(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**.

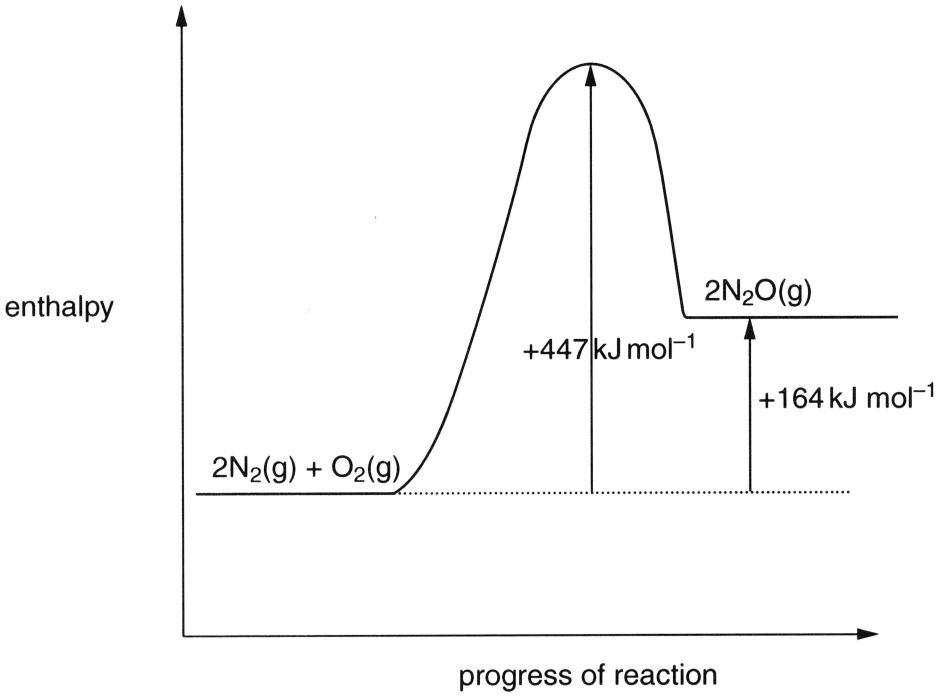


Fig. 5.3

(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]**

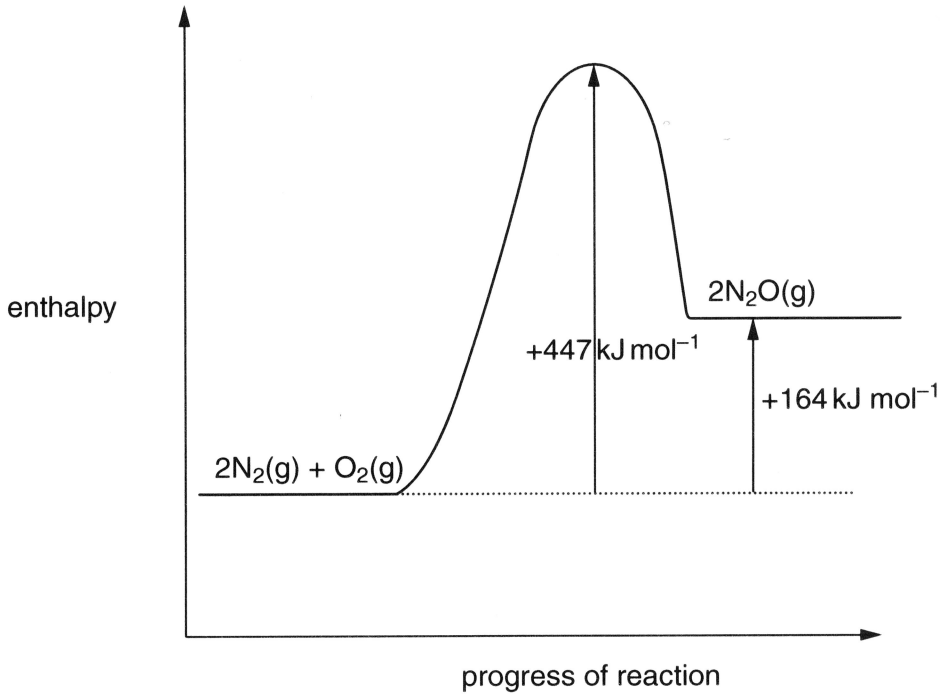


Fig. 5.3 (repeated)

(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.

.....

.....

.....

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

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

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

.....

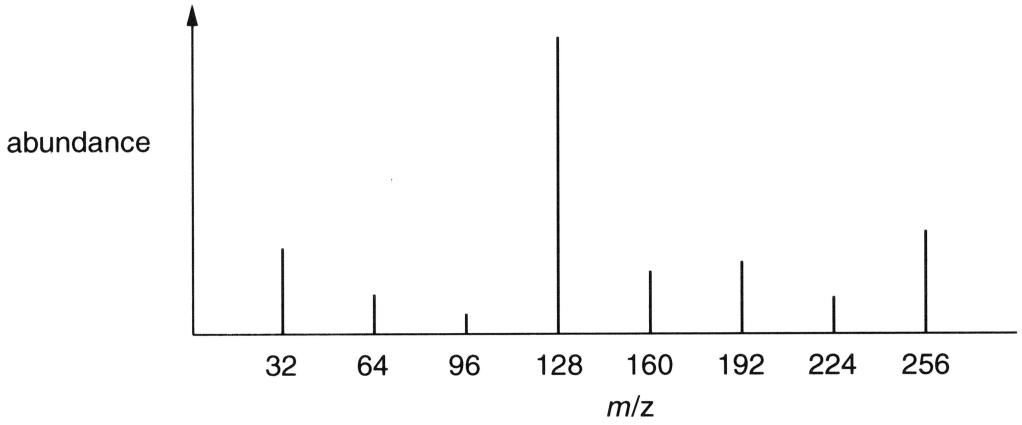
..... **[2]**

[Total: 11]

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.

