Name: ……………………………….(   )

ASSUMPTION ENGLISH SCHOOL
PRELIMINARY EXAMINATION 2024

CHEMISTRY
6092 / 02

LEVEL: Sec 4 Express **DATE:** 21 August 2024

CLASS: Sec 4/1 **DURATION:** 1 hour 45 minutes

Additional Materials Provided: -NIL-

INSTRUCTIONS TO CANDIDATES
Do not open this booklet until you are told to do so.

Write your NAME and INDEX NUMBER at the top of this page. This paper consists of 2 sections.

SECTION A
STRUCTURED QUESTIONS (70 marks)
Answer **ALL** questions.
Write your answers in the spaces provided.

SECTION B
FREE RESPONSE QUESTIONS (10 marks)
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.

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

A copy of the Periodic Table is provided on **Page 25**.

For Examiner's use:	
Paper 1	**/ 40**
Paper 2 Section A	**/ 70**
Paper 2 Section B	**/ 10**
Paper 3	**/ 40**
Total	**/ 160**
Total (%)	**/ 100**

This Question Paper consists of 25 printed pages including this page.
[Turn over

SECTION A: STRUCTURED QUESTIONS [70 marks]

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

1 A list of substances is shown below.

potassium iodide	silicon dioxide	copper(II) oxide	iron(III) chloride
graphite	lead(II) oxide	zinc bromide	aluminium

Choose from the list of substances to answer the questions below.

Each substance can be used once, more than once, or not at all.

(a) Which compound has a giant covalent structure?

……. [1]

(b) Which substance reacts with both acids and alkalis?

……. [1]

(c) Which ionic compound has a formula of XY_2?

……. [1]

(d) Which substance forms a yellow precipitate when added with aqueous silver nitrate?

……. [1]

(e) Which substance turns from black to red brown when heated with hydrogen gas?

……. [1]

[Total: 5]

2 Aqueous hydrogen peroxide, H_2O_2, is commonly used in the sterilisation of contact lenses due to its effective antimicrobial properties. It decomposes at room temperature to form water and oxygen.

(a) Write a balanced chemical equation for the decomposition of hydrogen peroxide.

……. [1]

(b) Draw a 'dot-and-cross' diagram for hydrogen peroxide, H_2O_2.
Show outer electrons only.

[2]

(c) Aqueous hydrogen peroxide decomposes faster when it is warmed and kept at a temperature of 50°C.

Use ideas about collisions between particles to explain why.

…….

…….

…….

……. [2]

(d) A disproportionation reaction is one in which an element is both oxidised and reduced in the same reaction.

Using ideas about oxidation states, state and explain if the decomposition of hydrogen peroxide is a disproportionation reaction.

…….

…….

…….

……. [2]

[Total: 7]

3 Group 1 of the periodic table consists of the alkali metals.

Table 3.1 shows some information about the atomic radii and ionic radii of the first four metals in Group 1.

Table 3.1

element	atomic radius / pm	ionic radius / pm
lithium (Li)	152	68
sodium (Na)	185	98
potassium (K)	227	133
rubidium (Rb)	244	148

[1 pm = 10^{-12} m]

(a) State **one** physical property unique to Group 1 metals.

……. [1]

(b) Using the data provided in **Table 3.1**, explain why the reactivity of Group 1 metals increases going down the group.

…….

…….

…….

……. [2]

(c) Suggest a reason for the difference in radius of a lithium atom when it forms a lithium ion.

…….

……. [1]

(d) A piece of sodium metal was dropped in a trough of water and the following observations were noted.

element	observations
sodium (Na)	Reacts very quickly with water. It skids around the surface of the water and a yellow flame is seen.

(i) Suggest a reason for the underlined observation.

……

…… [1]

(ii) Describe how the observations will differ when a piece of potassium is dropped in the same trough of water. Explain your answer.

