BEATTY SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY FOUR EXPRESS

CANDIDATE NAME			
CLASS		REGISTER NUMBER	

CHEMISTRY

6092/02

Paper 2
Setter: Mdm Stella Soh

16 August 2024
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 22.

The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
A	70
B….	10
Total	80

Section A

Answer **all** questions in this section in the spaces provided.

A1 The formulae of some elements and compounds are listed.

I_2

$ZnCl_2$

$BaCl_2$

PbO

KI

$CuCO_3$

$PbBr_2$

SO_2

Answer the following questions using elements or compounds from the list. You may use each element or compound once, more than once or not at all.

(a) Which substance can react with both an acid and an alkali?

…… [1]

(b) Which substance in aqueous form reacts with aqueous chlorine to form a brown solution with black crystals?

…… [1]

(c) Which substance has a mass of 8.00 g for every 0.125 mol?

…… [1]

(d) Which substance can be prepared by precipitation?

…… [1]

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

…… [1]

[Total: 5]

A2 Chlorine exists as two isotopes, chlorine-35 and chlorine-37.

(a) In a sample of 100 chlorine atoms, there are 76 atoms of chlorine-35 and 24 atoms of chlorine-37.

Find the average relative atomic mass of this chlorine sample.

average relative atomic mass = …… [1]

(b) An element T is found in period 3 of the Periodic Table. It reacts with chlorine to form a chloride with a formula T_2Cl_2, which has a melting point of −80°C and a boiling point of 137°C.

(i) Use ideas about bonding and structure to explain why T_2Cl_2 is a liquid at room temperature and pressure.

……

……

…… [2]

(ii) Draw a 'dot and cross' diagram to show the arrangement of the outer shell electrons in T_2Cl_2.

[2]

[Total: 5]

A3 Sodium chlorate(V), $NaClO_3$, is used in some aircrafts as a source of emergency oxygen when there is a drop in cabin pressure. The catalyst, iron powder, is mixed with sodium chlorate(V) and can be ignited by a charge, which is activated by pulling on the emergency mask.

Some information on sodium chlorate(V) is shown.

	$NaClO_3$
melting point/°C	248
boiling point/°C	--

(a) Sodium chlorate(V) decomposes as shown.

$$2NaClO_3\ (s) \rightarrow 2NaCl\ (s) + 3O_2\ (g)$$

(i) What does (V) in sodium chlorate(V) indicate?

……. [1]

(ii) The decomposition of sodium chlorate(V) is a redox reaction.

Use oxidation states to show that this statement is true.

……

……

……

……. [2]

(iii) After the catalytic decomposition of sodium chlorate(V), the catalyst, iron is mixed with the sodium chloride product. Describe how sodium chloride salt can be separated, if all the sodium chlorate(V) has fully decomposed.

……

……. [1]

(b) Suggest why there is no data for the boiling point in the table for sodium chlorate(V).

……. [1]

(c) If 5.00g of impure sodium(V) chlorate can decompose to form 450 cm^3 of oxygen gas, calculate the percentage purity of sodium(V) chlorate in the sample.

[3]

[Total: 8]

A4 Methane, methanol and hydrogen have been investigated as possible alternative fuels for motor vehicles that currently use petrol. The table below compares the energy released on combustion of these fuels.

The enthalpy change of combustion of a substance, ΔH, is defined as the energy released when one mole of the substance is completely burnt in oxygen.

Table 4.1

fuel	density/g/dm^3	ΔH/ kJ/mol
petrol	710 - 770	–
methane	0.667	–891
methanol	792	–726
hydrogen	0.0884	–286

(a) Suggest a reason why no value is quoted for the enthalpy change of combustion of petrol in Table 4.1.

……

…… [1]

(b) Methane and methanol undergo complete combustion to give the same products.

(i) Write a chemical equation for the combustion of methane.

…… [1]

(ii) Explain why the enthalpy change of combustion of methane is more negative than the enthalpy change of combustion of methanol.

