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RECOGNISING ACHIEVEMENT

Tuesday 4 June 2013 – Afternoon

AS GCE CHEMISTRY A

F322/01 Chains, Energy and Resources

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

F 3 1 4 6 2 0 6 1 3

F 3 2 2 0 1

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. If additional space is required, you should use the lined page at the end of this booklet. The question number(s) must be clearly shown.
- 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.

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Answer **all** the questions.

1 Crude oil is a complex mixture of many hydrocarbons.

Crude oil is processed by the petroleum industry to make fuels and petrochemicals.

(a) The straight-chain alkane, **A**, is present in crude oil.
A has molecules with ten carbon atoms.

(i) What is the molecular formula of **A**?

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

(ii) **B** is a branched-chain isomer of **A**.

Draw the skeletal formula of a possible structure for **B**.

Name your structure.

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

(iii) The branched-chain isomer **B** has a lower boiling point than the straight chain alkane **A**.

Explain why.

.....

.....

.....

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

(b) A chemist heats a pure sample of $C_{15}H_{32}$ in the presence of a catalyst.

A reaction called cracking happens.

(i) Construct an equation to show the cracking of $C_{15}H_{32}$.

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

(ii) When cracking takes place, a large number of products are formed.

Suggest why a large number of products are formed.

.....

.....

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

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(c) The petroleum industry processes straight-chain alkanes into cyclic hydrocarbons.

For example, octane can be processed into a cyclic hydrocarbon and hydrogen.

(i) Suggest the structure of this cyclic hydrocarbon.

[1]

(ii) Why does the petroleum industry process straight-chain alkanes into cyclic hydrocarbons?

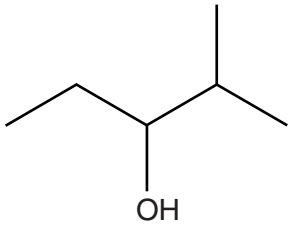
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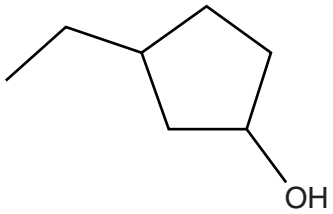
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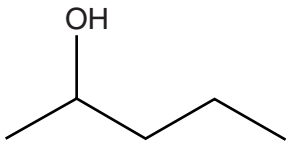
2 The skeletal formulae of six alcohols, **C**, **D**, **E**, **F**, **G** and **H**, are shown below.



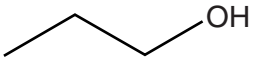
C



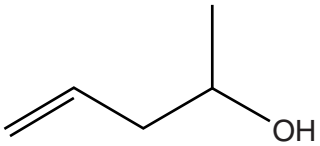
D



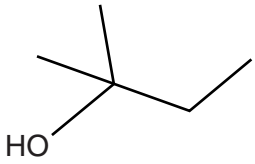
E



F



G



H

(a) (i) Which **two** alcohols are structural isomers of one another?

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

(ii) Which alcohol is a tertiary alcohol?

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

(iii) Which alcohol can be oxidised to a carboxylic acid using acidified $K_2Cr_2O_7$?

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

(b) (i) What is the molecular formula of alcohol **G**?

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

(ii) What is the name of alcohol **C**?

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

(c) The alcohols are members of a homologous series.

Explain the term *homologous series*.

