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**

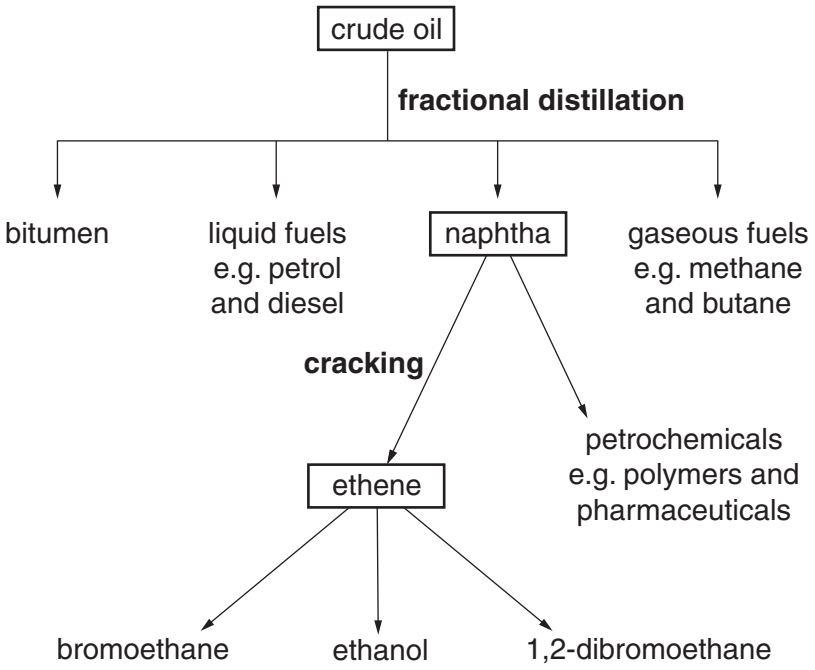
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  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.

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]**

**(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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**(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.

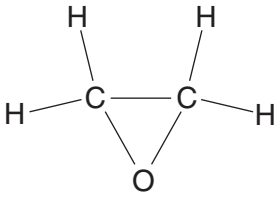
**[1]**

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

**[1]**

**[Total: 21]**

**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.

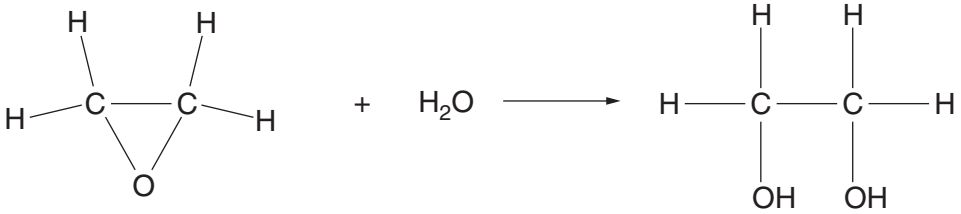
**[1]**

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

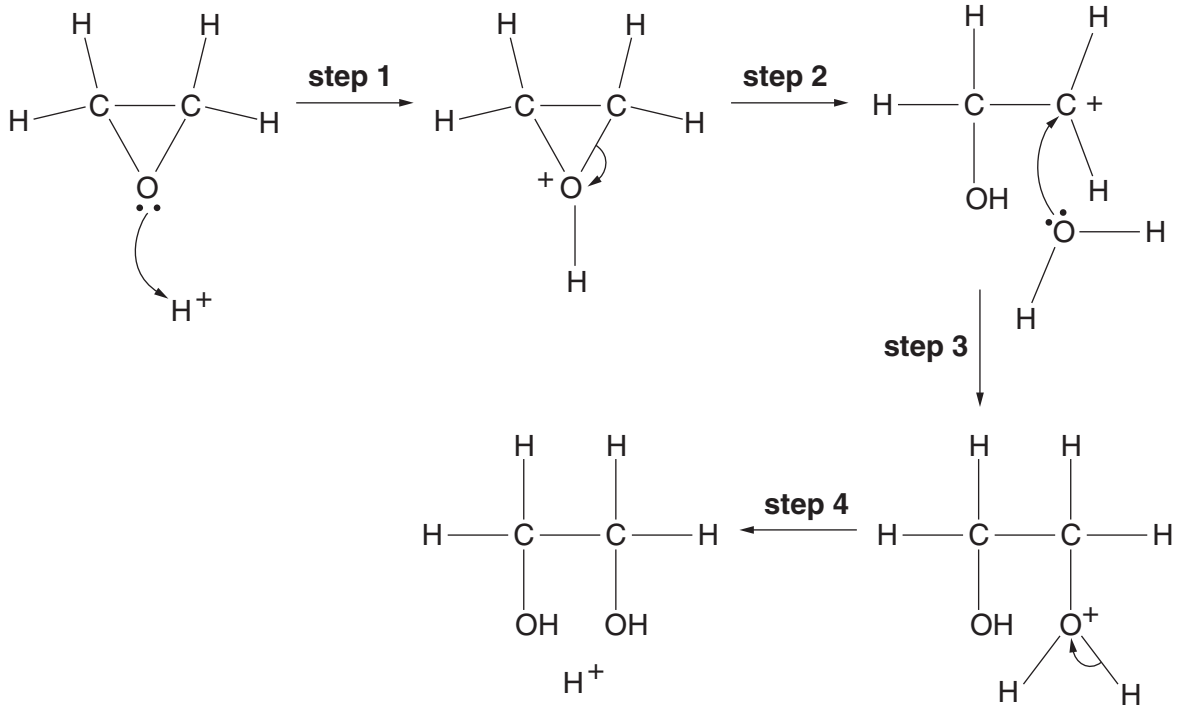
Write the equation for the complete combustion of ethene.