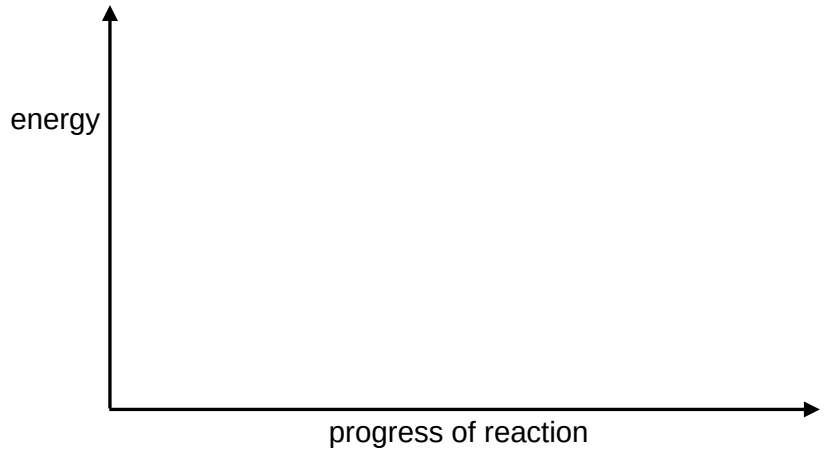
……

……

……

…… [2]

(iii) Draw the energy profile diagram for the reaction in **(b)(i)**. Label on the diagram the activation energy and the enthalpy change.



[3]

(c) Although the combustion of hydrogen releases less energy as compared to methane per mole, many people believed that hydrogen is a better alternative fuel compared to methane, in terms of environment impact. Suggest why is this so.

……

……

…… [2]

(d) One alternative fuel technology involves the conversion of liquid methanol into hydrogen gas as shown by the chemical equations below. The hydrogen obtained can then be used as a fuel.

Step 1: CH_3OH (l) $\rightarrow$ CH_3OH (g)

Step 2: CH_3OH (g) $\rightarrow$ $2H_2$ (g) + CO (g)

Suggest why this alternative fuel technology to produce hydrogen is sometimes said to have a harmful effect.

……..……..……..

……..……...……..

……...…… [1]

[Total: 10]

A5 To investigate the rate of reaction between magnesium and an excess of dilute hydrochloric acid, Amy set up an experiment as shown in Fig. 5.1.

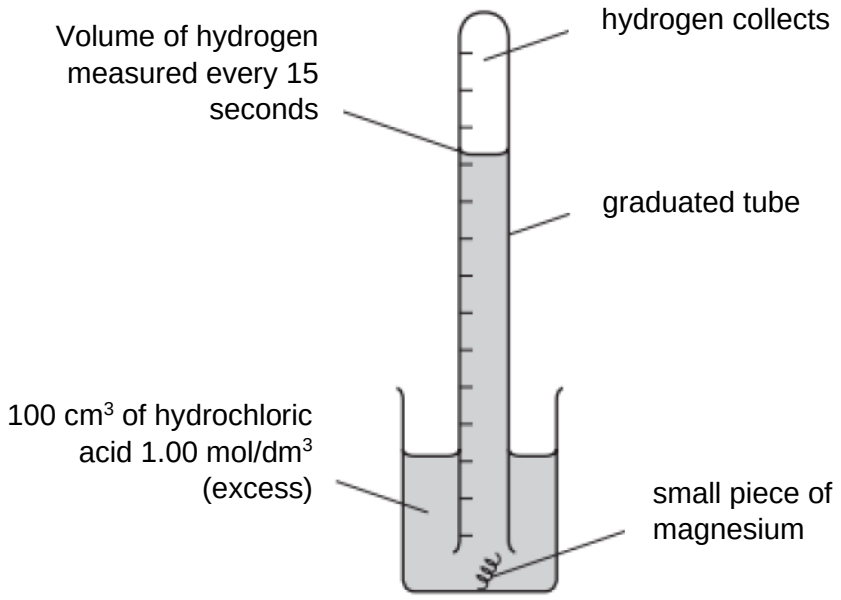


Fig. 5.1

(a) Explain why Amy added dilute hydrochloric acid in excess.

……

…….. [1]

(b) Explain, in terms of collisions and energy, how the rate of reaction would be affected if the concentration and the temperature of the acid is increased in Fig 5.1.

……

……

……

……

…… [3]

(c) During the experiment, the small piece of magnesium kept rising to the surface. Suggest a reason why the small piece of magnesium kept floating to the surface.

……

…… [1]

(d) To prevent the piece of magnesium from rising to the surface. Amy decided to attach the piece of magnesium to another substance. To determine if the choice of the substance affects the rate of reaction, she conducted the experiment twice, once with copper and the other time with plastic. The results from the two experiments are shown in Fig. 5.2.