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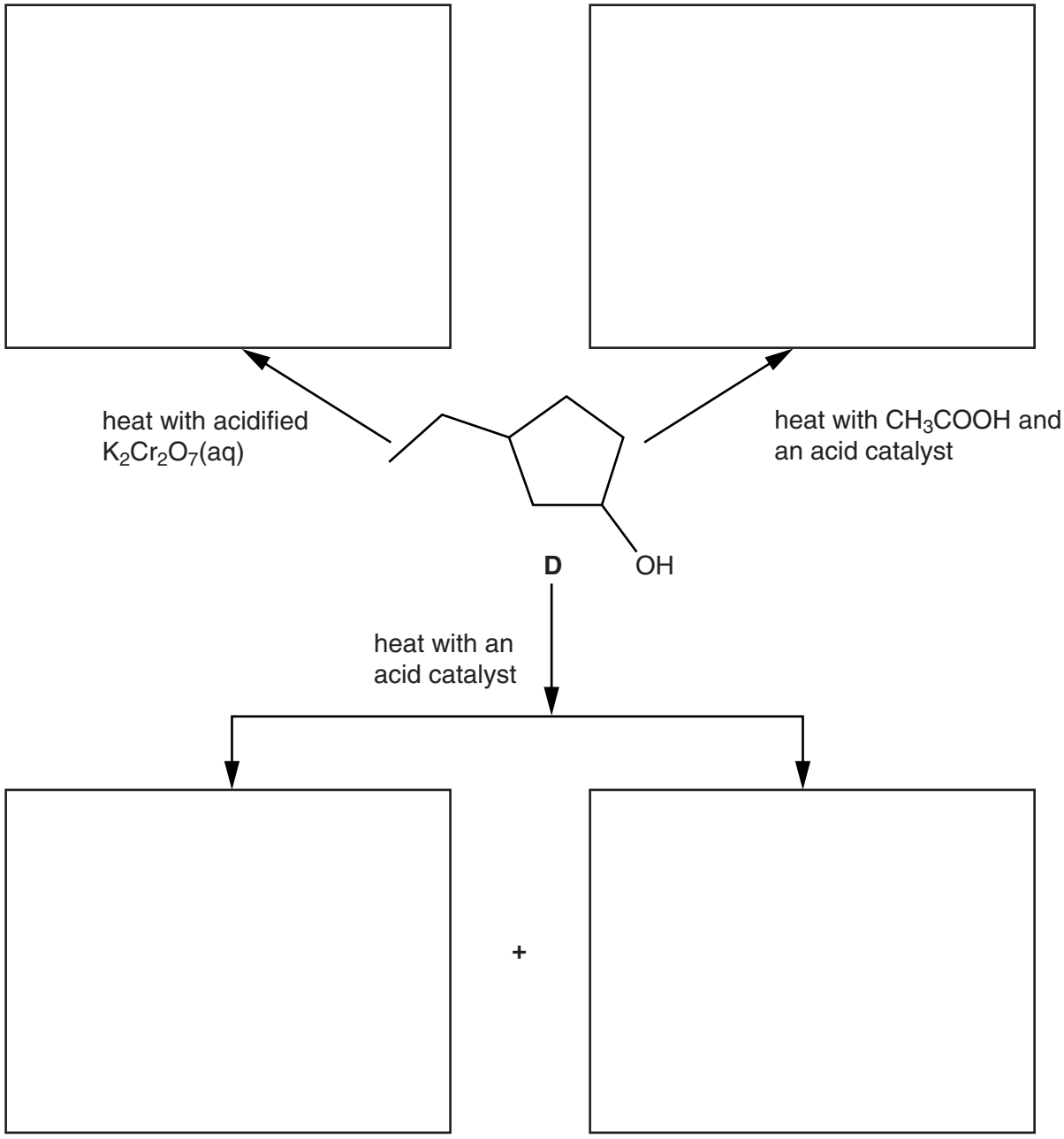
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..... **[2]**

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(d) Alcohol **D** is reacted with three different reagents.

Complete the flowchart below to show the organic product(s) formed in each of the reactions of alcohol **D**.

