THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY A

Chains, Energy and Resources

F322

OCE/T73768

Candidates answer on the question paper

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

Other Materials Required:
- Scientific calculator

Wednesday 3 June 2009
Morning

Duration: 1 hour 45 minutes

F322

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, 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 **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**13**	
2	**14**	
3	**15**	
4	**14**	
5	**13**	
6	**12**	
7	**19**	
TOTAL	**100**	

Answer **all** the questions.

1 Crude oil is a source of hydrocarbons which can be used as fuels or for processing into petrochemicals.

Octane, C_8H_{18}, is one of the alkanes present in petrol.

Carbon dioxide is formed during the complete combustion of octane.

$$C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$$

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

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

(b) Carbon monoxide, CO, is formed during the incomplete combustion of octane.

(i) Write an equation for the incomplete combustion of octane, forming carbon monoxide and water.

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

(ii) Why does incomplete combustion sometimes take place?

.....

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

(c) In cars fitted with a catalytic converter, two toxic gases, CO and NO, react together to form two non-toxic gases.

(i) Write an equation for the reaction between CO and NO in a catalytic converter.

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

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

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

(d) Oil companies process hydrocarbons, such as octane, into branched and cyclic hydrocarbons that promote efficient combustion in petrol.

Draw the skeletal formulae of a branched hydrocarbon and a cyclic hydrocarbon, each containing eight carbon atoms.

[2]

(e) Some scientists believe that increased CO_2 levels arising from the combustion of hydrocarbons lead to global warming because CO_2 is a greenhouse gas. Carbon capture and storage, CCS, is being developed as a method for removing CO_2 produced by combustion.

(i) Different gases have different contributions to global warming.

State **two** factors that affect the contribution of a greenhouse gas to global warming.

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

(ii) Outline **two** methods that could be developed to achieve carbon capture and storage, CCS.

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

[Total: 13]

2 Enthalpy changes of combustion, ΔH_c, are amongst the easiest enthalpy changes to determine directly.

(a) Define the term *enthalpy change of combustion*.

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

(b) A student carried out an experiment to determine the enthalpy change of combustion of pentan-1-ol, $CH_3(CH_2)_4OH$.

In the experiment, 1.76 g of pentan-1-ol was burnt. The energy was used to heat 250 cm^3 of water from 24.0 °C to 78.0 °C.

(i) Calculate the energy released, in kJ, during combustion of 1.76 g pentan-1-ol.

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

Density of water = 1.00 $g\,cm^{-3}$.

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

(ii) Calculate the amount, in moles, of pentan-1-ol that was burnt.

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

(iii) Calculate the enthalpy change of combustion of pentan-1-ol.

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

ΔH_c = ... $kJ\,mol^{-1}$ **[3]**

(c) The standard enthalpy change of formation of hexane can be defined as:

The enthalpy change when 1 mol of hexane is formed from its constituent elements in their standard states under standard conditions.

Hexane melts at –95 °C and boils at 69 °C.

(i) What are *standard conditions*?

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

(ii) An incomplete equation is shown below for the chemical change that takes place to produce the standard enthalpy change of formation of hexane.

Add state symbols to the equation to show each species in its standard state.

$$6C(\ldots\ldots) + 7H_2(\ldots\ldots) \longrightarrow C_6H_{14}(\ldots\ldots)$$ **[1]**

(iii) It is very difficult to determine the standard enthalpy change of formation of hexane directly. Suggest a reason why.

.....

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

(iv) The standard enthalpy change of formation of hexane can be determined indirectly.

