YUAN CHING SECONDARY SCHOOL

Secondary Four Express Course
Preliminary Examination 2024

CANDIDATE NAME			
CLASS		INDEX NUMBER	

CHEMISTRY

6092/02

Paper 2

23 Aug 2024

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Section A (70 marks)
Answer **all** questions.
Write your answers in the spaces provided.

Section B (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.
A copy of the Periodic Table can be found on Page **26**.

The use of a scientific calculator is expected, where appropriate.

For Examiner's Use		
Section A		
Section B	11:	12:
Total	/ 80	

This paper consists of **26** printed pages.

Section A [70 marks]

Answer **all** the questions in this section.
Write your answers in the spaces provided on the question paper.

1 Choose from the following compounds in Fig. 1.1 to answer the questions.

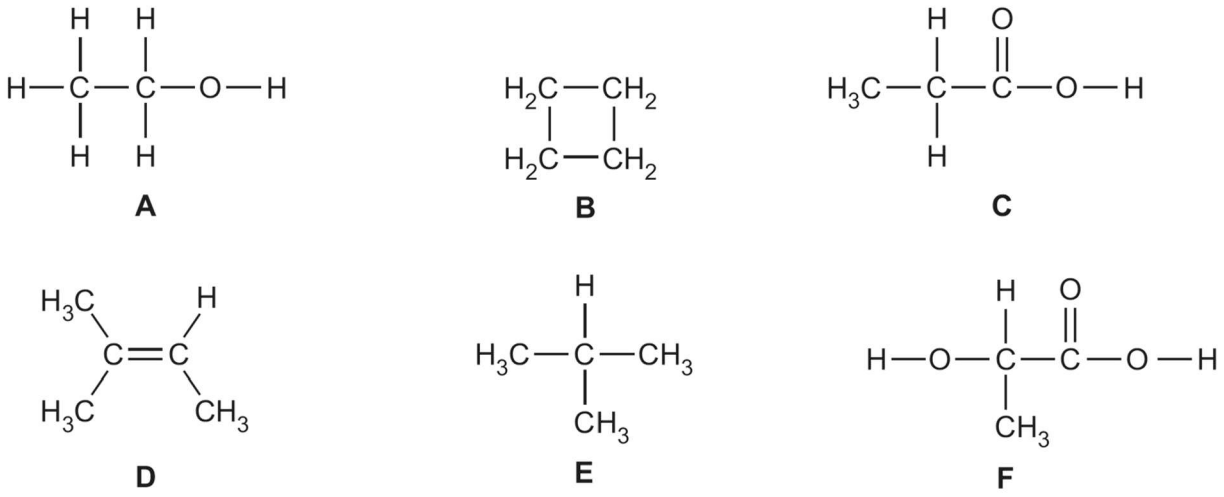


Fig. 1.1

Each compound, **A**, **B**, **C**, **D**, **E** and **F** may be used once, more than once or not at all.

State which compound:

(a) has a molecule with only 11 atoms

.....

[1]

(b) is oxidised to form ethanoic acid

.....

[1]

(c) is an isomer of butene

.....

[1]

(d) reacts with hydrogen in the presence of a catalyst to make an alkane

.....

[1]

[Total: 4]

2 An experiment in Fig. 2.1 was set up for measuring the rates of diffusion of gases. The time taken for 100 cm^3 of some gases at room temperature and pressure to diffuse from this apparatus are shown in the Table 2.1.

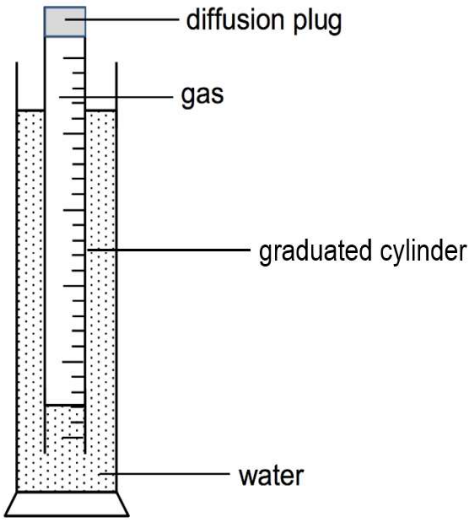


Fig. 2.1

Table 2.1

gas tested	time /s
carbon monoxide, CO	132
chlorine, Cl_2	211
methane, CH_4	100
nitrogen, N_2	?
oxygen	141

(a) Name and explain the gas that diffused fastest.