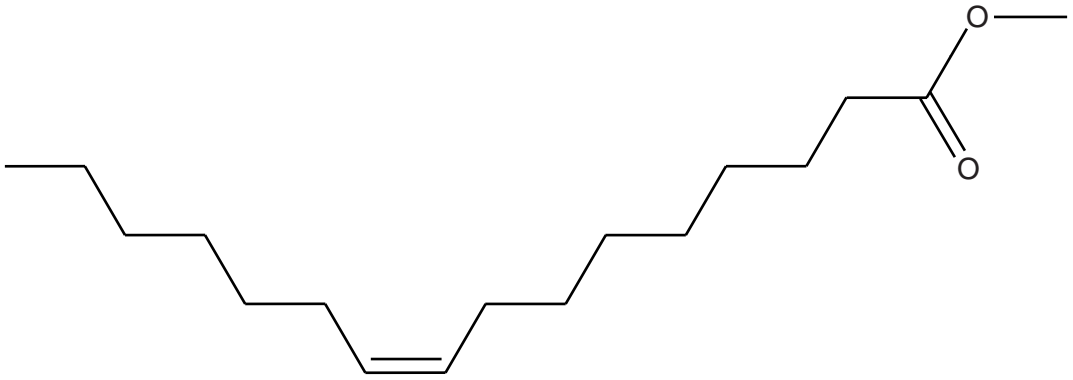


[4]

[Total: 11]

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3 Compound **I** is found in biodiesel. It has the skeletal formula shown below.



(a) Name the **two** functional groups that are present in a molecule of **I**.

.....

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

(b) Why is compound **I** unsaturated?

.....

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

(c) A sample of compound **I** is shaken with aqueous bromine.

What colour change would you see?

from ..... to ..... **[1]**

(d) Compound **J** is a stereoisomer of compound **I**.

(i) What is meant by the term *stereoisomers*?

.....

.....

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

(ii) Draw or describe how the structure of **J** differs from that of **I**.

.....

.....

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

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(e) A student determined the enthalpy change of combustion for compound **I**.

In her experiment, 1.34 g of compound **I** was used to heat 50.0 g of water.

The temperature of the water changed from 20.2 °C to 54.0 °C.

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

.....

.....

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

(ii) Calculate the energy released, in kJ, in the student's experiment.

The specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

energy = ... kJ **[2]**

(iii) The molecular formula of compound **I** is $C_{17}H_{32}O_2$.

Calculate the amount, in moles, of compound **I** used by the student.

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

(iv) Calculate the enthalpy change of combustion of compound **I**.

ΔH_c = ... kJ mol^{-1} **[3]**

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(v) The student noticed that compound **I** burnt with a yellow flame and produced black smoke.

Suggest an explanation for these observations.

.....

.....

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

(f) Some scientists believe that we should use more biofuels such as biodiesel and bioethanol.

Bioethanol is made by the fermentation of plant sugars such as glucose.

Write the equation for the fermentation of glucose to make ethanol and state **two** essential conditions for this fermentation.

equation

.....

essential conditions

.....

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

[Total: 19]

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4 Iodine monobromide, IBr, has a permanent dipole.

Alkenes react with IBr in a similar way to the reactions of alkenes with HBr.

(a) Propene reacts with IBr to make two possible organic products.

One of these products is 2-bromo-1-iodopropane.

(i) Using the curly arrow model, complete the mechanism to make 2-bromo-1-iodopropane.



[3]

(ii) What is the name of this mechanism?

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

(iii) Draw the structure of the other possible organic product of the reaction of propene with IBr.

[1]

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(b) Methane reacts with IBr to form many products.

Two of these products are iodomethane and hydrogen bromide.

(i) Suggest the essential condition needed for this reaction.

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

(ii) The mechanism of the reaction involves three steps, one of which is called termination.

Describe the mechanism of the reaction that forms iodomethane and hydrogen bromide.

Include in your answer:

- the name of the mechanism
- the names for the **other two** steps of the mechanism
- equations for these two steps of the mechanism
- the type of bond fission
- one equation for a termination step.



Your answer should link the named steps to the relevant equations.

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

[Total: 13]

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5 Nitrogen forms several oxides including N_2O_4, N_2O and NO.

(a) A rocket uses the reaction between N_2O_4 and methylhydrazine, CH_3NHNH_2, **equation 5.1**, to release a large amount of energy.

$$4CH_3NHNH_2(l) + 5N_2O_4(l) \longrightarrow 4CO_2(g) + 12H_2O(g) + 9N_2(g) \quad \textbf{equation 5.1}$$

Some enthalpy changes of formation, ΔH_f, are shown in the table.