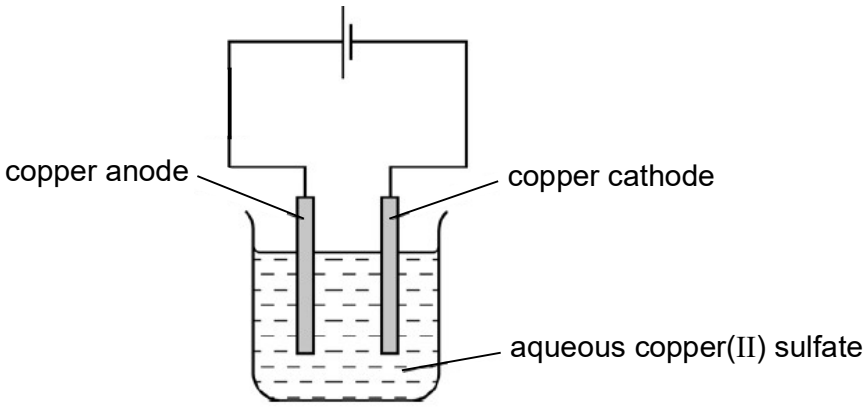
……

……

…… [2]

[Total: 7]

4 The electrolysis of aqueous copper(II) sulfate using copper electrodes is shown in the set-up below.



The table shows some information about the conduct of the experiment.

current used/ A	time taken/ s	mass of cathode	
		before starting / g	after electrolysis / g
4.0	360	1.24	1.52

(a) Describe **two** differences in electrical conductivity between copper and copper(II) sulfate.

……

……

……

…… [2]

(b) **(i)** Explain, with the aid of a half equation, why the mass of the cathode increased.

……..

……..

…….. [2]

(ii) The anode had a mass of 1.20 g at the start.

Determine the mass of the anode after electrolysis.

mass of anode = …… g [1]

(c) In a second experiment, graphite electrodes were used instead of copper electrodes in the same set-up and electrolyte.

(i) Write an ionic equation, including state symbols, for the reaction that happen at the anode.

……... [1]

(ii) Describe one similarity observed at the electrode(s) used in both experiments.

……...

……... [1]

(iii) State and explain the colour observed when a few drops of Universal Indicator were added to the electrolyte at the end of the electrolysis.

……..

……..

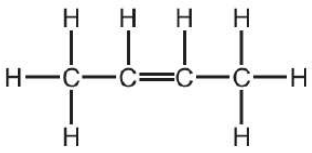
……..

……... [2]

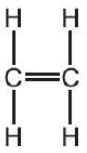
[Total: 9]

5 The diagrams show the structure of six organic compounds.

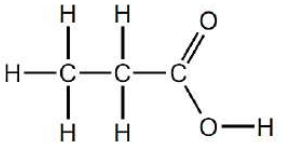
A



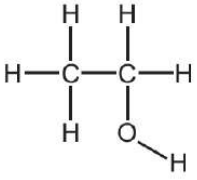
B



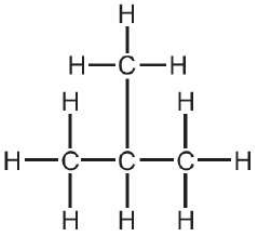
C



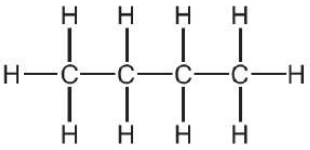
D



E



F



(a) Define the term *isomer*. Use your definition to show which of the above compounds are isomers of each other.

……

……

……

…… [2]

(b) Compound **D** can be manufactured using one of the other compounds.

(i) State which is the other compound and the reagent and conditions required for the reaction.

compound ……

reagent and conditions ……

…… [2]

(ii) A bottle of compound **D** was left unstoppered for a week.