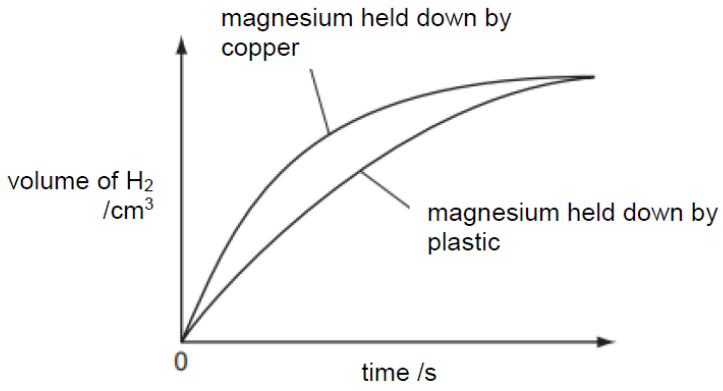


Fig. 5.2

(i) Iron, zinc and copper have similar densities.

Stanley said that copper is a better choice than iron or zinc to weigh down the magnesium. Do you agree with him? Explain your answer.

……

…… [1]

(ii) With reference to Fig. 5.2, which experiment shows a faster rate of reaction? Suggest a reason for your answer.

……

……

…… [1]

(iii) Describe how the shape of the graph will change if ethanoic acid is used instead.

……

……

…… [1]

[Total: 8]

A6 Fig. 6.1 shows the electrolysis of concentrated aqueous potassium chloride while Fig. 6.2 shows the simple cell used in the electrolysis. A few drops of Universal Indicator were added to the concentrated aqueous potassium chloride before the start of the experiment.

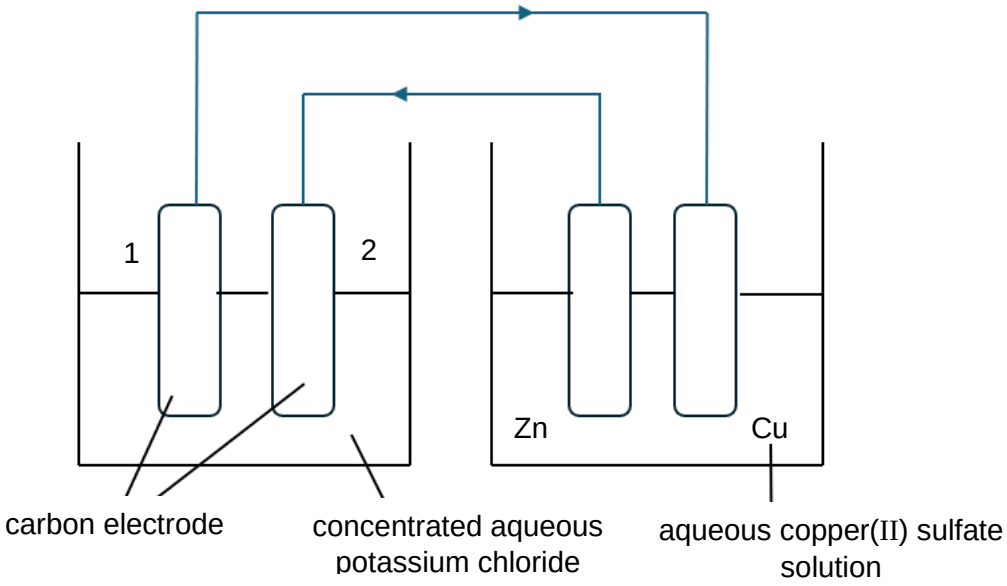


Fig. 6.1

Fig. 6.2

(a) State and explain if electrode 2 is the anode or cathode.
Write the half-equation for the reaction that occurs at this electrode.

……

……

……

…… [2]

(b) Describe the observations at electrode 1.

……

…… [1]

(c) State and explain the observations made on the electrolyte in Fig. 6.1 as the experiment proceeds.

……

……

…… [2]

(d) The electrolyte used in Fig. 6.2 is aqueous copper(II) sulfate.
Write the half-equation for the reaction at the copper metal.

…… [1]

(e) Suggest a way to increase the voltage of the simple cell.

……

…….. [1]

(f) If the position of the zinc and copper electrodes in Fig. 6.2 were switched with each other, what would be observed instead at the electrode 1 and 2 in Fig. 6.1?