Substance	ΔH_f / kJ mol^{-1}
$CH_3NHNH_2(l)$	+54
$N_2O_4(l)$	–20
$CO_2(g)$	–394
$H_2O(g)$	–242

Using the enthalpy changes of formation, ΔH_f, calculate the enthalpy change of reaction in **equation 5.1**.

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

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(b) Under certain conditions nitrogen reacts with oxygen to make N_2O.

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g) \quad \textbf{equation 5.2}$$

The enthalpy profile diagram for this reaction is shown in **Fig. 5.3**.

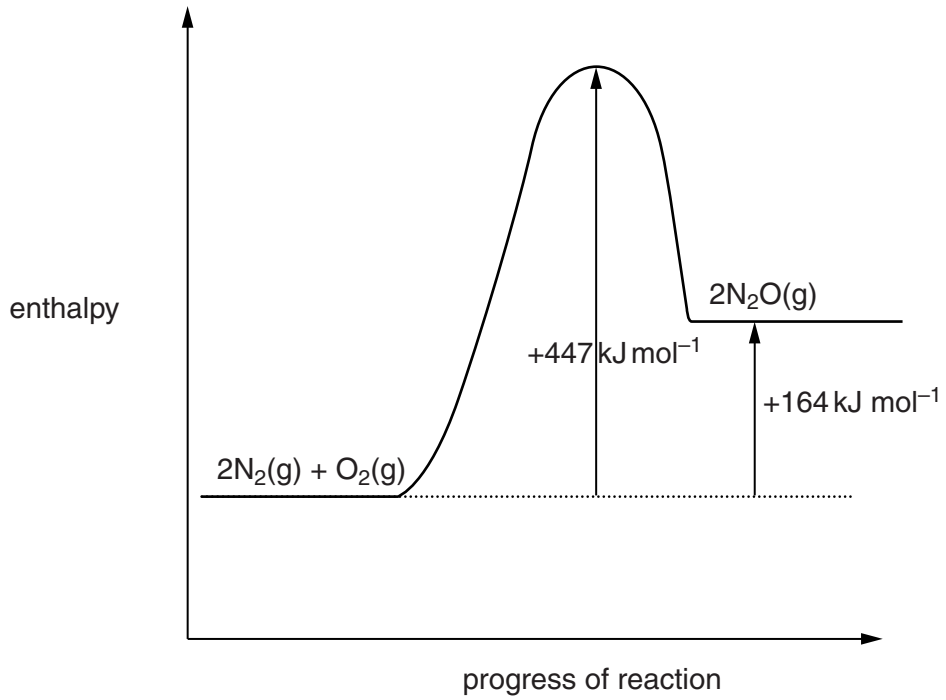


Fig. 5.3

(i) Calculate the enthalpy change when 240 dm^3 of $N_2O(g)$, measured at room temperature and pressure, is formed from N_2 and O_2.

enthalpy change = ... kJ **[2]**

(ii) What is the enthalpy change of formation, ΔH_f, of $N_2O(g)$?

ΔH_f = ... $kJ\,mol^{-1}$ **[1]**

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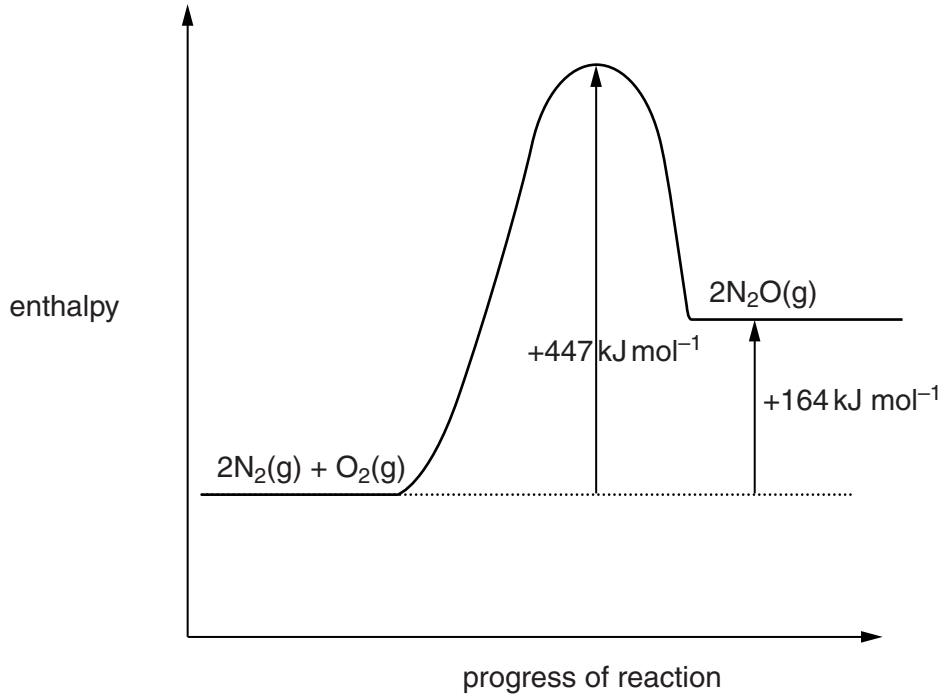