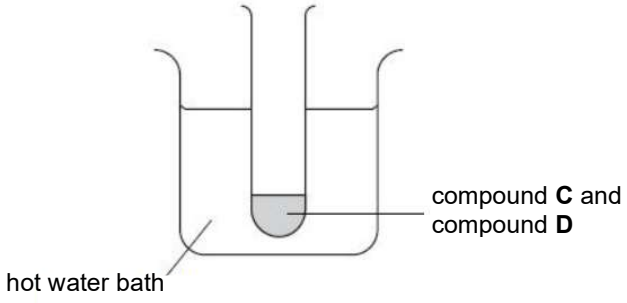
Describe a test to determine if compound **D** has been oxidised and include the observation seen.

……

……

…… [2]

(c) An ester can be prepared in the laboratory by heating compound **C** with compound **D** in the set-up shown below.



(i) Name the ester formed and draw its full structural formula.

name: ……..

structural formula:

[2]

(ii) A mixture of the ester and water was formed in the test-tube after the reaction was completed.

Suggest a method to recover the ester from the mixture, explaining your answer.

……

……

…… [2]

[Total: 10]

6 Paracetamol is a widely used over-the-counter medication for pain relief and fever reduction. It works by inhibiting the production of certain chemicals in the brain that cause pain and fever.

(a) The percentage by mass of the elements in paracetamol is given in the table below.

element	percentage by mass
carbon	63.6
hydrogen	5.9
nitrogen	9.3
oxygen	21.2

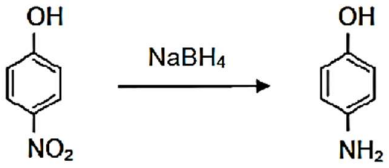
Show, by calculation, that the empirical formula of paracetamol is $C_8H_9NO_2$.

[3]

(b) Paracetamol can be synthesised in the laboratory via a three-step process.

Step 1: phenol $\xrightarrow[NaNO_3]{\text{dilute } H_2SO_4}$ 2-nitrophenol + 4-nitrophenol

Step 2:



4-nitrophenol ($C_6H_5NO_3$) 4-aminophenol (C_6H_7NO)

Step 3: $C_6H_7NO + C_4H_6O_3 \rightarrow C_8H_9NO_2 + C_2H_4O_2$

4-aminophenol paracetamol ethanoic acid

(i) Suggest a reason why the final yield of paracetamol in Step 3 is less than 50%.

……..

…….. [1]

(ii) State whether $NaBH_4$ is acting as an oxidising agent or reducing agent in Step 2. Explain your reasoning.

……..

……..

…….. [2]

(iii) One paracetamol tablet contains 0.5 g of the active ingredient paracetamol.

Calculate the mass of 4-aminophenol required in Step 3 to synthesise 10 paracetamol tablets.

mass of 4-aminophenol required = …… g [3]

(iv) Describe how the purity of the paracetamol can be tested.

……..

…….. [1]

(c) After synthesis, paracetamol is a solid while ethanoic acid is a liquid.

Explain in terms of bonding, the difference in physical states between paracetamol and ethanoic acid.

…….

…….

…….

…….

……. [2]

[Total: 12]