.....

..... [1]

(b) Explain in terms of kinetic particle theory why the temperature must be kept constant in this experiment.

.....

..... [2]

(c) Suggest the time that 100 cm^3 of nitrogen would take to diffuse out of the apparatus.

.....

..... [1]

(d) Explain why this apparatus is unsuitable for finding the rate of diffusion for ammonia gas.

.....

..... [1]

[Total: 5]

3 Table 3.1 shows results of different tests conducted to compare the properties of two dibasic acid, sulfuric acid and tartaric acid, of the same concentration.

Table 3.1

acid	X	Y
Universal Indicator	red	orange
volume of gas collected 10 s after reacting with magnesium	14 cm^3	6 cm^3
volume of sodium hydroxide required for complete neutralisation of 25.0 cm^3 of acid	22.00 cm^3	22.00 cm^3

(a) Use information from Table 3.1 to explain which is the weak acid.

.....

.....

.....

.....

..... [3]

(b) The reaction of acid Y with aqueous sodium hydroxide can be represented by the equation below, where the anion of the acid is given the symbol A.

$$H_2A\ (aq) + 2NaOH\ (aq) \rightarrow Na_2A\ (aq) + 2H_2O\ (l)$$

Calculate the concentration of acid Y in mol/dm^3, if 0.100 mol/dm^3 of sodium hydroxide is used.

[3]

[Total: 6]

4 The halogens are a group in the Periodic Table consisting of six reactive elements.

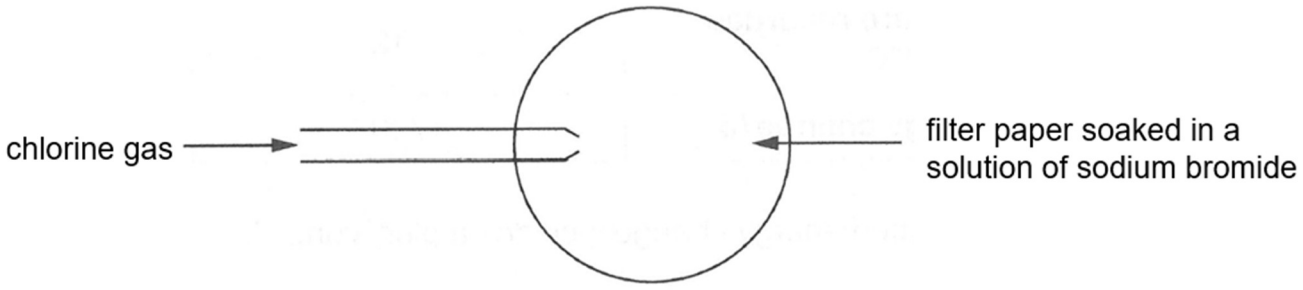
(a) Complete Table 4.1 to show the colour and state of chlorine, bromine and iodine at room temperature and pressure.

Table 4.1

halogen	colour and state at room temperature and pressure
chlorine	
bromine	
iodine	

[2]

(b) A jet of chlorine gas is aimed at a filter paper soaked in a solution of sodium bromide.



The solution on the filter paper quickly turns brown.

(i) Explain why the solution turns brown.

.....

..... [1]

(ii) The experiment is repeated twice.

- A jet of iodine gas is aimed at a filter paper soaked in a solution of sodium bromide.
- A jet of bromine gas is aimed at a filter paper soaked in a solution of sodium iodide.

State and explain what you would expect to see in each experiment.

.....

.....

.....

.....

..... [3]

(c) Chlorine is an oxidising element.

Explain, in terms of electrons, why chlorine is described as an oxidising element.

.....

..... [1]

[Total: 7]

5 The graph in Fig. 5.1 shows the volume of gas produced with time for some experiments of a metal, **M** with hydrochloric acid. In all experiments, **M** forms an ion with a 2+ charge. The mass of **M** used in each experiment is 0.195 g.

Only one of the experiments has an exact stoichiometric ratio of the reactants (i.e. there is no excess of either reactant), while the rest of the experiments have an excess of metal **M**.

