Section A

Answer **all** questions.

1 Use the list of substances to answer the questions.
Each option may be used once, more than once or not at all.

ammonium chloride

barium sulfate

lead (II) fluoride

potassium carbonate

potassium iodide

potassium manganate(VII)

sodium chloride

(a) Which substance reacts with methanoic acid to produce a gas?

…….. [1]

(b) Which substance is used to test for an oxidising agent?

…….. [1]

(c) Which substance, when warmed with aqueous sodium hydroxide, produces a gas that turns moist red litmus blue?

…….. [1]

(d) Which substance reacts with aqueous chlorine to form a brown solution?

…….. [1]

(e) Which substance produces a pale yellow vapour when electricity is passed through its molten state?

…….. [1]

(f) Which **two** salts cannot be prepared by titration method?

…… and ……..…….. [1]

[Total: 6]

2 Crystals of a salt produced was found to have the following composition by mass: 31.5% K, 25.6% Cu and C*l*.

(a) Deduce the empirical formula of the salt crystal formed.

Show your working.

Empirical formula: …….. [3]

(b) **(i)** The ion of an isotope of copper has the formula $^{66}_{29}Cu^{2+}$.

Complete the table with information about this ion.

subatomic particles	number of subatomic particles
protons	
neutrons	
electrons	

[1]

(ii) Describe a chemical reaction that can be carried out to identify $^{66}_{29}Cu^{2+}$.
Include relevant observations in your answer.

……..

……..

…… [2]

[Total: 6]

3 Calcium carbide, CaC_2, is an ionic compound. This compound is commonly used in industries for the manufacture of fertilisers and in steelmaking.

Calcium carbide and carbon monoxide is produced when quicklime, CaO, reacts with carbon at high temperature.

(a) Explain, in terms of structure and bonding, why there is a need to carry out this reaction at a high temperature.

……

……

……

……

…….. [3]

(b) Write a balanced chemical equation, with state symbols, for this reaction.

…….. [2]

(c) Calculate the percentage purity of a sample of quicklime when 8 g of quicklime is reacted with carbon to produce 2400 cm^3 of carbon monoxide at room temperature and pressure.

percentage purity: ……% [3]

[Total:8]

4 Barium hydroxide is placed in a beaker. Ammonium chloride is then added into the beaker and the mixture is stirred.

The equation below shows the reaction between barium hydroxide and ammonium chloride.

$$Ba(OH)_2{\cdot}8H_2O(s) + 2NH_4Cl(s) \rightarrow BaCl_2{\cdot}2H_2O(s) + 2NH_3(g) + 8H_2O(l)$$

Fig. 4.1 shows what happens when the beaker is placed on a wooden block with a small pool of water.

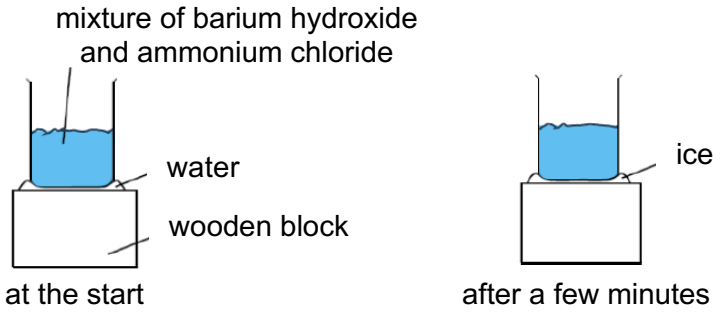


Fig. 4.1

(a) Suggest an explanation for the observations seen after the beaker was placed on the wooden block for a few minutes.