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

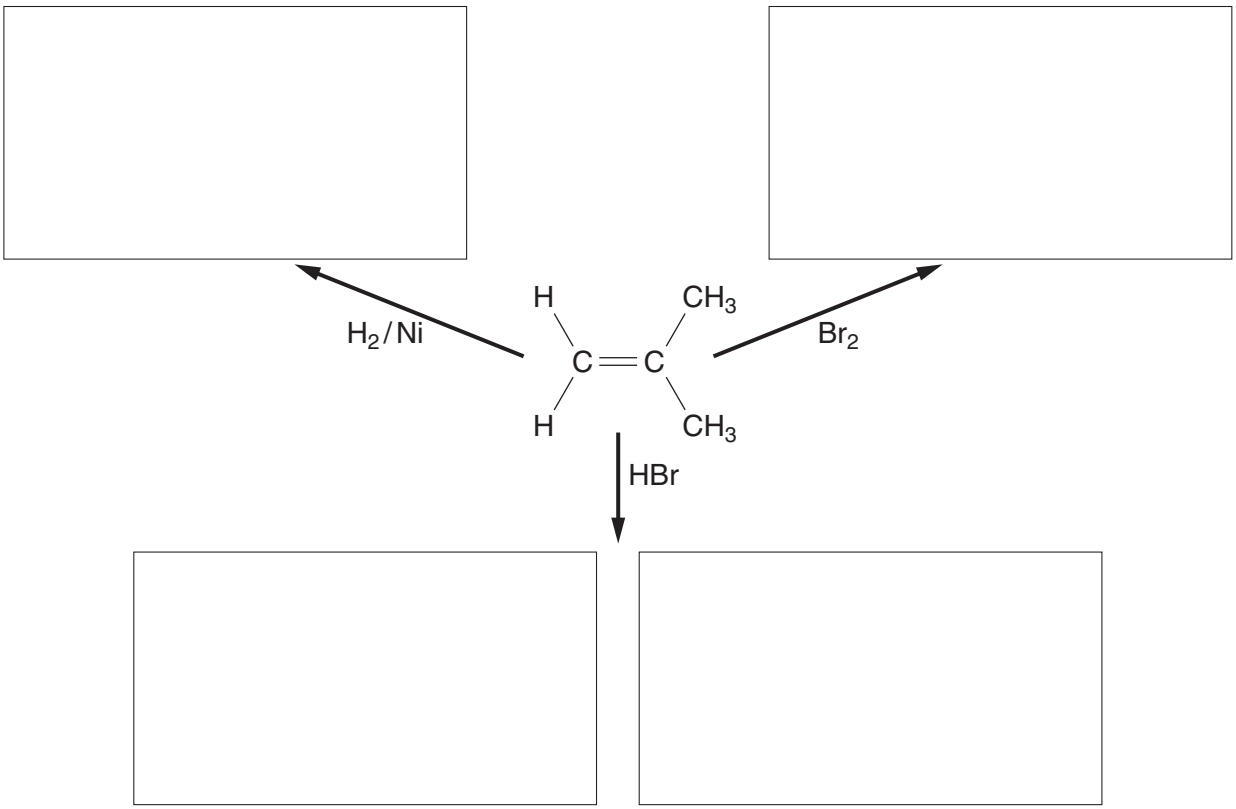
substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C	–394
H_2	–286
C_6H_{14}	–4163

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

[Total: 14]

3 Alkenes are unsaturated hydrocarbons used in the industrial production of many organic compounds.

(a) Complete the flowchart below to show the organic product formed in each addition reaction of methylpropene.



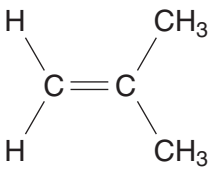
mixture of isomers

[4]

(b) Curly arrows are used in reaction mechanisms to show the movement of electron pairs during chemical reactions.

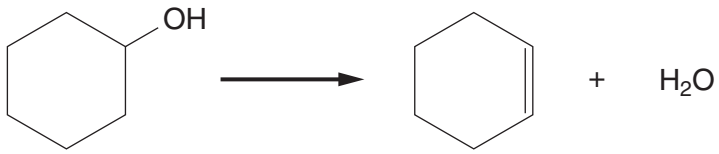
Use curly arrows to outline the mechanism for the addition reaction of methylpropene with bromine. The structure of methylpropene has been drawn for you.

