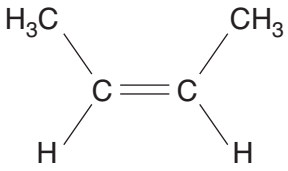
B



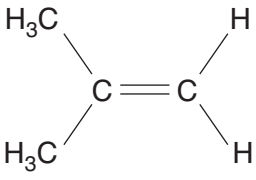
C



D



E



F

You will have to refer to these alkenes throughout the question.

(a) Describe, using the orbital overlap model, how the π-bond in alkene **D** is formed.

[2]

(b) Many alkenes show *E*/*Z* isomerism.

(i) Explain why *E*/*Z* isomerism is shown in some alkenes.

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

(ii) Which **two** alkenes are a pair of *E*/*Z* isomers?

Choose from **B**, **C**, **D**, **E** and **F**.

…….. and ……. **[1]**

(c) What is the main organic product of the reaction between alkene **D** and steam in the presence of a phosphoric acid catalyst?

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

(d) Describe and explain the reaction of hydrogen bromide, HBr, with alkene **B** and with alkene **D**.

Include in your answer

- equations and structures of the products,
- why one of these alkenes gives just one product but the other gives more than one product,
- the reaction mechanism for the reaction with alkene **D** using the curly arrow model showing any relevant dipoles.

*Your answer needs to be clear and well organised using appropriate examples from the chemistry of alkenes **B** and **D**.*

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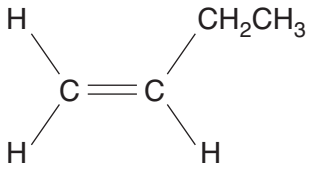
..... **[9]**

(e) Alkenes are a major source of polymers.
Alkene **B** can be polymerised.



B

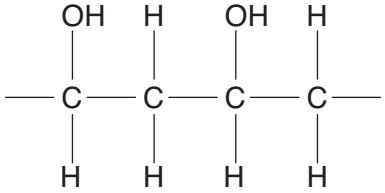
(i) Draw a section of the resultant polymer showing **two** repeat units.

[1]

(ii) Give the name of this polymer.

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

(f) Poly(ethenol) is a very unusual polymer because it can dissolve in water under certain conditions.



(i) Suggest why poly(ethenol) can dissolve in water.

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

(ii) Waste poly(ethenol) does not cause many environmental problems.
Other polymers such as poly(ethene), PVC or PTFE cause significant environmental problems.

Outline **two** ways in which waste polymers can be processed to reduce their environmental impact.

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

[Total: 21]

6 An important reaction in the manufacture of nitric acid is the catalytic oxidation of ammonia.

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \qquad \Delta H = -909 \text{ kJ mol}^{-1}$$

(a) Low pressures and low temperatures would give the maximum equilibrium yield of NO.

Explain why.

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

(b) The actual conditions used in the catalytic oxidation of ammonia include 900 °C and an increase in pressure.

Suggest why these conditions are a compromise.

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

(c) A factory makes 2.50×10^5 mol of NO a day.

(i) How much energy is released every day?

energy released = ... kJ **[1]**

(ii) Suggest how this energy can be used to reduce the cost of making NO.

.....

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

[Total: 7]

7 Compound **G** was extracted from the leaves of a plant. A sample of **G** was analysed by a research chemist. A summary of the chemist's results is shown in the table.

type of analysis	**evidence**
infrared spectroscopy	absorptions at 1080, 1720 and a very broad absorption at 2900 cm^{-1}
percentage composition by mass	C, 26.7%; H, 2.22%; O, 71.1%
volumetric analysis	0.00105 mol of **G** has a mass of 0.0945 g

Use this information to suggest a possible structure for compound **G**.

In your answer, you should make clear how your explanation is linked to the evidence.

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[Total: 8]

END OF QUESTION PAPER

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