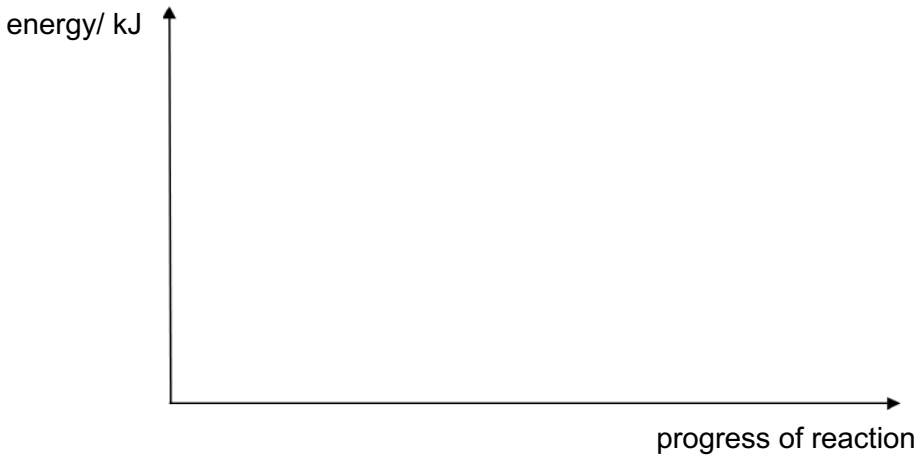
……

……

…… [2]

(b) Draw an energy profile diagram for the reaction.
Your diagram should include:

- the reactants and products of the reaction
- the energy profile and activation energy, E_A, for the reaction
- the enthalpy change of reaction, ΔH .



[3]

[Total: 5]

5 Magnesium chloride can be produced by reacting 1.0 g of magnesium oxide with dilute hydrochloric acid.

$$MgO\ (s) + 2\ HCl\ (aq) \rightarrow MgCl_2\ (aq) + H_2O\ (l)$$

A pH probe data logger is used to measure the pH changes when magnesium oxide is slowly added to 25 cm^3 of 0.1 mol/dm^3 of dilute hydrochloric acid.

Fig. 5.1 shows the results of the changes in pH.

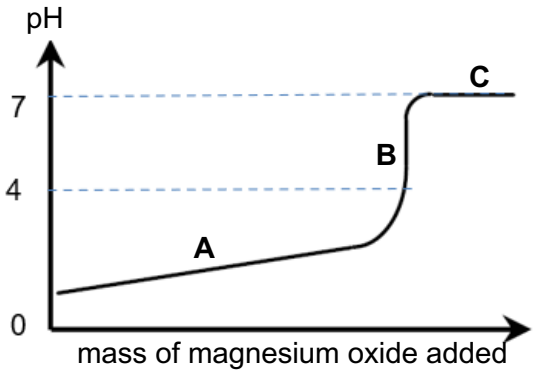


Fig. 5.1

(a) Calculate the maximum mass of magnesium chloride that can be obtained from this experiment. Give your answer to **three** significant figures.

maximum mass: ……g [3]

(b) Explain the shape of the different regions of the graph as magnesium oxide is slowly added till it is in excess.

region **A**……

……

region **B**……

……

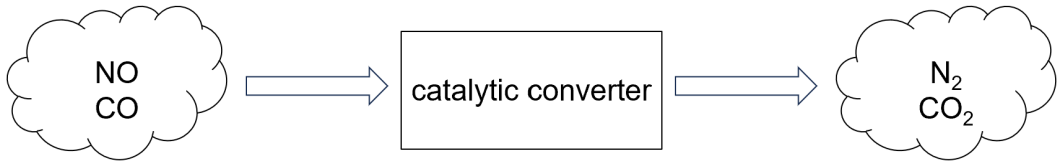
region **C**……

…….. [4]

[Total: 7]

6 Cars have catalytic converters fitted to reduce problems caused by some of the exhaust gases.

The diagram shows some of the gases that enter and leave a catalytic converter.



(a) **(i)** Describe how nitrogen monoxide and carbon monoxide are formed in the engine of a car.

……

……

…… [2]

(ii) Identify a health problem caused by nitrogen monoxide and carbon monoxide respectively.

nitrogen monoxide..……

……

carbon monoxide..……

…… [2]

(b) When catalytic converters were first available, some advertisements claimed they 'solved all car environmental problems'.

Explain why this is **not** true.

……

……

…….. [2]

[Total: 6]

7 Citric acid is a weak acid that is commonly used as a natural food flavouring and in cleaning metal parts.

Fig. 7.1 shows the structure of citric acid.

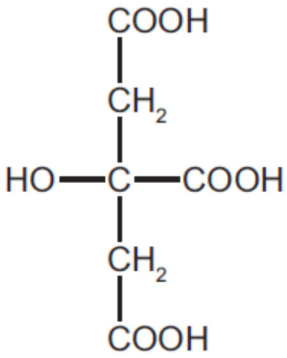


Fig. 7.1

(a) State the number of carboxylic acid functional groups in a citric acid molecule.

