OCR
RECOGNISING ACHIEVEMENT

Wednesday 23 May 2012 – Afternoon

AS GCE CHEMISTRY A

F322 Chains, Energy and Resources

F3146206122

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. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- 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.

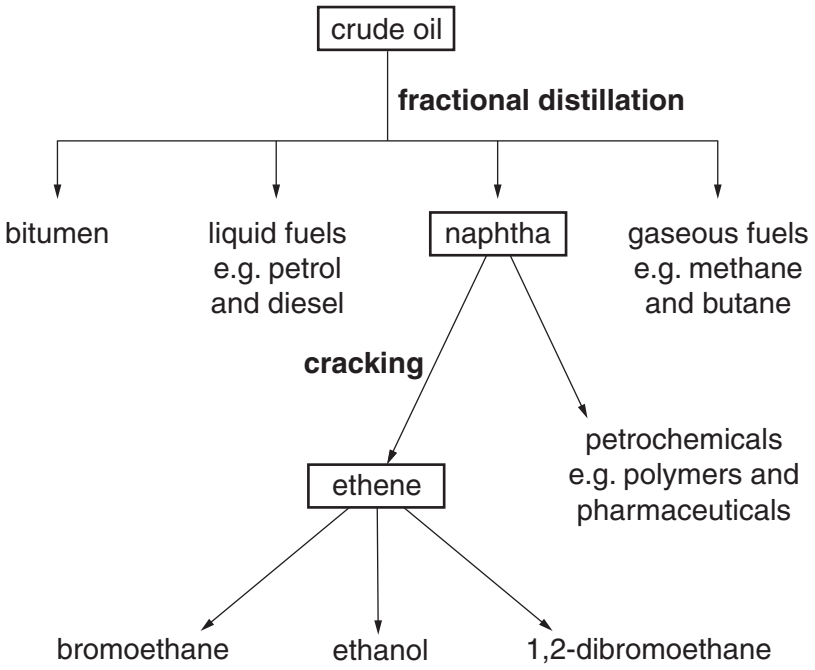
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use a scientific calculator.
- A copy of the *Data 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 **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Crude oil is a source of many important petrochemicals.

The flow chart shows some of the petrochemicals that can be made and the processes used to make them.



(a) Explain why crude oil can be separated into different fractions.

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

(b) Many scientists believe that we should use more fuels such as biodiesel or bio-ethanol rather than petrol and diesel.

Suggest **one** reason why these scientists take this view.

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

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(c) Cracking converts the alkane dodecane, $C_{12}H_{26}$, into more useful short chain alkanes and alkenes.

(i) When $C_{12}H_{26}$ is cracked, a variety of alkanes and alkenes are formed with different chain lengths.

Explain why a variety of alkanes and alkenes are formed with different chain lengths.

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

(ii) One molecule of $C_{12}H_{26}$ is cracked to produce one molecule of propane and several molecules of an alkene, **A**.

The mass spectrum of **A** contains peaks with the following *m*/*z* values: 15, 27 and 42. There are no *m*/*z* values above 42.

- Write the formula of the particle responsible for the peak at *m*/*z* = 27.
- Identify, with a reason, alkene **A**.
- Write an equation to show this cracking of $C_{12}H_{26}$ to form alkene **A**.

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

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(d) Ethene can be converted into petrochemicals.

- Describe how ethene can be converted into 1,2-dibromoethane, bromoethane and ethanol.

- Name and describe the mechanism for the conversion of ethene into 1,2-dibromoethane using the 'curly arrow' model.
  Include any relevant dipoles.

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(e) Draw and explain the shape of an ethene molecule.
State the H–C–H bond angle in ethene.

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

(f) Addition polymers are made by the polymerisation of alkenes.

E-Pent-2-ene can be made into an addition polymer.

(i) Draw the structure of *E*-pent-2-ene.

[1]

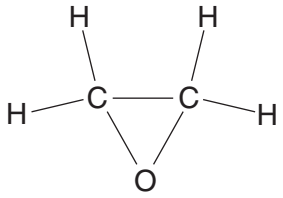
(ii) Draw the structure of poly(pent-2-ene).
Include **two** repeat units.