Include relevant dipoles in your answer.



[4]

(c) Alkenes can be prepared by the dehydration of alcohols with an acid catalyst. Cyclohexene can be prepared by the dehydration of cyclohexanol, shown below.



A student reacted 7.65 g of cyclohexanol, $C_6H_{12}O$, and obtained 0.0268 mol of cyclohexene.

(i) What is the molecular formula of cyclohexene?

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

(ii) Calculate the percentage yield of cyclohexene.

answer = ... % **[3]**

(d) Percentage yield has been used for many years to measure the 'success' of a reaction. Recently, chemists have turned their thoughts also to the atom economy of a reaction.

(i) Explain the term *atom economy*.

.....

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

(ii) Cyclohexene can also be prepared by the reaction below.

Explain why the atom economy of this cyclohexene preparation is higher than that from cyclohexanol in **(c)**.

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

[Total: 15]

4 In the chemical industry methanol, CH_3OH, is synthesised by reacting together carbon monoxide and hydrogen in the presence of copper, zinc oxide and alumina which act as a catalyst. This is a reversible reaction.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \qquad \Delta H = -91\,kJ\,mol^{-1}$$

(a) High pressures and low temperatures would give the maximum equilibrium yield of methanol. Explain why.

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

(b) Explain why the actual conditions used in the chemical industry might be different from those in **(a)** above.

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

(c) Catalysts are increasingly being used in chemical processes.

A catalyst speeds up a reaction without being consumed by the overall reaction.
A catalyst provides an alternative reaction route with a lower activation energy.

(i) Chlorine radicals, $Cl^{\bullet}$, catalyse some reactions.

Choose a reaction that you have studied that is catalysed by chlorine radicals.

Write down an equation for the overall reaction and show how chlorine radicals are **not** consumed by the overall reaction.

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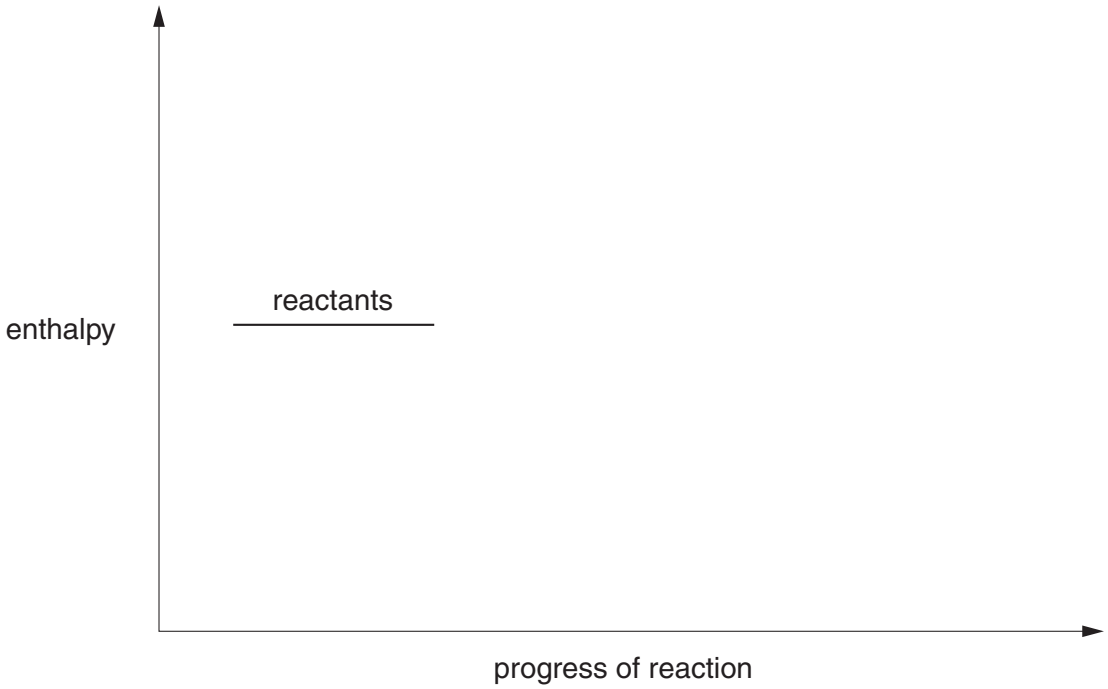
..... **[3]**