……..

……..

……..…. [1]

[Total: 8]

A7 Most vehicles operated using the petrol engine where the air: fuel ratio in the engine plays an important role to determine the relative levels of emission of different air pollutants as shown in Fig. 7.1.

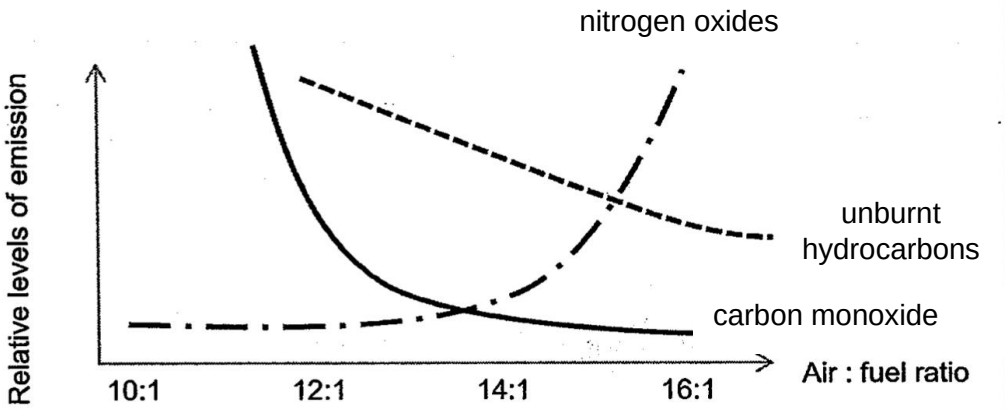


Fig. 7.1

(a) Use the information from Fig. 7.1, explain why the trends of emission of unburnt hydrocarbon and carbon monoxide follow the same general trend.

……

……

……

…… [2]

(b) Explain why the level of oxides of nitrogen oxides increases when the air : fuel ratio is greater than 14 : 1.

……

……

…… [2]

(c) An engineer suggests that air : fuel ratio of 13.8 : 1 is the optimum condition for the engine to produce the least amount of pollutants. Explain why this statement is not true.

……

……

…… [1]

(d) Catalytic converter installed in cars reduce the amounts of carbon monoxide and nitrogen oxides from cars.

(i) Write an equation to show how a catalytic converter reduces the amount of carbon monoxides and nitrogen oxides from cars.

…… [1]

(ii) A statement reads, “Catalytic converters do not solve all environmental problems.”
Based on the equation in **(d)(i)** and Fig. 7.1, explain why this is true.

……

……. [1]

[Total: 7]

A8 **(a)** Ammonium iodide, NH_4I, is a white solid which decomposes when heated.

$$NH_4I\ (s) \rightarrow NH_3(g) + HI(g)$$

Describe how you would know when all the ammonium iodide has decomposed.

……

……. [1]

(b) Aqueous ammonium iodide reacts with three halogens, fluorine, chlorine and bromine, but not with astatine.

(i) Write a general equation to show the reaction of ammonium iodide with a halogen. Use X_2 as the symbol of the halogen.

……. [1]

(ii) Explain why aqueous ammonium iodide will have no reaction with astatine.

……

……. [1]

(c) Ammonium iodide is able to conduct electricity in aqueous state but not in the solid state.

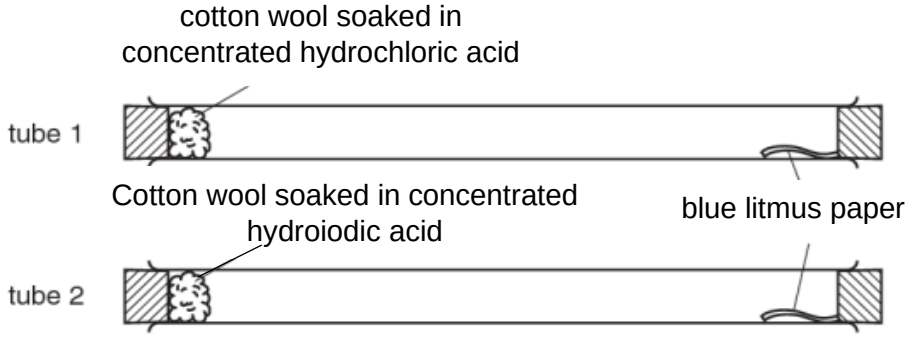
Explain this observation.

