OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

CHEMISTRY A

F322

Chains, Energy and Resources

Candidates answer on the question paper.

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

Other Materials Required:
- Scientific calculator

Friday 27 May 2011
Afternoon

Duration: 1 hour 45 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

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

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry A* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.
- The total number of marks for this paper is **100**.
- This document consists of **24** pages. Any blank pages are indicated.

Answer **all** the questions.

1 Many organisms use the aerobic respiration of glucose, $C_6H_{12}O_6$, to release useful energy.

(a) The overall equation for aerobic respiration is the same as for the complete combustion of $C_6H_{12}O_6$.

(i) Write the equation for the aerobic respiration of $C_6H_{12}O_6$.

.... **[1]**

(ii) Explain, in terms of bond breaking and bond forming, why this reaction is exothermic.

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.... **[2]**

(b) The table shows some enthalpy changes of combustion, ΔH_c.

substance	ΔH_c / kJ mol^{-1}
C(s)	–394
H_2(g)	–286
$C_6H_{12}O_6$(s)	–2801

(i) What is meant by the term *enthalpy change of combustion*, ΔH_c?

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.... **[2]**

(ii) The enthalpy change of formation, ΔH_f, of glucose, $C_6H_{12}O_6$, cannot be determined directly. The equation for this enthalpy change is shown below.

$$6C(s) + 6H_2(g) + 3O_2(g) \rightarrow C_6H_{12}O_6(s)$$

Suggest why the enthalpy change of formation of $C_6H_{12}O_6$ **cannot** be determined directly.

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....

.... **[1]**

(iii) Use the ΔH_c values in the table to calculate the enthalpy change of formation of $C_6H_{12}O_6$.

ΔH_f = ... kJ mol^{-1} **[3]**

[Total: 9]

2 The alcohols are an example of an homologous series.

The table shows the boiling points for the first four members of straight-chain alcohols.

alcohol	structural formula	boiling point / °C
methanol	CH_3OH	65
ethanol	CH_3CH_2OH	78
propan-1-ol	$CH_3CH_2CH_2OH$	97
butan-1-ol	$CH_3CH_2CH_2CH_2OH$	118

(a) (i) What is the general formula of a member of the alcohol homologous series?

.... **[1]**

(ii) Deduce the molecular formula of the alcohol that has 13 carbon atoms per molecule.

.... **[1]**

(b) Alcohols contain the hydroxyl functional group.

What is meant by the term *functional group*?

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.... **[2]**

(c) (i) At room temperature and pressure, the first four members of the alcohol homologous series are liquids whereas the first four members of the alkanes homologous series are gases.

Explain this difference.

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.... **[3]**

(ii) Methylpropan-1-ol and butan-1-ol are structural isomers. Methylpropan-1-ol has a lower boiling point than butan-1-ol.

Suggest why.

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.... **[2]**

(d) Alcohols, such as methanol, can be used as fuels.

(i) Write equations for the complete and incomplete combustion of methanol.

complete: ....

incomplete: .... **[2]**

(ii) Suggest what conditions might lead to incomplete combustion of methanol.

....

.... **[1]**

(iii) In addition to its use as a fuel, methanol can be used as a solvent and as a petrol additive to improve combustion.

State **another** large-scale use of methanol.

.... **[1]**

(e) Butan-1-ol can be oxidised by heating under reflux with excess acidified potassium dichromate(VI).

Write an equation for the reaction that takes place.
Use [O] to represent the oxidising agent.

.... **[2]**

(f) Butan-1-ol is one of the structural isomers of $C_4H_{10}O$.

(i) Write the name and draw the structure of the structural isomer of $C_4H_{10}O$ that is a tertiary alcohol.

name: ....

structure:

[2]

(ii) Draw the structure of the structural isomer of $C_4H_{10}O$ that can be oxidised to form butanone.