Fig. 5.3 (repeated)

(iii) The reaction in **equation 5.2** is reversible.

$$2N_2(g) + O_2(g) \rightleftharpoons 2N_2O(g) \quad \textbf{equation 5.2}$$

Calculate the activation energy, E_a, for the reverse reaction.

E_a (reverse reaction) = ... kJ mol^{-1} **[1]**

(c) Describe and explain, using equations, how the concentration of ozone in the stratosphere is maintained.

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

(d) In the stratosphere, NO catalyses the breakdown of ozone.

Write **two** equations to show how NO catalyses this breakdown.

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

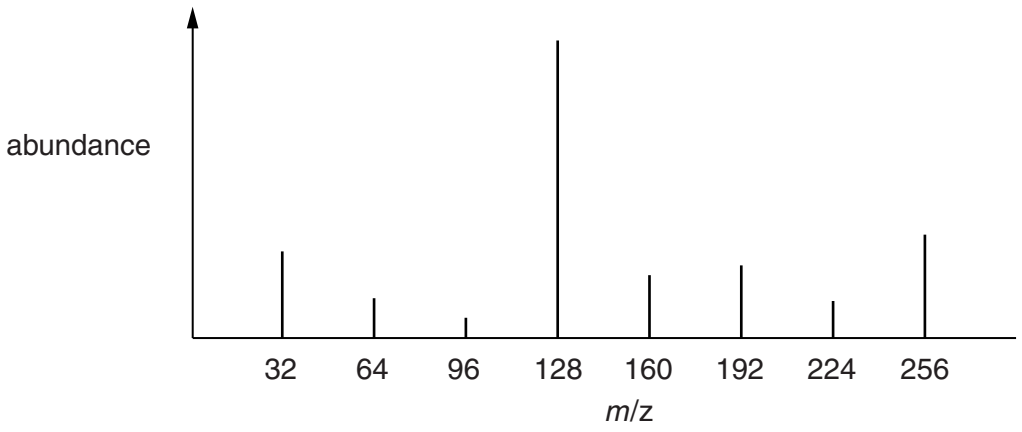
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6 Mass spectrometry and infrared spectroscopy are used in analysis.

(a) The element sulfur exists as molecules, S_n.

The mass spectrum that would be given by a sample of sulfur is shown below.
All the sulfur atoms are the same isotope.



(i) State the *m/z* value of the molecular ion.

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

(ii) Suggest the formula for a molecule of sulfur.