……

……

……. [2]

(d) Two students set up an experiment to investigate the rate of diffusion of gases.



Concentrated hydrochloric acid produces fumes of hydrogen chloride, HC*l*.

Concentrated hydroiodic acid produces fumes of hydrogen iodide. HI.

The students made the following observations and conclusions:

Observations

- Four minutes after setting up the experiment, the litmus paper in tube 1 turns red.
- Twelve minutes after setting up the experiment, the litmus paper in tube 2 turns red.

Conclusion

'The rate of diffusion is inversely proportional to the relative molecular mass of each gas.'

Do the observations support this conclusion? Explain your reasoning.

……..……..……..……...

……..……..……..……...

……..……..……..……...

……..……..……..…… [2]

[Total: 7]

A9 Plastics

Plastics are commonly made up of polymers. The properties of plastic polymers depend on the monomers they are made up from, and all plastic polymers have their own characteristic physical properties, depending on their specific molecular structure.

Homopolymer

A homopolymer is a polymer that consists of only one kind of monomer which repeats regularly to construct the polymer chain.

Poly(ethene) is a type of homopolymer which is made from the polymerisation of ethene and is usually represented as a simple addition polymerisation reaction which produces a linear chain of carbon and hydrogen atoms as shown in Fig. 9.1.

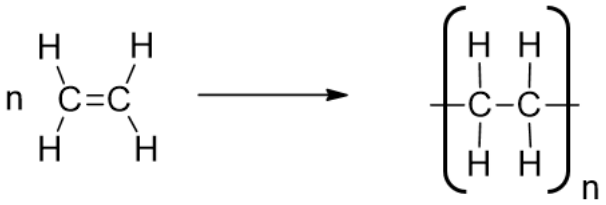


Fig. 9.1

Different processes can be used to manufacture several types of poly(ethene), each with a different structure. Fig. 9.2 shows the structure of two types of poly(ethene).

low-density poly(ethene) (LDPE) **high-density poly(ethene) (HDPE)**

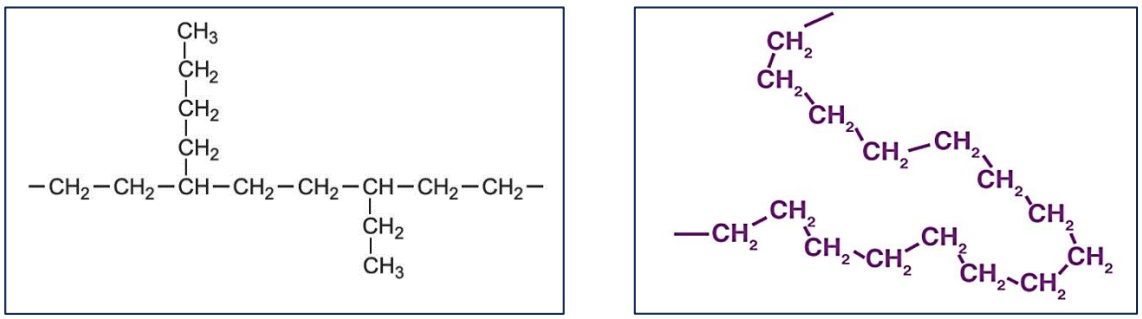


Fig. 9.2

Co-polymer

A co-polymer is a polymer that is formed from two (or more) different types of monomer.

Poly(ethylene terephthalate) is an example of co-polymer formed by condensation polymerisation of ethylene glycol and terephthalic acid. Fig. 9.3 show the structure of a repeat unit of poly(ethylene terephthalate).