7 A simplified carbon cycle is shown in Fig. 7.1.

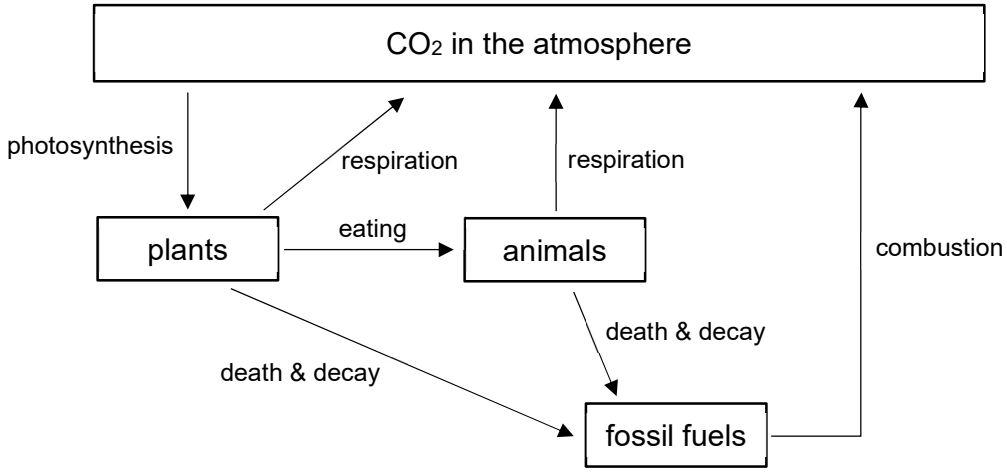


Fig. 7.1

(a) **(i)** Write equations for the processes that occur during photosynthesis and respiration.

photosynthesis: ……

respiration: …… [2]

(ii) Hence, explain how these natural processes help to regulate the amount of carbon dioxide in the atmosphere.

……

…… [1]

(b) State a reason why the amount of carbon dioxide in our atmosphere is increasing and explain how it leads to global warming.

……

……

……

……

…… [2]

(c) Biofuels are renewable energy sources derived from plant and animal matter. They are considered a more sustainable alternative to fossil fuels.

Biofuels such as biodiesels can be mixed with petroleum diesel (e.g. B20) to make a fuel for cars. Fig. 7.2 compares the relative amounts of waste products released when 3 different types of diesel fuel are burnt in a car engine.

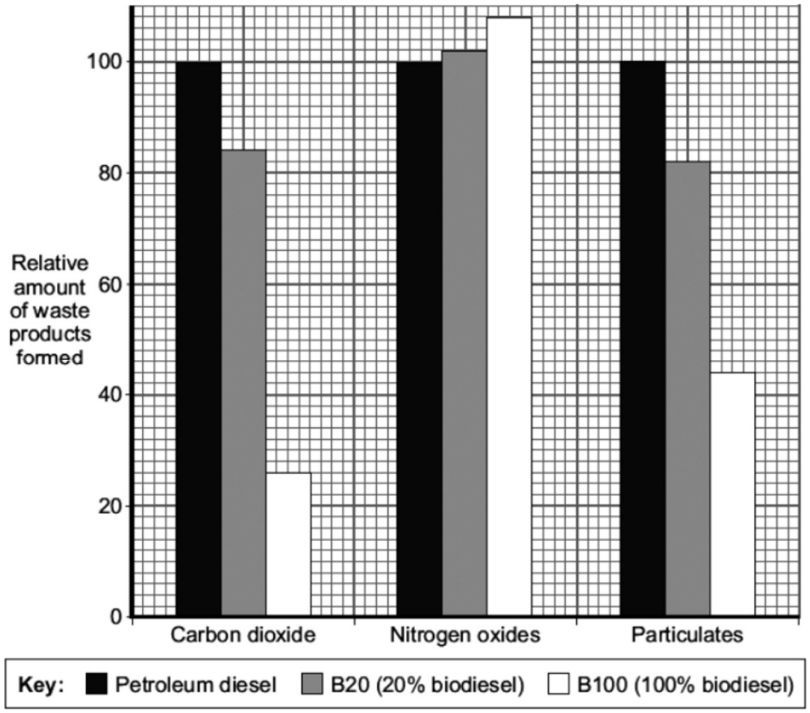


Fig. 7.2

(i) State the percentage reduction in particulates when B20 is used instead of petroleum diesel.

…… [1]

(ii) A carbon neutral fuel does not add extra carbon dioxide to the atmosphere.

Some people think that biodiesels like B100 is a carbon neutral fuel. Use the data in **Fig. 7.2** and your knowledge to explain why this is incorrect.