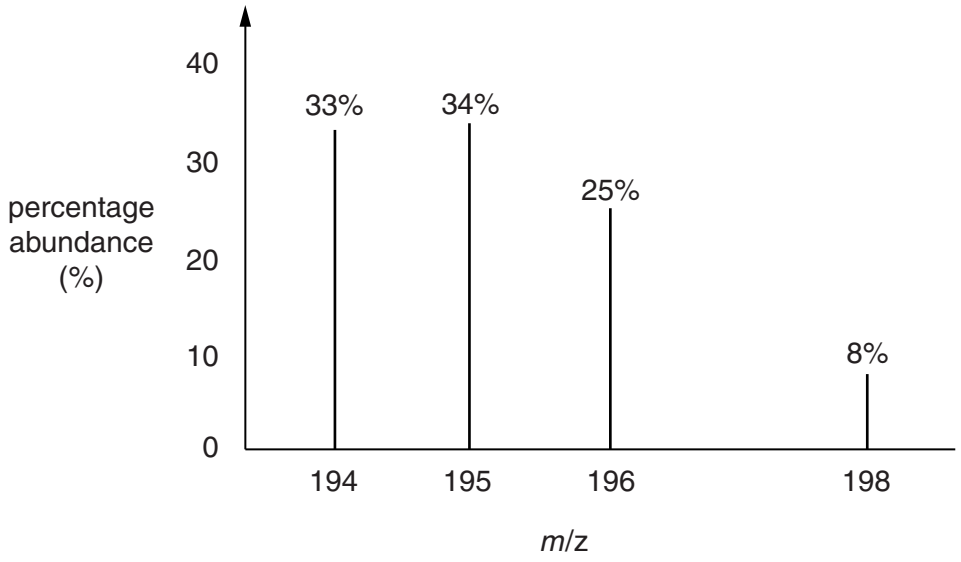
..... **[1]**

(iii) What is the formula for the fragment ion with *m/z* = 128?

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

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(b) A sample of an element, **L** is analysed using mass spectrometry.
The mass spectrum is shown below.



Calculate the relative atomic mass of **L**.
Give your answer to **one** decimal place.

relative atomic mass of **L** = ... **[2]**

(c) Give an everyday use for infrared spectroscopy.

.....

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

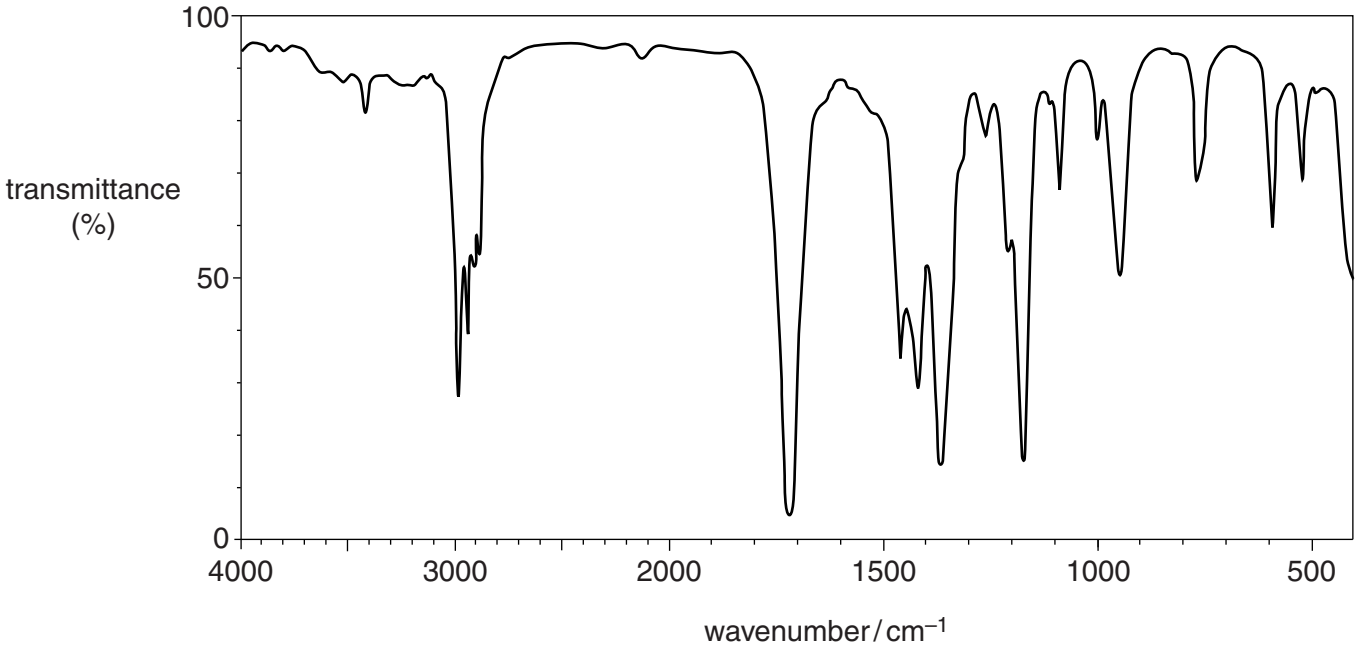
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(d) The solvent, **M**, is an organic compound used in paints. The solvent **M** was analysed.