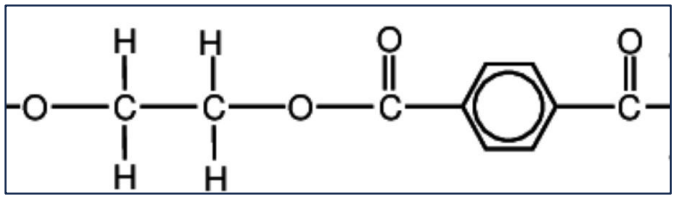


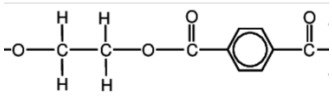
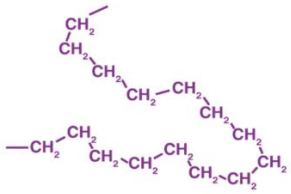
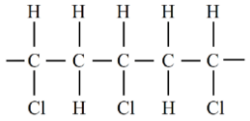
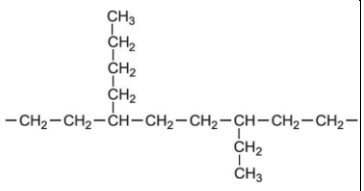
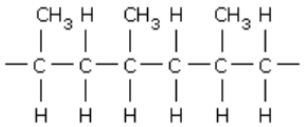
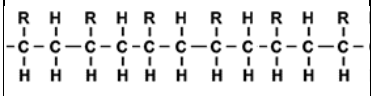
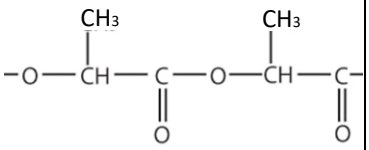
Fig.9.3

Plastic Recycling

Plastic recycling is the processing of plastic waste into new and useful products. To ensure the quality and value of the recycled plastic, plastics of different polymer types have to be sorted out before they can be recycled. The Resin Identification Code (RIC) was introduced so that plastic item can be labelled for easier sorting.

Plastics usually consist of polymer chains of varying lengths. Table 9.1 shows the names of the polymers that fall under the seven different RIC, the general range of molar masses of the different plastics and their percentages of plastic waste generated.

Table 9.1

RIC	polymer name	chemical structure	molar mass / (g/mol)	% of plastic waste generated
1 PETE	poly(ethylene terephthalate)		8000 – 31 000	18.8
2 HDPE	high density poly(ethene)		100 000 – 250 000	19.8
3 V	poly(vinyl chloride)		50 000 – 120 000	5.3
4 LDPE	low density poly(ethene)		100 000 – 250 000	13.9
5 PP	poly(propene)		75 000 – 700 000	19.1
6 PS	poly(styrene)	 R:represents a hydrocarbon	100 000 – 400 000	5.9
7 OTHER	other plastics, such as polycarbonate, polyamides	 Eg: Poly(lactic acid)	—	17.2

Two commonly used methods of plastic recycling are mechanical recycling and chemical depolymerisation.

Mechanical recycling is a physical method that melts plastics of the same polymer before making them into small pellets to be used again, while chemical depolymerisation is a chemical method that uses either heat or chemical reactions to convert the polymers back into its monomers.

Since each polymer has its unique chemical properties, the method of recycling is based on the RIC. Mechanical recycling is mostly used to recycle plastics with RIC 1,2, 4 and 5 whereas depolymerisation is mostly used to recycle plastics with RIC 1 and 7.

(a) (i) State one similarity and one difference between the structures of LDPE and HDPE

……..…….……

……..…….……

……. [2]

(a) (ii) Explain how and why HDPE has a different density from LDPE.

……..…….……

……..…….……

……...[2]

(b) (i) Draw the repeat unit of poly(lactic acid).

[1]

(ii) Hence classify if poly(lactic acid) is a homopolymer or a co-polymer.

……..…….……

……..…….……. [1]

(c) The shortest chain of poly(styrene) consists of 962 repeating units. Elemental analysis of poly(styrene) found that the polymer contains 92.3% of carbon and 7.7% of hydrogen by mass.

Calculate and deduce the formula of **R** in poly(styrene) in Table 9.1.

formula of **R** in poly(styrene) …… [3]

(d) Some people think that "mechanical recycling can only recycle homopolymers while depolymerisation can only recycles co-polymers."

Explain why this information is incorrect.

……

……

…… [1]

(e) **(i)** Suggest a possible reason why RIC 3-PVC is not recycled using mechanical recycling or chemical depolymerisation.

……

…… [1]

(ii) Since RIC 3-PVC is not commonly recycled. Suggest a reason why its percentage of plastic waste generated is still low.

……

……

…… [1]

[Total: 12]

Section B

Answer **one** question in this section.

B10 **(a)** A student investigated the strength of sulfuric acid and hexanesulfonic acid.

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

$$C_6H_{13}SO_3H \rightarrow H^+ + C_6H_{13}SO_3^-$$

The student is given 0.1 mol/dm^3 of aqueous sulfuric acid and 0.2 mol/dm^3 of aqueous hexanesulfonic acid.