[1]

[Total: 18]

3 Nitrogen monoxide is an atmospheric pollutant, formed inside car engines by the reaction between nitrogen and oxygen.

$$N_2(g) + O_2(g) \longrightarrow 2NO(g) \qquad \Delta H = +66\,kJ\,mol^{-1}$$

This reaction is endothermic.

(a) (i) Explain the meaning of the term *endothermic*.

....

.... **[1]**

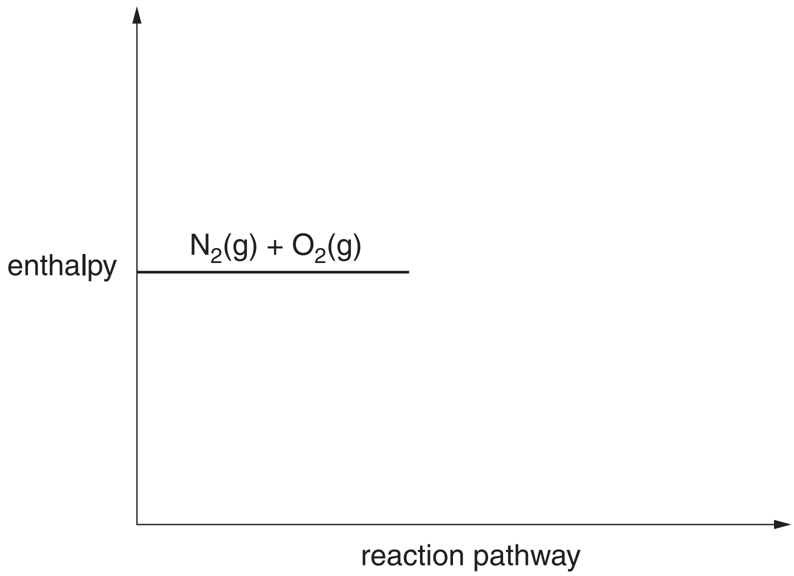
(ii) What is the value for the enthalpy change of formation of nitrogen monoxide?

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

(b) (i) Complete the enthalpy profile diagram for the reaction between nitrogen and oxygen.

On your diagram

- add the product
- label the activation energy as E_a
- label the enthalpy change as ΔH.



[3]

(ii) Explain the meaning of the term *activation energy*.

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.... **[1]**

(c) A research chemist investigates the reaction between nitrogen and oxygen.
She mixes nitrogen and oxygen gases in a sealed container.
She then heats the container at a constant temperature for one day until the gases reach a dynamic equilibrium.

(i) Explain, in terms of the rate of the forward reaction and the rate of the backward reaction, how the mixture of N_2(g) and O_2(g) reaches a dynamic equilibrium containing N_2(g), O_2(g) **and** NO(g).

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.... **[2]**

(ii) The research chemist repeats the experiment at the same temperature using the same initial amounts of N_2(g) and O_2(g). This time she carries out the experiment at a much **higher pressure**.

Suggest why

- much less time is needed to reach dynamic equilibrium
- the composition of the equilibrium mixture is the same as in the first experiment.

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.... **[5]**

(iii) The reaction between nitrogen and oxygen in a car engine does not reach a dynamic equilibrium.

Suggest why not.

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.... **[1]**

(d) Nitrogen monoxide is a radical.

What does this tell you about a molecule of nitrogen monoxide?

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.... **[1]**

(e) Oxides of nitrogen, NO_x, are atmospheric pollutants.

(i) Nitrogen monoxide reacts with oxygen to form NO_2.

Write an equation for the formation of NO_2 from nitrogen monoxide and oxygen.

.... **[1]**

(ii) Aeroplane engines produce nitrogen monoxide.

Describe, with the aid of equations, how nitrogen monoxide catalyses ozone depletion in the stratosphere.

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.... **[3]**

(iii) Outline the use of infrared spectroscopy in identifying air pollutants such as NO_x.