[1]

[Total: 21]

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2 Epoxyethane, C_2H_4O, is a synthetic intermediate that is used to make ethane-1,2-diol and some polymers. The structure of epoxyethane is shown below.



(a) The controlled catalysed reaction of ethene with oxygen forms epoxyethane as the only product.

(i) Write the equation for this reaction.

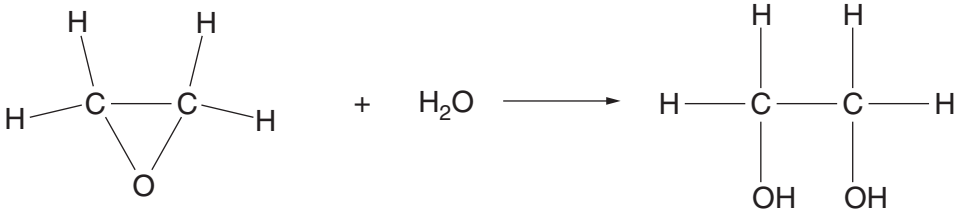
[1]

(ii) When burnt in excess oxygen, ethene completely combusts.

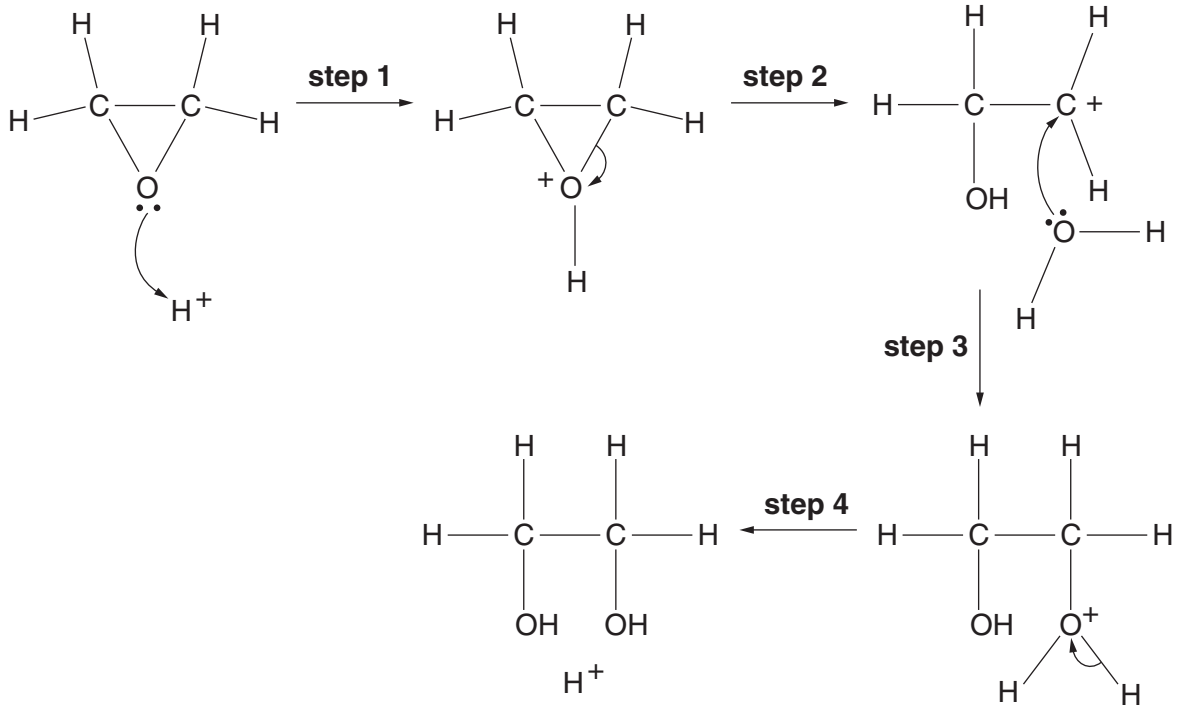
Write the equation for the complete combustion of ethene.

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

(b) Epoxyethane reacts with water in the presence of an acid catalyst to form ethane-1,2-diol.