……

……

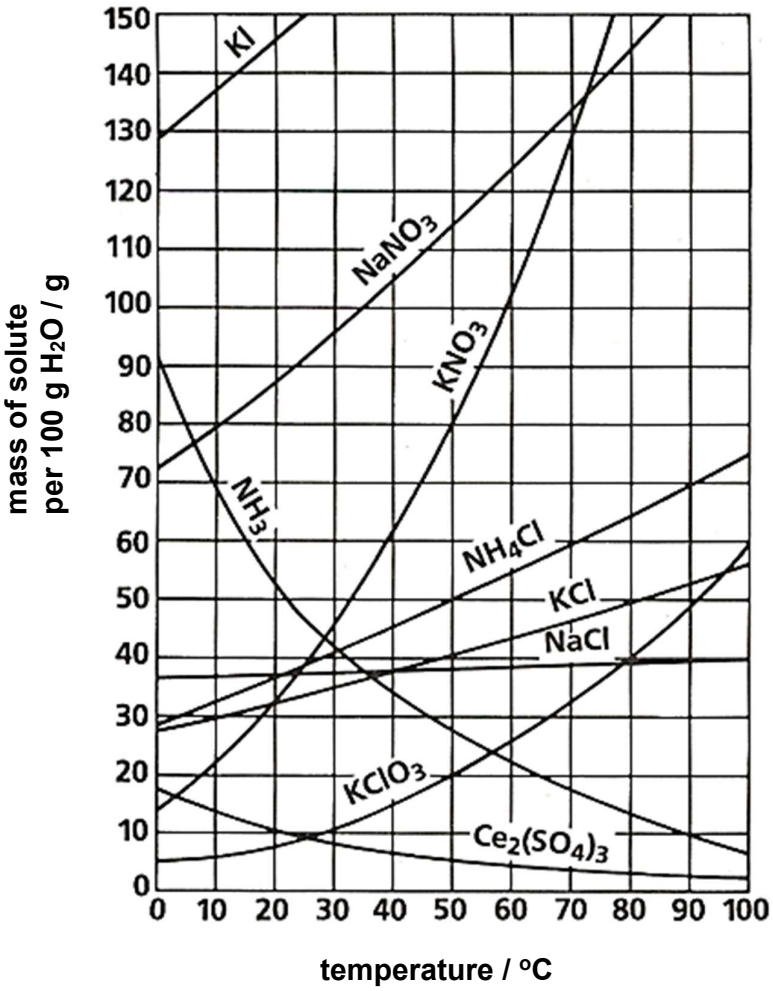
…… [2]

[Total: 8]

8 Solubility of Ionic Compounds and Temperature

The solubility of a compound is the maximum number of grams of a compound that can be dissolved in a given quantity of solvent at a given temperature. It is often measured in terms of grams of solute per 100 grams of solvent. Both the solvent and temperature are stated as solubility is specific to a particular solvent and varies with temperature.

The relationship between solubility and temperature can be expressed using a solubility curve. Fig 8.1 shows the solubility curves of some compounds, with water as the solvent.



Source: Solubility Chart, Sasketchewan Schools

Fig. 8.1

Solubility and Solute-Solvent Interactions

Besides temperature, the solubility of an ionic compound is also largely dependent on the solute-solvent interactions and the enthalpy change, ΔH, that results from a compound dissolving in solution to form hydrated ions.

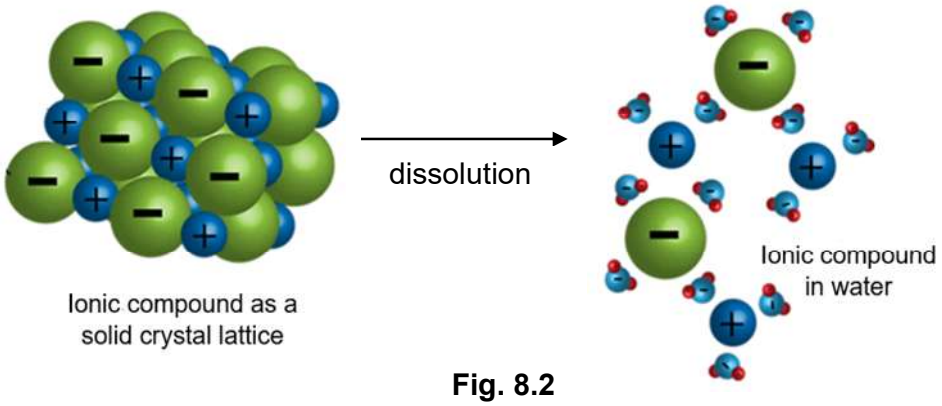


Fig. 8.2

The enthalpy change associated with the dissolution of a compound in a solvent is known as the enthalpy of solution. It can be represented by the following equation:

$$\Delta H^{\theta}_{solution} = \Delta H^{\theta}_{lattice} + \Delta H^{\theta}_{hydration}$$

where $\Delta H^{\theta}_{solution}$ is enthalpy of solution,
$\Delta H^{\theta}_{lattice}$ is the lattice enthalpy of the ionic compound, and
$\Delta H^{\theta}_{hydration}$ is the enthalpy of hydration of the ions.

In the dissolution of an ionic compound, the lattice enthalpy is defined as the enthalpy change when one mole of ionic compound dissociates into its constituent ions from its solid crystal lattice. Consequently, the enthalpy of hydration is the change in enthalpy when one mole of ions undergoes hydration. This occurs when water molecules surround the constituent ions and separate the ions from each other.

The sum of the lattice enthalpy and total enthalpy of hydration of ions will determine the overall enthalpy of solution and hence the solubility of the compound. Generally, a compound is soluble in a solvent when it has a negative enthalpy of solution and insoluble in a solvent when it has a positive enthalpy of solution.

Table 8.1 provides information about the lattice enthalpies of some Group 2 sulfate salts, along with their corresponding enthalpies of hydration of their metal cation, M^{2+} and sulfate anion, SO_4^{2-}.

Table 8.1

Group 2 Sulfate	**Lattice enthalpy/ kJ mol^{-1}**	**Enthalpy of hydration/ kJ mol^{-1}**	
		M^{2+} cation	SO_4^{2-} anion
$MgSO_4$	+2874	-1920	-995
$SrSO_4$	+2484	-1480	
$BaSO_4$	+2374	-1360	

(a) Describe the trends in solubility of the compounds shown in **Fig. 8.1**.

……

……

……

……

…… [2]

(b) With reference to the solubility curves, state the compound which is **least soluble** at 70°C.

…… [1]

(c) 200 g of a saturated solution of potassium nitrate, KNO_3, at 50°C was evaporated to dryness.

Calculate the mass of potassium nitrate that would remain after evaporation.

mass of potassium nitrate = …… g [1]

(d) Suggest a reason why the solubility curves do not go beyond 100°C.

……

…… [1]

(e) Explain why the lattice enthalpy of ionic compounds is positive.

……

…… [1]

(f) **(i)** Using the data provided in **Table 8.1**, calculate enthalpies of solution of $MgSO_4$ and $SrSO_4$.

enthalpy of solution of $MgSO_4$ = …… kJ/ mol

enthalpy of solution of $SrSO_4$ = …… kJ/ mol [2]

(ii) Hence, state and explain the solubility of $MgSO_4$ in water.

……...

……...

……...

……... [2]

(iii) Hence, describe how a sample of strontium sulfate, $SrSO_4$, can be prepared from strontium carbonate.

……...

……...

……...

……... [2]

[Total: 12]

SECTION B: FREE RESPONSE QUESTIONS [10 marks]
Answer **one** question in the spaces provided.

9 Poly(propene) and polyethylene terephthalate (PET) are two of the most commonly used plastics due to their versatility, durability, and lightweight nature.

Poly(propene) is an addition polymer while PET is a condensation polymer.

(a) Describe **two differences** between addition polymers and condensation polymers.

……

……

……

……

……

…… [2]

(b) The uses of poly(propene) range from plastic parts for machinery to fibres and textiles. Fig. 9.1 shows the structure of poly(propene).