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.... **[2]**

[Total: 21]

4 Atom economy and percentage yield are important factors in deciding the sustainability of a manufacturing process.

(a) Complete the expression below for atom economy.

$$\text{atom economy} = \frac{\text{sum of} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots}{\text{sum of} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots} \times 100\%$$

[1]

(b) The following five reactions all represent important industrial processes.

Process 1 $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3 \rightarrow (CH_3)_2CHCH_2CH_2CH(CH_3)_2$

Process 2 $CH_3CH_2OH + CH_3COOH \rightarrow CH_3COOCH_2CH_3 + H_2O$

Process 3 $CH_2CH_2 + H_2O \rightarrow CH_3CH_2OH$

Process 4 $NH_3 + HNO_3 \rightarrow NH_4NO_3$

Process 5 $C_8H_{18} \rightarrow C_2H_4 + C_6H_{14}$

(i) Which process is an example of cracking?

.... **[1]**

(ii) Which process makes a structural isomer of the reactant?

.... **[1]**

(iii) Which process does **not** have an atom economy of 100%?

Explain your answer.

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.... **[2]**

(c) The manufacture of ethanol by the fermentation of glucose can be represented by the following equation.

$$C_6H_{12}O_6(aq) \longrightarrow 2C_2H_5OH(aq) + 2CO_2(g)$$

The atom economy is 51.1% and the percentage yield is 88.6%.

(i) Suggest **two** reasons why it is a good idea to find uses for the carbon dioxide produced.

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.... **[2]**

(ii) Some scientists believe that it is more important to have a high percentage yield in fermentation but others think that a high atom economy is more important.

Is it more important to have high percentage yield or a high atom economy in fermentation?

Explain your answer.

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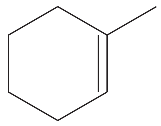
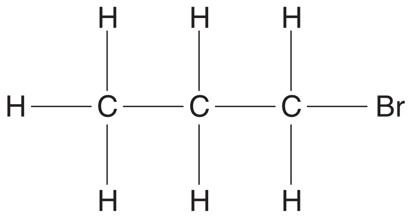
.... **[2]**

[Total: 9]

5 This question is about the following organic compounds.



A



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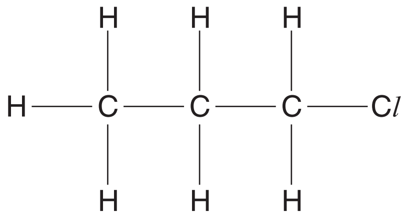

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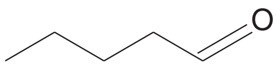
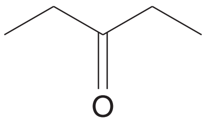
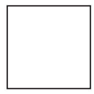


D



E



F

$CH_3CH{=}CHCH_3$

G

$CH_3CH{=}CH_2$

H

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

(a) Explain why compound **A** is a hydrocarbon.

....

.... **[1]**

(b) Which compound is a saturated hydrocarbon?

…………… **[1]**

(c) What is the molecular formula for compound **E**?

.... **[1]**

(d) Which compounds are structural isomers of one another?

.... **[1]**

(e) In compound **G**, there are different shapes around different carbon atoms.

(i) State and explain the shape around carbon atom number **1** in compound **G**.

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.... **[2]**

(ii) State the shape around carbon atom number **2** in compound **G**.

.... **[1]**

(f) **(i)** Which compound shows *E*/*Z* isomerism?

.... **[1]**

(ii) Explain why some molecules show *E*/*Z* isomerism.

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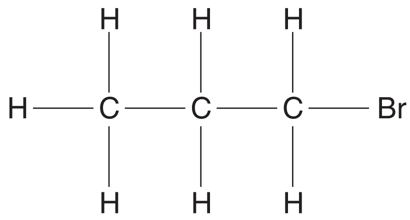
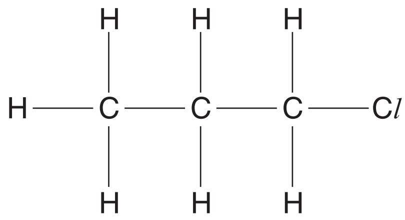
.... **[2]**

TURN OVER FOR PART (g)

(g) Compounds **B** and **C** are halogenoalkanes. Both compounds can be hydrolysed with aqueous potassium hydroxide, KOH(aq).