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

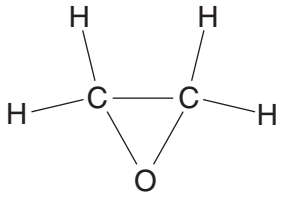
**(b)** Epoxyethane reacts with water in the presence of an acid catalyst to form ethane-1,2-diol.



The mechanism for this reaction is shown below.



**(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]**

**(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]**

**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]**

**(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 = $1 \times 10^6$ g)

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

**(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]**

**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, $NH_3$.

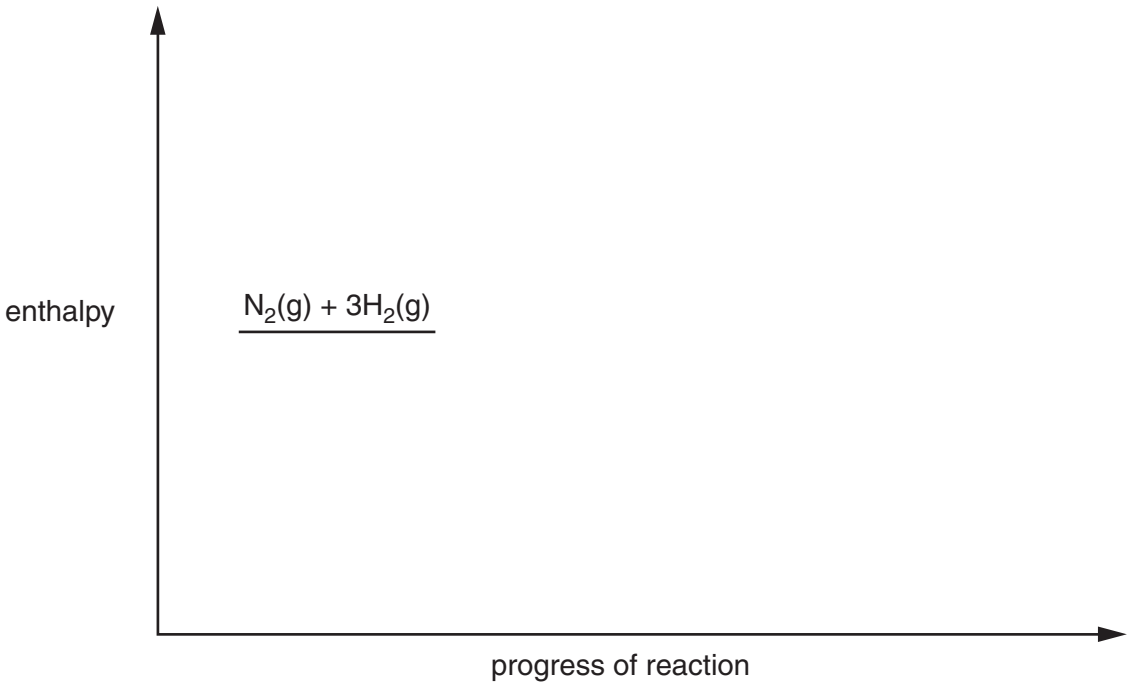
$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \qquad \Delta H = -92\,kJ\,mol^{-1}$$

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, $\Delta H$
- 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]**

**(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]**

**(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, $\Delta H_f$, 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, $\Delta H_f$, 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 $\Delta H_f$ for $N_2O(g)$.

$\Delta H_f$ = ..... kJ mol$^{-1}$ **[2]**

**[Total: 19]**

**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]**

**(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]**

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

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

**[Total: 16]**

**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**.

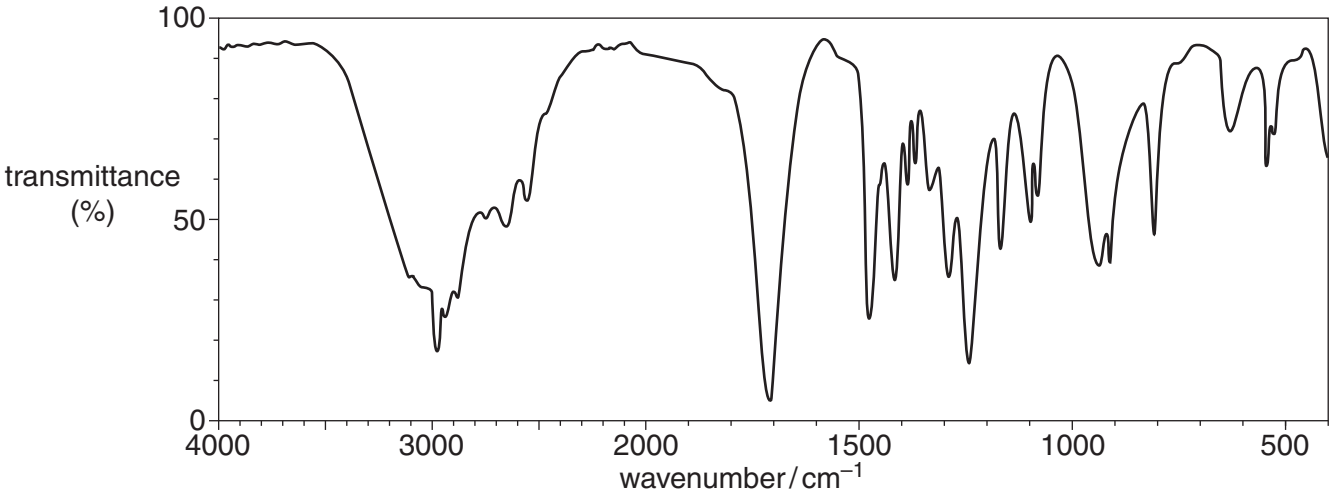
**[4]**

**(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.




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**