…… [1]

(b) Citric acid is effective in removing rust, hydrated iron(III) oxide, from steel parts and is often used in cleaning metal objects.

(i) It was suggested that since citric acid is effective in removing rust, steel parts should be soaked in citric acid to reduce the hassle of cleaning regularly.

Do you agree with the above suggestion? Why?

……..

…… [1]

(ii) The student says that citric acid removes rust faster than sulfuric acid.

Do you agree with the above statement? Why?

……..

……..

……..

…… [2]

(c) It is thought that as calcium citrate is insoluble in water, it can be prepared by reacting citric acid with calcium carbonate.

The mixture is then filtered, and calcium citrate is obtained as the residue.

Comment whether this experimental technique is appropriate to be used to obtain calcium citrate.

Explain your answer.

……

……

…… [2]

[Total: 6]

8 2.00 g samples of different metal carbonates are heated strongly using a bunsen burner until there is no further change in mass.

Table 8.1 shows the mass of solid remaining after heating.

Table 8.1

carbonate	mass after heating/ g
copper(II) carbonate	1.29
magnesium carbonate	0.95
potassium carbonate	
zinc carbonate	1.30

(a) Although the initial mass of each carbonate is the same, the mass of solid remaining after heating is different.

Explain the difference in the loss in mass.

……

……

……

…….. [2]

(b) Predict the mass of the solid obtained after heating potassium carbonate.

Explain your reasoning.

mass of solid after heating: ……..g

……

……

…….. [3]

(c) A pure metal can be extracted by further heating one of the solids remaining at the end of the reaction in Table 8.1 with dry hydrogen gas.

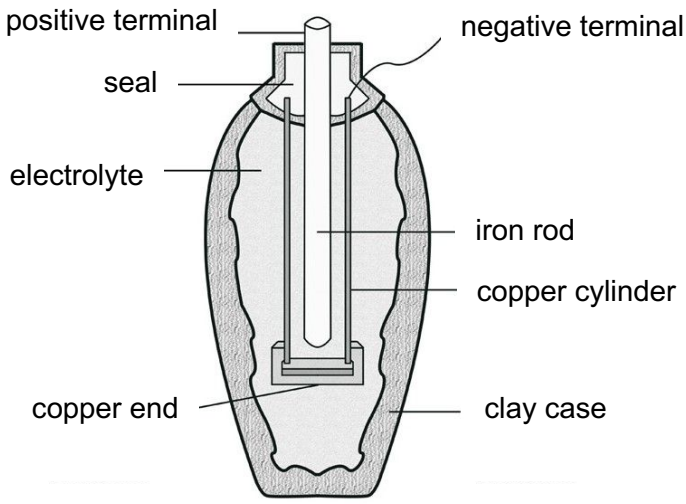
State the metal that can be extracted.

…….. [1]

[Total: 6]

9 The Baghdad battery was first discovered in 1799.

It is a simple cell made of a clay case consisting of an iron rod and a copper cylinder within. It is said to be able to generate electricity when an aqueous electrolyte such as vinegar (ethanoic acid solution) is poured into the case before sealing it.



(a) State the formulae of all the ions present in aqueous ethanoic acid.

…….. [2]

(b) A model of the battery was made and tested in the laboratory. The voltage was measured to be 0.78 V.

(i) Write the half-equation for the reaction at the positive terminal of the battery.

…… [1]

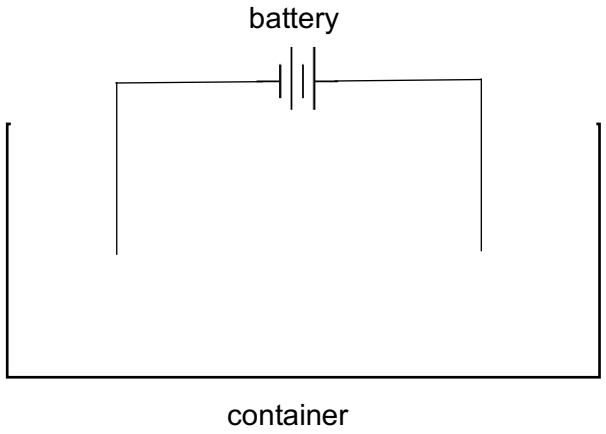
(ii) Suggest **one** change that can be made to the battery to increase the voltage produced.

……..……

……... [1]

(c) Scientists concluded that the battery might be used for electroplating of silver onto metal objects.