B



C

Describe and explain the hydrolysis of **B** and **C**.

In your answer, include

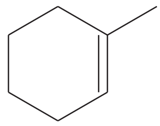
- one equation including the structure of the organic product
- the reaction mechanism, using the curly arrow model, showing any relevant dipoles
- the type of bond fission that occurs
- the reasons for the difference in the rate of hydrolysis.

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

.... [10]

TURN OVER FOR PART (h)

(h) Compound **A** is 1-methylcyclohex-1-ene.



A

Compound **A** reacts with H_2 to give one product and with HBr to give two products.

Draw the structures of the products of these reactions.

product of reaction of H_2 with **A**

two products of reaction of HBr with **A**	

[3]

[Total: 23]

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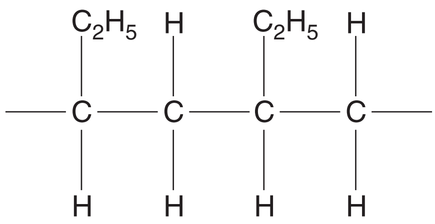
TURN OVER FOR QUESTIONS 6 AND 7

Turn over

6 Plastics contain polymer molecules. The disposal of waste plastics is causing many environmental problems. In the middle of the Pacific Ocean, there is a huge area of sea water contaminated with very small pieces of plastic waste. In some parts of the Pacific Ocean, there are as many as one third of a million of small pieces of plastic waste per square kilometre of ocean.

(a) A short section of one of the polymers found in the Pacific Ocean is shown below.



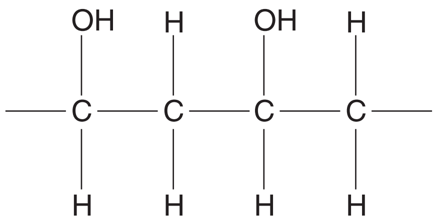
(i) Name and draw the structure of the monomer used to produce this polymer.

name of monomer: ....

structure:

[2]

(ii) The short section of poly(ethenol) is shown below.



Large quantities of poly(ethene) and poly(ethenol) are disposed of each year.

Poly(ethene) is found as a waste plastic in the Pacific Ocean but poly(ethenol) is not because it slowly dissolves in water.

Suggest why poly(ethenol) dissolves in water.

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.... **[2]**

(b) One way of disposing of poly(chloroethene) is incineration.

This process can cause environmental damage. Incineration produces a mixture of carbon dioxide, carbon monoxide and hydrogen chloride.

Carbon dioxide can cause climate change because it is a greenhouse gas.

- Describe examples of environmental damage that may result from carbon monoxide and hydrogen chloride.
- Outline the methods developed by chemists to reduce environmental damage caused by incineration.

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.... **[4]**

(c) Explain why it is important to establish international cooperation to reduce the pollution levels of waste plastics.

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.... **[2]**

[Total: 10]