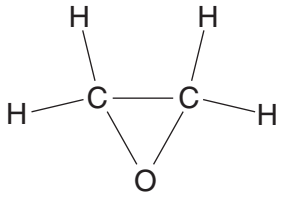


The mechanism for this reaction is shown below.



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(i) Draw dipoles on the carbon and oxygen atoms on the displayed formula of epoxyethane.



[1]

(ii) The mechanism uses the 'curly arrow' model.

What does a '*curly arrow*' represent?

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

(iii) What type of bond fission occurs in **step 2**?

Explain your answer.

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

(iv) How can you tell that water is behaving as a nucleophile in **step 3**?

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

(v) How does the mechanism show that H^+ ions act as a catalyst in this reaction?

Refer to the steps in the mechanism in your answer.

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

(vi) Epoxyethane reacts with methanol, CH_3OH, to form a compound with the molecular formula $C_3H_8O_2$.

Suggest the structure of this compound.

[1]

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(c) Ethane-1,2-diol is much less volatile than ethanol.

Suggest why.

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

(d) Ethane-1,2-diol reacts with an excess of ethanoic acid, CH_3COOH, in the presence of an acid catalyst. A compound is formed with the molecular formula $C_6H_{10}O_4$.

Draw the structure of this compound.

[2]

(e) Ethane-1,2-diol reacts with warm acidified potassium dichromate(VI). A number of different organic products are formed.

Draw the displayed formulae of **two** of these organic products.

[2]

[Total: 15]

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3 Hydrogen has many industrial uses including making margarine and ammonia.

Hydrogen can be made by the reaction between methane and steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g) \qquad \Delta H = +210\,kJ\,mol^{-1}$$

(a) The pressure of the equilibrium mixture is **increased**.

Explain what happens to the position of the equilibrium.

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

(b) The temperature of the equilibrium mixture is **increased**.

Explain what happens to the position of the equilibrium.

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

(c) The reaction is actually carried out in the presence of a nickel catalyst at a pressure of 30 atmospheres.

(i) Suggest why the manufacturer uses a pressure of 30 atmospheres.

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

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(ii) The nickel catalyst increases the rate.

Use a labelled diagram of the Boltzmann distribution of molecular energies to explain why.

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

(d) A chemical factory uses 200 tonnes of methane a day. The factory produces 68.4 tonnes of hydrogen per day by reacting methane with steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

Calculate the percentage yield of hydrogen.

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

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

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(e) The carbon monoxide produced in the equation below can be reacted with hydrogen to make methanol.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

(i) Construct the equation for the reaction of carbon monoxide with hydrogen to make methanol.

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

(ii) Suggest **two** reasons why it is important to use the carbon monoxide to make methanol.

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

(f) Describe how hydrogen can be used in the manufacture of margarine.

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

[Total: 16]

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4 The uses of catalysts have great economic and environmental importance. For example, catalysts are used in ammonia production and in catalytic converters.

(a) Nitrogen and hydrogen react together in the production of ammonia, NH_3.

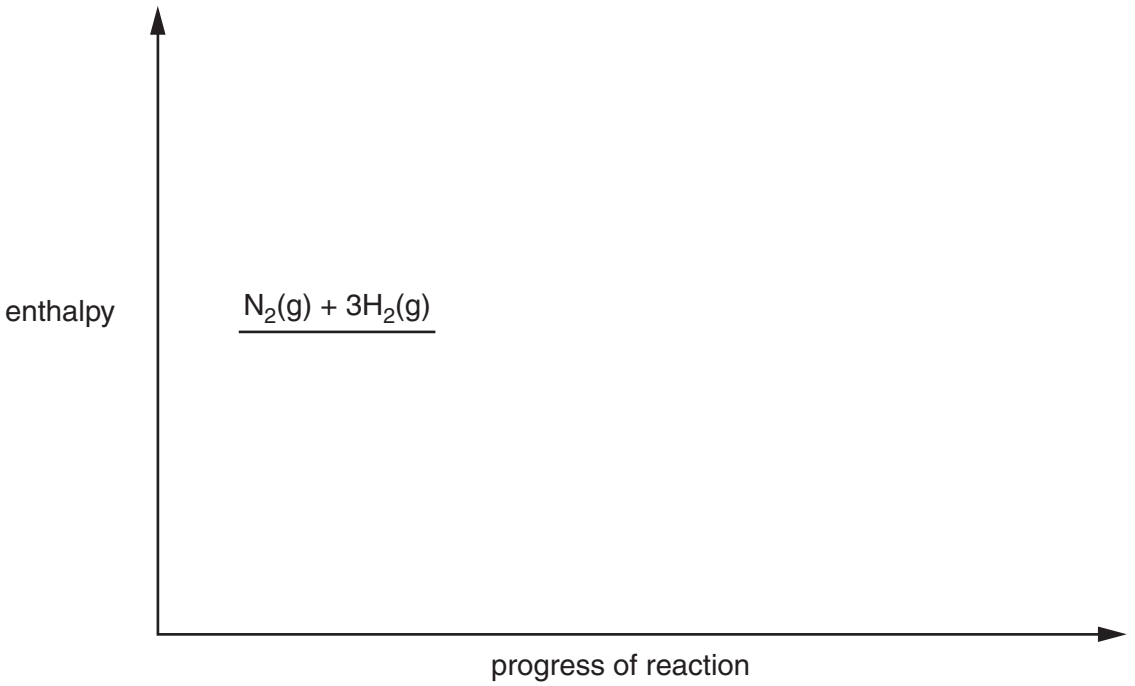
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