(i) Draw a labelled diagram to show the set-up for electroplating silver onto a metal object with aqueous silver nitrate electrolyte. The battery, wires and container have been drawn for you.



[1]

(ii) Describe what happens to each electrode and the electrolyte after the setup has been running for some time.

Positive electrode (anode): ……

Negative electrode (cathode): ……

Electrolyte: …… [2]

(iii) Explain your answer in **(c)(ii)**.

……..……

……..……

……..……

……..……

…… [3]

[Total: 10]

10 Azo compounds are compounds that contain the −N=N− functional group. In the pure form at room temperature and pressure, it is an extremely explosive yellow gas.

Azo compounds are also commonly used as dyes because they have vivid colours like red, yellow and orange. Some of these compounds can also be used as indicators in acid-base titrations.

The simplest azo compound is diazomethane, with the structural formula $H_3C{-}N{=}N{-}CH_3$.

(a) (i) Draw the 'dot-and-cross' diagram to show the bonding in diazomethane.

Show the outer shell electrons only.

[2]

(ii) Using ideas on bonding and structure, explain the electrical conductivity of diazomethane.

……..

……..

…… [2]

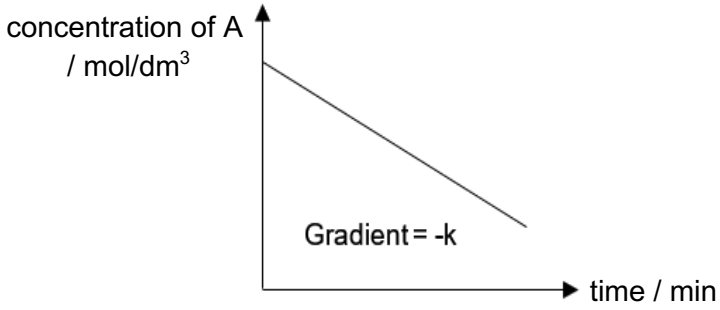
(b) The rate equation and order of reaction

The rate equation for a chemical reaction is a mathematical equation that links the rate of forward reaction with the concentrations or pressures of the reactants and constant parameters.

For many reactions, the rate of reaction is given by **Rate = k[A]^x** ,where k is the rate constant and x is the order of reaction with respect to reactant A and [A] refers to concentration of A.

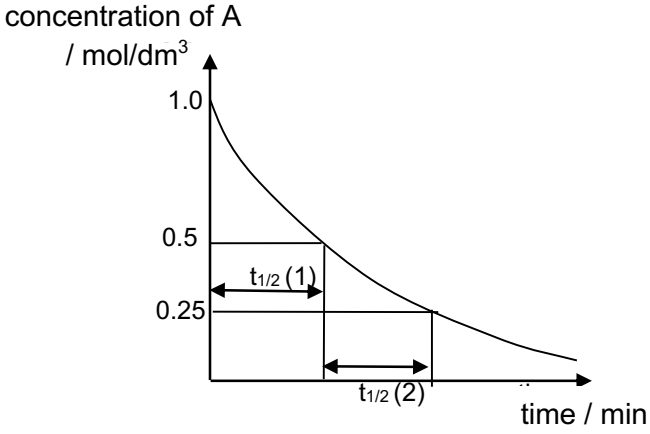
The order of reaction, x, with respect to a reactant can be determined graphically.

0th order reaction



- Rate of reaction is unaffected by concentration of reactants.
- Gradient of concentration against time graph is **constant**.

1st order reaction

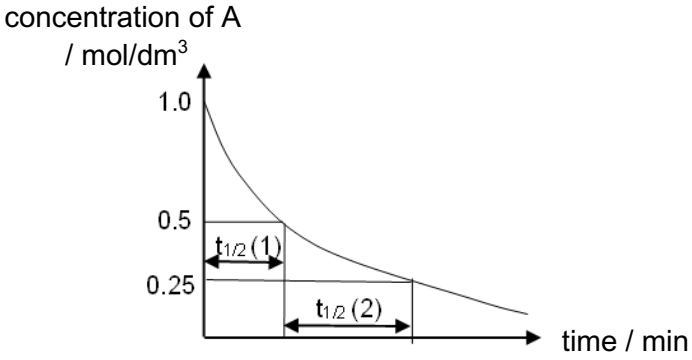


- Rate of reaction decreases as concentration of reactants decreases.
- Gradient of concentration against time graph decreases with time with a **constant half-life**, $t_{1/2}$.