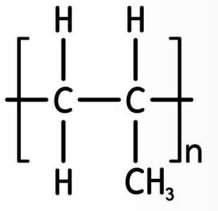


Fig. 9.1

(i) Draw the structure of the monomer that forms poly(propene).

[1]

(ii) A sample of poly(propene) contains molecules with an average relative molecular mass of 231 000.

Calculate the number of carbon atoms present in an average molecule of the polymer.

number of carbon atoms = …….. [2]

(iii) State what you would observe when a few drops of aqueous bromine is added to a sample of poly(propene).

……..

…….. [1]

(c) Unlike poly(propene), polyethylene terephthalate, PET, is widely used in the manufacturing of food packaging and beverages, such as in carbonated soft drinks and water bottles. The structure of PET is shown in Fig. 9.2.

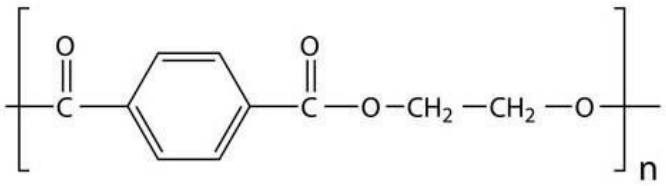


Fig. 9.2

(i) Due to its versatile properties, PET is the most recycled plastic in the world. One method of recycling PET is by the chemical process of depolymerisation.

Describe what is *depolymerisation*.

……..

…….. [1]

(ii) Draw the structural formulae of the **two** products formed after the depolymerisation of PET.

monomer 1

monomer 2

[2]

(iii) Suggest one possible challenge in the chemical recycling of PET.

……..

…….. [1]

[Total: 10]

10 Nylon is a synthetic polymer that has a wide range of applications due to its strength, elasticity, and resistance to abrasion and chemicals.

(a) One type of nylon is nylon-5,10. It is synthesised by reacting the two monomers shown in Fig. 10.1 in a polymerisation reaction.

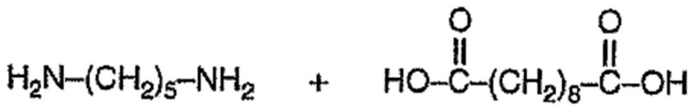


Fig. 10.1

(i) Is nylon-5,10 an addition polymer or a condensation polymer? Explain your answer.

……..

……..

…….. [2]

(ii) Draw the repeating unit of nylon-5,10.

[1]

(b) Another type of nylon is nylon-6,6. The repeating unit of nylon-6,6 is shown in Fig. 10.2.

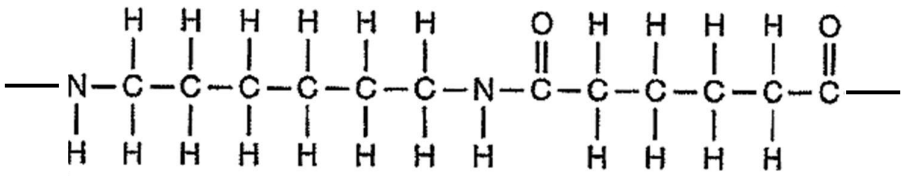


Fig. 10.2

(i) State **one difference** between the structures of the repeating units of nylon-6,6 and nylon-5,10.

……..

…….. [1]

(ii) Draw the structures of the two monomers that react to form nylon-6,6.

monomer 1

monomer 2

[2]

(iii) During the manufacturing process, the chain length of nylon is controlled so that nylon-6,6 polymer molecules will have an average relative molecular mass in the range of 12 000 to 24 000.

What is the range of the average number of repeating units in one nylon-6,6 polymer molecule?

Show your working. You are to round the average number of repeating units to the nearest whole number.

[2]

(iv) Plastics such as nylon-5,10 and nylon-6,6 are non-biodegradable.

Describe two pollution problems caused by non-biodegradable plastics.

……..

……..

……..

…….. [2]

[Total: 10]

– End of Paper –

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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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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