The activation energy for the forward reaction, E_a, is $+250\,kJ\,mol^{-1}$.

(i) Complete the enthalpy profile diagram for this reaction between nitrogen and hydrogen.

Include the

- products
- enthalpy change of reaction, ΔH
- activation energy for the forward reaction, E_a.



[3]

(ii) What is the value of the enthalpy change of formation of ammonia?

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

(iii) The reaction between nitrogen and hydrogen can be catalysed.

Suggest a possible value for the activation energy of the **catalysed** forward reaction.

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

(iv) What is the value of the activation energy for the uncatalysed **reverse** reaction (the decomposition of ammonia into nitrogen and hydrogen)?

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

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(b) In a catalytic converter, nitrogen monoxide reacts with carbon monoxide.

(i) Write the equation for this reaction.

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

(ii) Outline the stages that allow nitrogen monoxide and carbon monoxide to react in a catalytic converter.

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

(c) Scientists monitor pollutant gases in the atmosphere.

(i) State **two** modern analytical techniques that scientists can use to monitor environmental pollution.

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

(ii) Explain why it is important to establish **international** cooperation to reduce pollution levels.

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

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(d) In the stratosphere, nitrogen monoxide, NO, is linked with ozone depletion.

Complete the equations below that describe how NO contributes to ozone depletion.

step 1 $NO + O_3 \longrightarrow$ ..... + ...

step 2 NO_2 + ... $\longrightarrow NO$ + ...

overall ..... + ... $\longrightarrow 2O_2$

[3]

(e) Hess' law can be used to calculate enthalpy changes of reaction.

The equation for the reaction that gives the enthalpy change of formation, ΔH_f, of $N_2O(g)$ is as follows.

$$N_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow N_2O(g)$$

(i) It is not possible to measure the enthalpy change of formation of $N_2O(g)$ directly.

Suggest why it is **not** possible.

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

(ii) The data below can be used to calculate the enthalpy change of formation, ΔH_f, of $N_2O(g)$.

reaction	enthalpy change of reaction / kJ mol^{-1}
$C(s) + N_2O(g) \longrightarrow CO(g) + N_2(g)$	–193
$C(s) + \tfrac{1}{2}O_2(g) \longrightarrow CO(g)$	–111

Calculate ΔH_f for $N_2O(g)$.

ΔH_f = ... kJ mol^{-1} **[2]**

[Total: 19]

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5 Methane and ethane are important fuels.

(a) Methane could be manufactured by the reaction between carbon dioxide and hydrogen.

$$CO_2(g) + 4H_2(g) \longrightarrow CH_4(g) + 2H_2O(g)$$

Using the table of bond enthalpies, calculate the enthalpy change of reaction for this manufacture of methane.

bond	average bond enthalpy / kJ mol^{-1}
C–H	+415
H–H	+436
C=O	+805
O–H	+464

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

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(b) Methane is a greenhouse gas. Scientists are concerned that the concentration of methane in the atmosphere is slowly increasing.