  Half-life ($t_{1/2}$) is defined to be the time taken for the concentration of the reactant to fall to half of its initial concentration.

For example, if the half life is 30s, the reactant will take 30 seconds to go from 1 mol/dm^3 to 0.5 mol/dm^3.

2nd order reaction



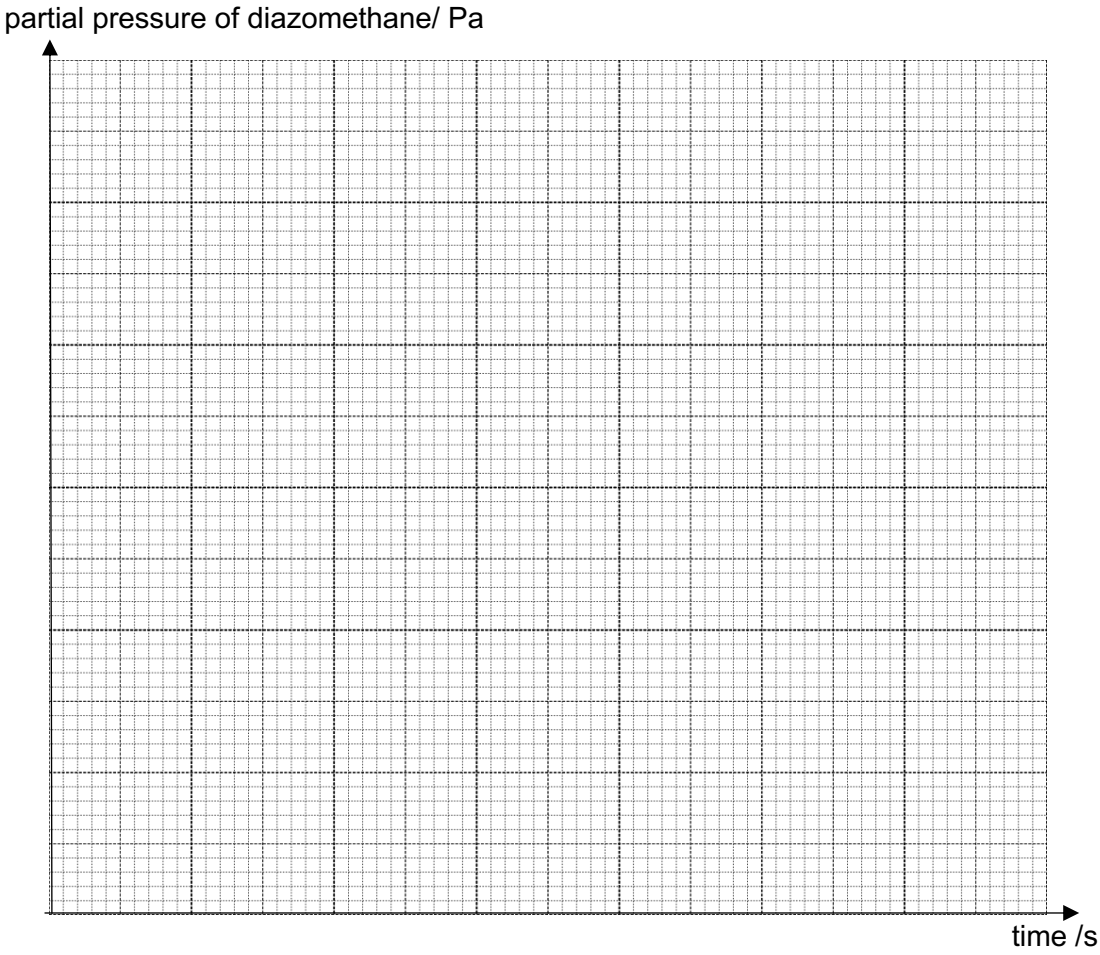
- Rate of reaction decreases sharply as concentration of reactants decreases.
- Gradient of concentration against time graph **decreases sharply with time**.
- Half-life increases significantly as the reaction proceeds.

The rate of decomposition of diazomethane was investigated by monitoring the concentration of diazomethane at various times and the following results were obtained at a fixed temperature is shown in Table 10.1.