(ii) Using the axes below, sketch an enthalpy profile diagram for an exothermic reaction to show how a catalyst provides an alternative reaction route with a lower activation energy. Include on your diagram labels for:

- enthalpy change, ΔH;
- activation energy for the catalysed route, E_c;
- activation energy for the uncatalysed route, E_a.



[3]

(d) Chemical companies are using catalysts to develop processes that are more sustainable. These processes reduce costs and are less harmful to the environment.

Suggest **two** ways in which the use of catalysts helps chemical companies to make their processes more sustainable.

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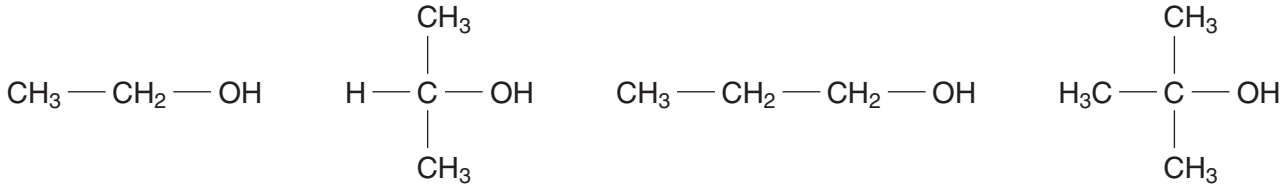
..... **[4]**

[Total: 14]

5 Alcohols **A**, **B**, **C** and **D** are shown below.



A **B** **C** **D**

(a) Compound **A** is ethanol, a very useful alcohol.

Identify the two main methods used in the industrial production of ethanol.
Write an equation for each method.

method 1 .....

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equation .....

method 2 .....

.....

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

(b) A student heated each alcohol, **A**–**D**, with acidified potassium dichromate(VI) as the oxidising agent. With alcohols **A**, **B** and **C**, the colour turned from orange to green.

(i) Identify the organic product and write a balanced equation for the reaction of alcohol **B** with acidified potassium dichromate(VI).

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

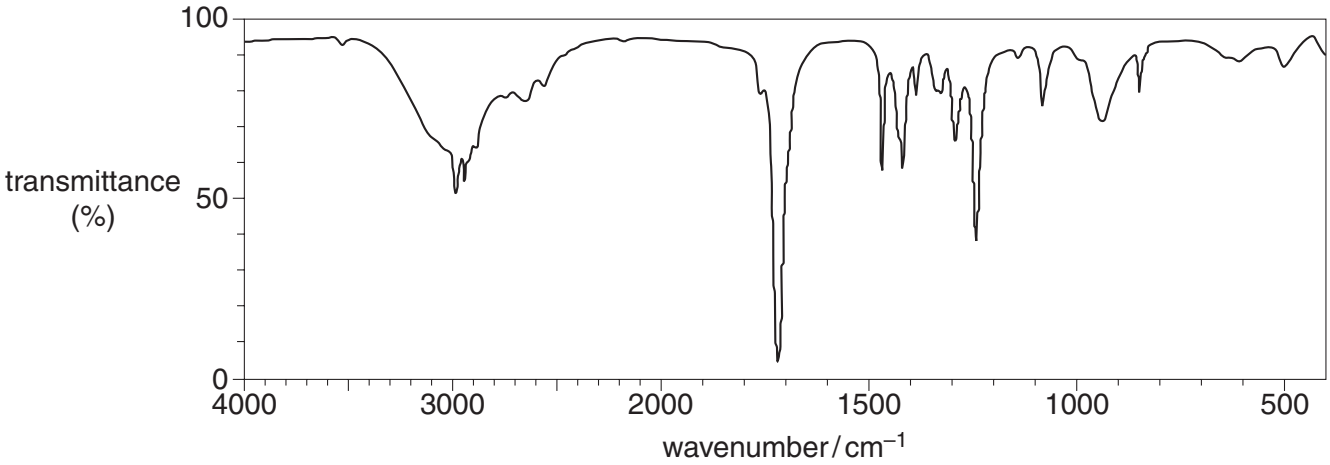
organic product:

balanced equation:

[2]

(ii) The organic product obtained from **C** was analysed by infrared (IR) spectroscopy.

The IR spectrum of the product is shown below.



Use your *Data Sheet* to identify the organic product. Explain your reasoning.

organic product:

reasoning .....

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

(c) The student heated alcohol **D** with ethanoic acid in the presence of an acid catalyst. An organic product **E** was formed with a fruity smell.

(i) Name alcohol **D**.

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

(ii) Name the functional group in the organic product **E**.

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

(iii) Draw the structure of the organic product **E**.

[2]

[Total: 13]

6 A student carried out an investigation to compare the rates of hydrolysis of 1-iodopropane and 1-bromopropane. The student heated hot aqueous sodium hydroxide with each halogenoalkane and found that 1-iodopropane was hydrolysed faster.

The equation for the reaction with 1-iodopropane is shown below.

$$CH_3CH_2CH_2I + OH^- \longrightarrow CH_3CH_2CH_2OH + I^-$$

(a) (i) Outline the mechanism for this hydrolysis of 1-iodopropane.

Show curly arrows and relevant dipoles.

[3]

(ii) State the name of this type of mechanism.

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

(b) Explain why 1-iodopropane is hydrolysed faster than 1-bromopropane.

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

(c) Chlorofluoroalkanes, CFCs, were developed from fluoroalkanes and were used in aerosols and as refrigerants. Under the Montreal Protocol, CFCs are now largely banned because of their ozone-depleting properties. CFCs have now been replaced in many applications.

Suggest **two** reasons why there is still concern about ozone depletion.

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

(d) Fluoroalkenes are used to make polymers. For example, PVF, $(CH_2CHF)_n$, is used to make non-flammable interiors of aircraft.

(i) Draw **two** repeat units of the polymer PVF showing all bonds.

[1]

(ii) Draw the structure of the monomer of PVF.

[1]

(e) Once polymers have been used, they become waste.

Outline **two** ways that waste polymers are processed usefully, rather than just dumped in landfill sites.

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

[Total: 12]

7 In this question, you are asked to suggest structures for several organic compounds.

(a) Compounds **F**, **G** and **H** are **unbranched** alkenes that are isomers, each with a relative molecular mass of 70.0.

Compounds **F** and **G** are *E*/*Z* stereoisomers.

Compound **H** is a structural isomer of compounds **F** and **G**.

- Explain what is meant by the terms *structural isomer* and *stereoisomer*.
- Explain why some alkenes have *E*/*Z* isomerism.
- Analyse this information to suggest possible structures for compounds **F**, **G** and **H**.

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

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..... **[11]**

(b) An analytical chemist was provided with a compound **J** which has an unbranched carbon skeleton. After analysis, the chemist obtained the following results.

type of analysis	**evidence**
infrared spectroscopy	broad absorption at 3350 cm^{-1}
percentage composition by mass	C, 70.59%; H, 13.72%; O, 15.69%
mass spectrometry	molecular ion peak at m/z = 102.0

Use this information to suggest all the possible structures for the **unbranched** compound **J**.

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

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..... **[8]**

[Total: 19]

END OF QUESTION PAPER

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