M has a relative molecular mass of 72.0.

The percentage composition by mass of **M** is C, 66.7%; H, 11.1%; O, 22.2%.

The infrared spectrum of **M** is shown below.



The analysis produces several possible organic structures.

Suggest, with reasons, **two** possible structures for **M**.

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..... **[5]**

[Total: 11]

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7 The list shows the structural formulae of some halogenoalkanes.

N	CF_3CFCl_2	**R**	$CH_3CH_2CHClCH_3$
O	CH_3CH_2Br	**S**	$CH_3CHBrCH_2CHICH_3$
P	$CH_3CH_2CH_2CH_2Br$	**T**	$(CH_3)_3CBr$
Q	$CH_3CH_2CH_2CH_2I$		

(a) Choose from the list above, the **letter** of the halogenoalkane that is extremely unreactive.

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

(b) Halogenoalkanes react with hot KOH(aq) to make alcohols.

(i) Choose from the list above, the **letter** of the halogenoalkane which reacts with hot KOH(aq) to form a diol (a molecule with two OH groups).

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

(ii) Using the curly arrow model, describe the mechanism of the reaction between $CH_3CH_2CH_2CH_2Br$ and hot KOH(aq) to make an alcohol.

Include relevant dipoles and the name of the mechanism.

name of mechanism ..... **[4]**

(iii) Why is the reaction of **P** with hot KOH(aq) slower than the reaction of **Q** with hot KOH(aq)?

.....

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

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(c) Write one equation, using structural formulae, to show how but-2-ene can be converted into one of the listed halogenoalkanes, **N**, **O**, **P**, **Q**, **R**, **S** or **T**.

[2]

(d) CFCs were once used as propellants but have now been replaced by biodegradable alternatives.

State **one** type of a biodegradable alternative.

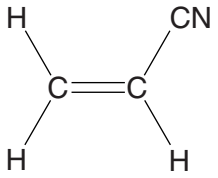
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8 Poly(propenenitrile) is used to make acrylic fibres for clothing.

Poly(propenenitrile) is a polymer manufactured from propenenitrile.



propenenitrile

(a) Draw a section showing **two** repeat units of poly(propenenitrile).

[1]

(b) Explain why this manufacture of poly(propenenitrile) has a 100% atom economy.

.....

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

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(c) Propenenitrile is manufactured from propene as shown in the equation.

$$C_3H_6(g) + NH_3(g) + 1\frac{1}{2}O_2(g) \rightleftharpoons CH_2CHCN(g) + 3H_2O(g) \quad \Delta H = -540\,kJ\,mol^{-1}$$

The conditions used are 450 °C and 2.5 atmospheres in the presence of a catalyst.

Describe and explain, using le Chatelier's principle, the effect on the position of equilibrium of the following changes:

- a temperature above 450 °C
- a pressure above 2.5 atmospheres
- the absence of a catalyst.



In your answer you should link the effects you describe with your explanations.

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..... **[5]**

Question 8 continues on page 22

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(d) A factory is able to make 11.13 kg of propenenitrile from 220 mol of propene.

Calculate the percentage yield of the reaction to form propenenitrile from propene.

percentage yield = ... % **[2]**

(e) The chemical industry uses temperature and catalysts to control the rate of reactions.

Using Boltzmann distribution diagrams, explain the effect on the rate of a reaction of:

- increasing the temperature
- adding a catalyst.

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END OF QUESTION PAPER

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ADDITIONAL ANSWER SPACE

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