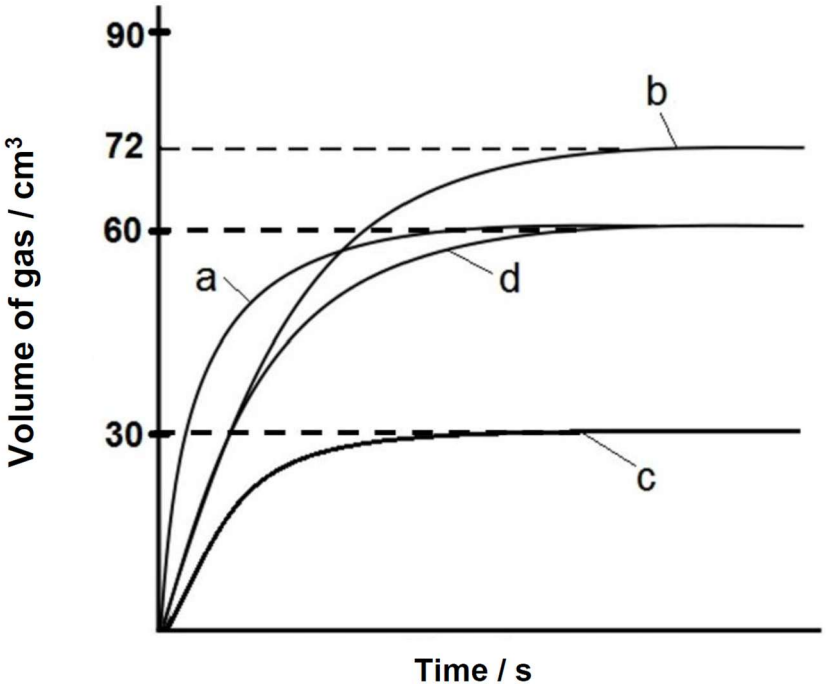


Fig. 5.1

(a) Complete Table 5.1 with appropriate answers.

Table 5.1

experiment	concentration of acid / mol/dm^3	volume of acid / cm^3	particle size of metals (small or large)
a	0.250	20	small
b	0.200	30	large
c	0.125	20	large
d	0.250		

[1]

(b) Using Collision Theory, account for the differences between graphs a and d.

.....

.....

.....

..... [3]

(c) State the experiment (a, b, c or d) that has the exact stoichiometric ratio of reactants.

..... [1]

(d) Hence, identify metal **M**. Show your working clearly.

Metal **M**: ..... [3]

[Total: 8]

6 Car manufacturers are developing fuel cells for use in cars.

Fuel cells produce electrical energy from reaction between a fuel and oxygen.

Two possible fuels for use in fuel cells are hydrogen and methanol.

Table 6.1 gives some data about these two fuels.

Table 6.1

fuel	melting point °C	boiling point °C	energy change of combustion kJ/mol
hydrogen	–259	–252	256
methanol	–97.7	64.5	715

(a) The table gives values for the energy change of combustion for each fuel in kJ/mol.

(i) Calculate the energy output for 1 g of each fuel.

[2]

(ii) Use the values you have calculated and information in the table to discuss the advantages and disadvantages of using each fuel in cars.

.....

.....

.....

.....

..... [3]

(b) The energy output of a fuel can be shown using an energy profile diagram.

In the space below, draw an energy profile diagram for the combustion of methanol.

Your diagram should include labels for the reaction enthalpy change and activation energy.

[3]

[Total: 8]

7 Chlorofluorocarbons (CFCs) have been used in large quantities as solvents and aerosol propellants.

When CFC molecules diffuse into the atmosphere, they destroy the ozone layer in the stratosphere, which is about 30 kilometres from the Earth's surface.

One of the most widely used CFCs was CCl_2F_2 and CH_3CCl_2F.

(a) CCl_2F_2 can be made from methane via photochemical substitution reaction with chlorine and fluorine gas.

Explain why the reaction between methane with chlorine and fluorine to form CCl_2F_2 is a substitution reaction and suggest why it is described as photochemical.

.....

.....

..... [2]

(b) CH_3CCl_2F is made by adding hydrogen fluoride to an unsaturated organic compound A.