(i) Explain how atmospheric methane molecules can contribute to global warming.

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

(ii) One way that scientists hope to minimise global warming is by developing Carbon Capture and Storage, CCS, techniques.

Describe **two** of these CCS techniques.

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

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(c) Ethane reacts with bromine in the presence of ultraviolet radiation to form many organic products.

(i) Two of these products are bromoethane and hydrogen bromide.

Describe the mechanism of the reaction between ethane and bromine that forms bromoethane and hydrogen bromide.

Include in your answer

- the type of bond fission that occurs
- equations for each step of the reaction
- the name of each step of the reaction.



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

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

(ii) Give **two** reasons why there are many organic products of the reaction between bromine and ethane.

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

[Total: 16]

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6 A student carries out an investigation on some halogenoalkanes.

(a) She decided to hydrolyse 1-bromopentane and 1-chloropentane using aqueous sodium hydroxide.

State and explain the difference in the rates of hydrolysis of 1-bromopentane and 1-chloropentane.

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

(b) A student wants to determine the structure of an unknown iodoalkane **B**.

She knows that the molecular formula of **B** is C_4H_9I.

The student heats **B** with aqueous sodium hydroxide. A reaction mixture forms containing the organic compound **C** and $I^-(aq)$.

(i) Draw all of the possible structural isomers for **B**.

[4]

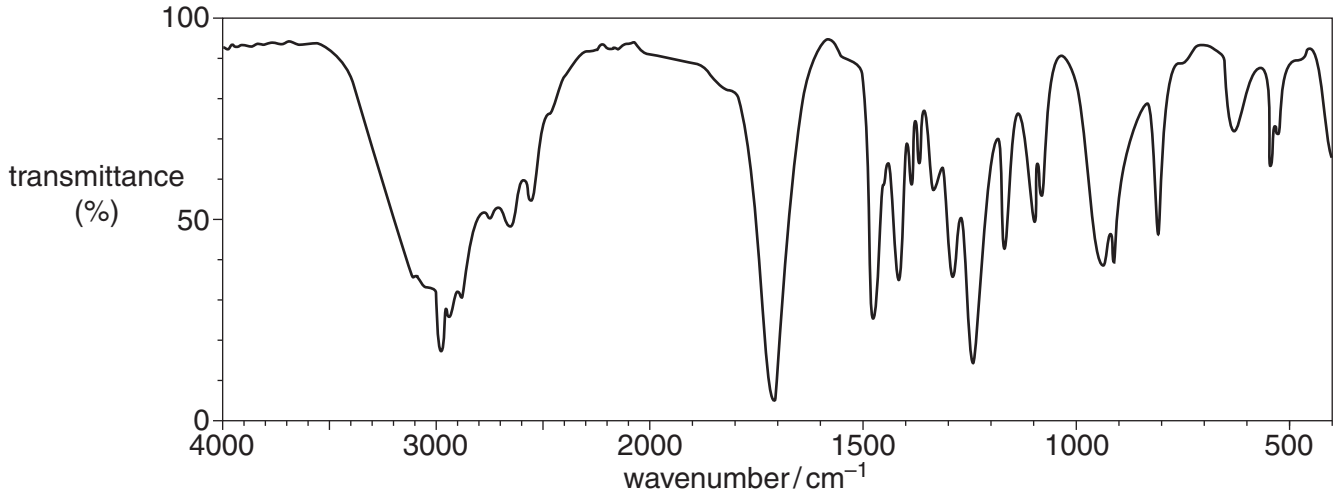
(ii) What is the molecular formula for compound **C**?

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

(iii) The student purifies compound **C** and splits it into two portions.

- She heats one portion of **C** with concentrated sulfuric acid. The product of this reaction is methylpropene.
- To the other portion of **C**, she adds acidified potassium dichromate(VI) and heats the mixture under reflux. The product of this reaction is compound **D**.
- The infrared spectrum for compound **D** is shown at the top of page 19.

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Use this evidence to suggest structures for **B**, **C** and **D**.

In your answer you should make clear how your explanations are linked to the evidence.

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[Total: 13]

END OF QUESTION PAPER

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