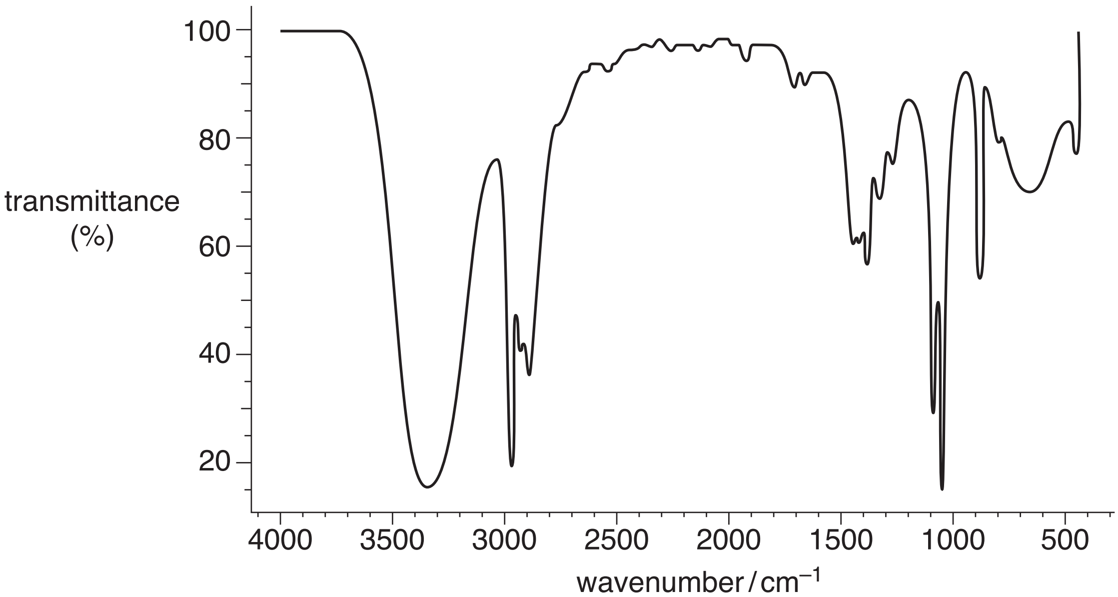
7 Compound **X** and compound **Y** react together to make an ester **Z**. Samples of **X** and **Y** were analysed by a research chemist. A summary of the chemist's results are shown below.

Analysis of compound X

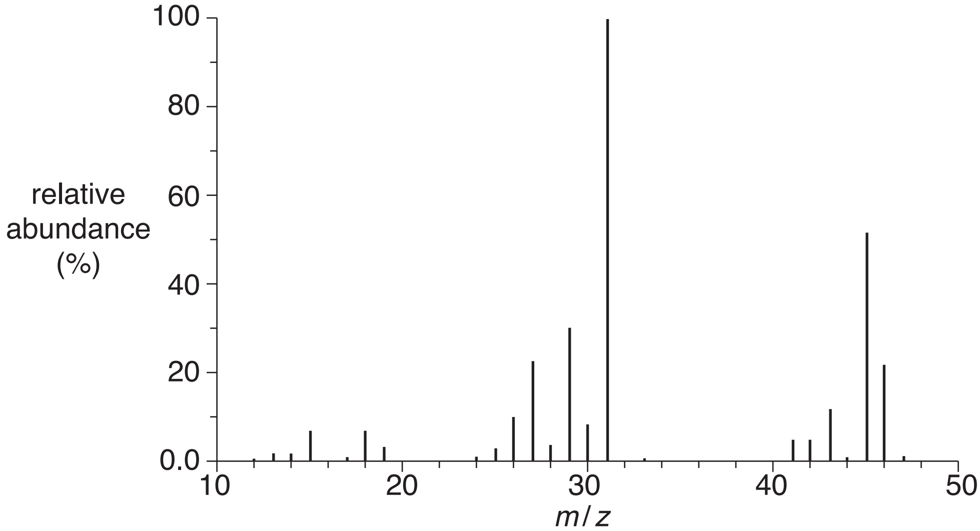
type of analysis	**evidence**
infrared spectroscopy	absorption at 1720 cm^{-1} and a very broad absorption between 2500 and 3300 cm^{-1}
percentage composition by mass	C, 48.65%; H, 8.11%; O, 43.24%
mass spectrometry	molecular ion peak at m/z = 74.0

Analysis of compound Y

infrared spectrum of **Y**



mass spectrum of **Y**



Use this information to suggest the identity of compound **X**, compound **Y** and ester **Z**.

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

[10]

[Total:10]

END OF QUESTION PAPER

ADDITIONAL PAGE

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

ADDITIONAL PAGE

ADDITIONAL PAGE