(i) Describe how the student could prove that both acids are also strong acids.

……

……

…… [2]

(ii) Explain why the student was given two different concentrations for this investigation.

……

…… [1]

(b) Methylamine, CH_2NH_2, is a weak alkali, with properties like aqueous ammonia.

$$CH_3NH_2 + H_2O \leftrightharpoons CH_3NH_3^+ + OH^-$$

Methylamine can neutralise acids, such as hydrochloric acid, to form methylammonium chloride as shown in the equation below.

$$CH_3NH_2 + HCl \rightarrow CH_3NH_3Cl$$

(i) Write a chemical equation for the reaction between methylamine and sulfuric acid.

…… [1]

(ii) Predict what will be observed when aqueous methylamine is added to aqueous iron(II) sulfate and then left to stand in air.

……

……

…… [2]

(c) Methylamine is a member of the amine homologous series and some information about the first 4 amines is shown in Table 10.1.

Table 10.1

name	molecular formula	boiling point /°C
methylamine	CH_3NH_2	−6.3
ethylamine	$CH_3CH_2NH_2$	16.6
propylamine	$CH_3CH_2CH_2NH_2$	48.6
butylamine	$CH_3CH_2CH_2CH_2NH_2$	

(i) Deduce the general formula of the amine homologous series.

……. [1]

(ii) Predict the boiling point of butylamine.

……. [1]

(iii) Propylamine can react with nitrous acid to form propanol. Propanol can be further reacted with ethanoic acid in the presence of warm concentrated sulfuric acid to form a sweet-smelling liquid.

Write the chemical equation for the reaction between propanol and ethanoic acid.

……. [1]

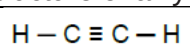
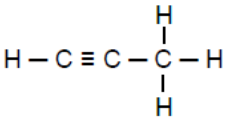
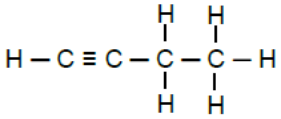
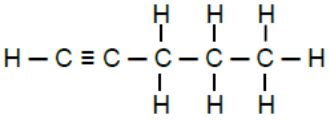
(iv) Draw the full structural formula of this sweet-smelling liquid as mentioned in **(c)(iii)**.

[1]

[Total: 10]

B11 **(a)** Alkynes are a homologous series of organic compounds.
Table 11.1 shows the names and structures of the first four members of alkynes.

Table 11.1

n	name of alkyne	structure of alkyne
2	ethyne	
3	propyne	
4	butyne	
5	pentyne	

(i) Use the information in Table 11.1 and deduce the general formula and functional group of alkynes.

general formula …….. [1]

functional group ……..

…… [1]

(ii) Explain why alkynes undergo addition reactions similar to alkenes. [2]

……..…….

…… [1]

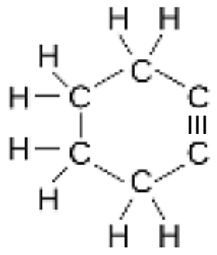
(iii) Predict and draw the structural formula of the product formed by the reaction between butyne and aqueous bromine. Predict the possible observation from the reaction.

structural formula of product

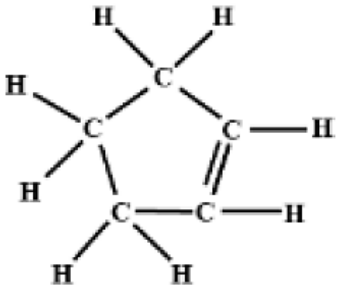
observation …….

…… [2]

(iv) The structure of two organic compounds (**X** and **Y**) are shown below.



compound **X**



compound **Y**

A statement from the internet states that "compound **X** and compound **Y** are isomers of pentyne".

Do you agree with the statement? Explain your answer.

……

……

……

…… [2]

(b) Ethanoic acid is a compound from another homologous series. Ethanoic acid is added to an alloy that consists of magnesium and copper.

(i) Write an equation to show how ethanoic acid reacts with the alloy.

…… [1]

(ii) Describe how pure copper can be obtained from the alloy by using ethanoic acid.

……

……

…… [2]

[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		Key proton (atomic) number atomic symbol name relative atomic mass									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 –		114 Fl flerovium –		116 Lv livermorium –		

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 –