Table 10.1

t/s	partial pressure of diazomethane/ Pa
0	10.8
1000	7.4
2000	5.0
3000	3.4
4000	2.4
5000	1.8
6000	1.4

(i) Using the data in Table 10.1, plot on the grid below, the partial pressure of diazomethane against time.



[2]

(ii) Determine the order of the reaction for diazomethane and explain your answer using information from the graph.

……

……

…….. [2]

(iii) Using ideas about collision between particles, explain how the rate of reaction will be affected for the decomposition of diazomethane when initial pressure is increased.

……..……..

……..……..

……..…… [2]

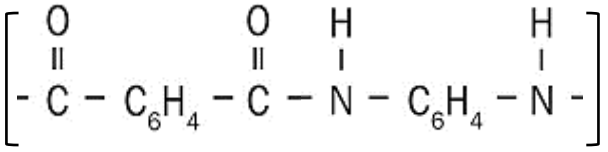
[Total: 10]

Section B

Answer **one** question from this section.

11 Kevlar is a type of synthetic fibre. It can be used to make bulletproof vests, army helmets and 'puncture-proof' tyres.

The structural formula of the polymer is shown below.



(a) (i) Draw the structures of the two monomers that react to form Kevlar.

monomer 1

monomer 2

[2]

(ii) During the manufacturing process, the chain length of Kevlar is controlled so that the Kevlar polymer molecules have an average relative molecular mass in the range of 12000 to 20000.

What is the range of the average number of repeating units in the Kevlar molecules?

Show your working.

[2]

range between ……. and ……

(b) Nylon is another type of synthetic fibre. It is commonly used to make fishing nets instead of natural fibre such as cotton.

Suggest **one** advantage and **one** disadvantage of using synthetic fibre rather than natural fibre to make fishing nets.

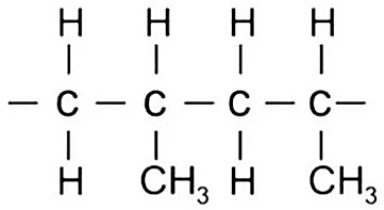
advantage……..…..

……

disadvantage……....

…….. [2]

(c) The diagram shows the partial structure of another polymer **M**.



(i) Name the monomer used to form polymer **M.**

…… [1]

(ii) Identify **three** differences in the formation of polymer **M** from that of the formation of Kevlar.

……..

……..

……..

……..

……..

……... [3]

[Total: 10]

12 **(a)** Bioethanol is a form of renewable energy made from common crops such as corn, sugarcane and potato. It is considered as a fuel which do not increase the amount of carbon dioxide in the atmosphere.

(i) Why is bioethanol considered a form of renewable energy?

……..

……. [1]

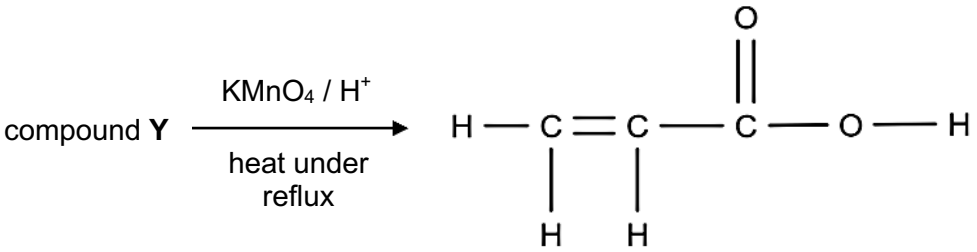
(ii) Explain why bioethanol is considered as a fuel which does not increase the amount of carbon dioxide in the atmosphere.

……..

……..

……. [2]

(b) Organic compound **Y** was heated under reflux with acidified potassium manganate(VII) solution to form compound **Z**. The reaction is shown below.



compound **Z**

(i) Name the reaction above.

……. [1]

(ii) Draw the full structural formula of compound **Y**.

[1]

(iii) A few drops of liquid bromine were added to compound **Z**.

Describe and explain the observation seen.

……...

……...

……. [2]

(iv) On warming compound **Z** with ethanol and a few drops of concentrated sulfuric acid, a sweet-smelling substance was formed.

Draw the full structural formula of the compound formed.

Circle the functional group that gave the compound the sweet smell.

[2]

(v) Under suitable conditions, compound **Z** undergoes addition polymerisation.

Draw the structural formula of the polymer formed, showing three repeating units.

[1]

[Total: 10]

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium –	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57–71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$