.....

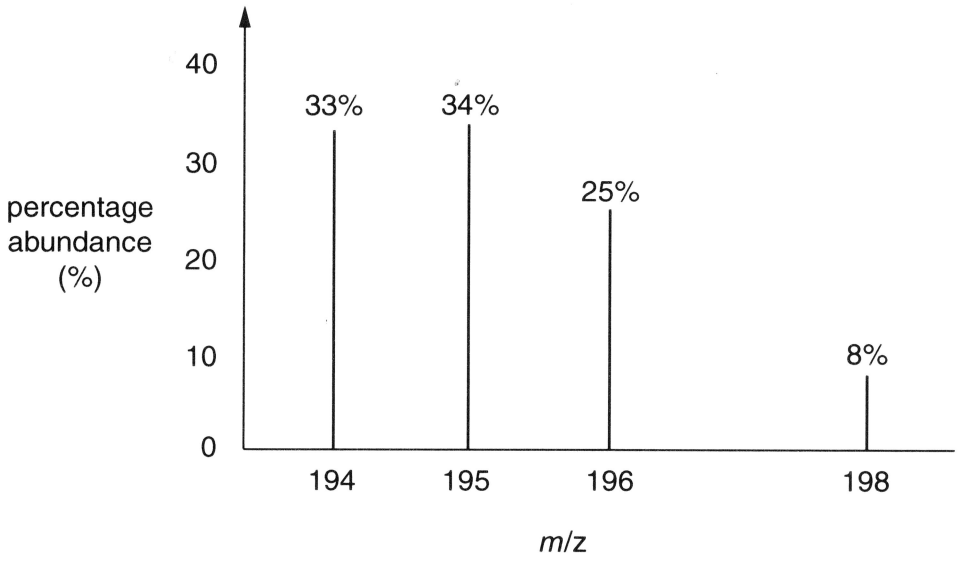
[1]

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

.....

[1]

(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.

.....

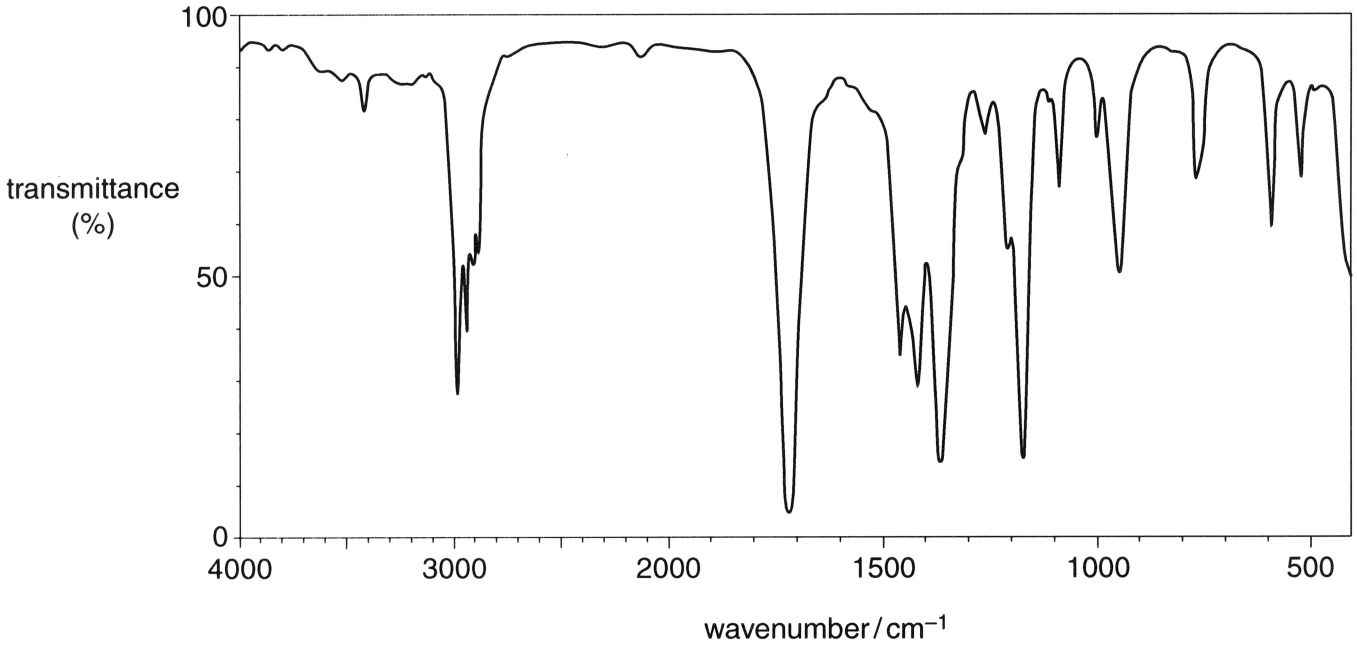
..... **[1]**

(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]

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]**

(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.

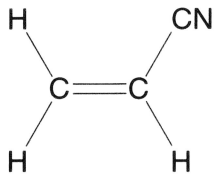
State **one** type of a biodegradable alternative.

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

[Total: 10]

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]**

(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

(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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[Total: 16]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page. The question number(s) must be clearly shown in the margin.