In the space below, draw the structural formulae of compound A.

compound A

[1]

(c) When CFCs rise to the stratosphere, energy from sunlight breaks C−C*l* bonds in CFCs to produce chlorine atoms. Chlorine atoms cause the breakdown of ozone in a two-step process.

step 1 $Cl + O_3 \rightarrow ClO + O_2$

step 2 $ClO + O_3 \rightarrow Cl + 2O_2$

A scientist comment, "*One C*l *atom can destroy 100 000 ozone molecules*."

Use the equations for step 1 and 2 to explain the comment made by the scientist.

.....

.....

..... [2]

(d) Why is the ozone layer important to us?

.....

..... [1]

[Total: 6]

8 Compounds **X**, **Y**, and **Z** in Fig. 8.1 are some components of a perfume, which usually has many different layers known as top note, middle note and base note. The structures of the compounds are given below.

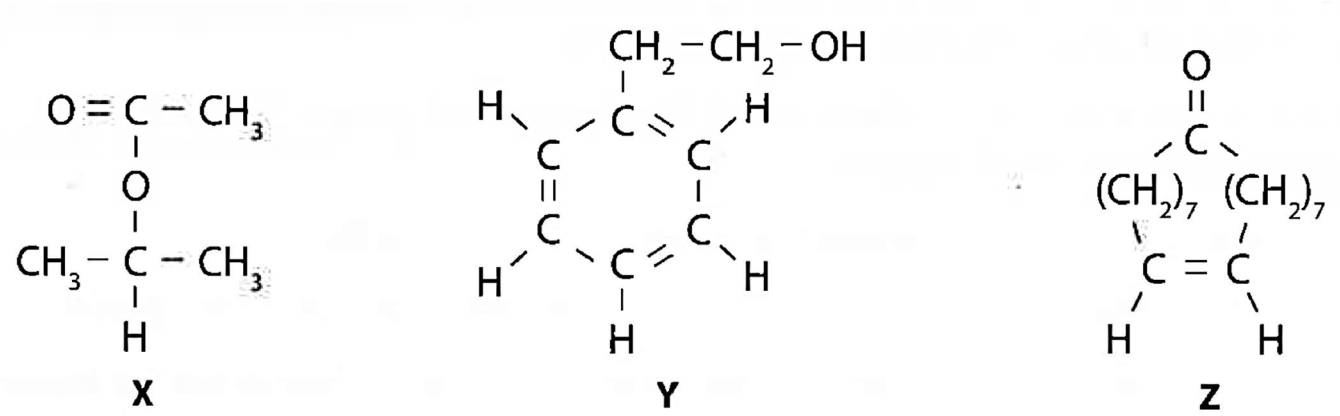


Fig. 8.1

(a) The top note gives the initial impression of a perfume and is an important selling point of any perfume.

(i) Suggest why compound **X** is most likely responsible for the top note of the perfume.

.....

.....

[1]

(ii) Write an equation to show the product of compound **X** from suitable reactants. Show the organic compounds as displayed formulae.

[2]

(b) The middle note emerges just before the dissipation of the top note. It usually covers up the less pleasant base note that comes after.

(i) Suggest why compound **Y** is most likely responsible for the middle note of the perfume than compound **Z**.

.....

..... [1]

(ii) Describe a simple test that can be used to distinguish between compound **Y** and compound **Z**.

.....

.....

..... [2]

[Total: 6]

9 Read the information about the relationships between the electronegativity of elements, chemical bonding between elements and their bond energies.

Electronegativity of elements

Electronegativity is a measurement of the tendency of an atom to attract a bonding pair of electrons. A bonding pair of electrons is the pair of electrons shared in a chemical bond.

The Pauling scale is used to measure the electronegativity of elements. It ranges from 0.7 to 4.0, with a higher value representing greater electronegativity. The greater the electronegativity of an atom, the greater the tendency for the atom to attract the bonding pair of electrons to itself in a chemical bond.

The values of the electronegativity of the first twenty elements in the Periodic Table are given in Table 9.1. The electronegativity value of sodium has been intentionally left out.

Table 9.1

element	electronegativity	element	electronegativity
H	2.20	Na	
He	no data	Mg	1.31
Li	0.98	A*l*	1.61
Be	1.57	Si	1.90
B	2.04	P	2.19
C	2.55	S	2.58
N	3.04	C*l*	3.16
O	3.44	Ar	no data
F	3.98	K	0.82
Ne	no data	Ca	1.00

The difference in electronegativity between two elements involved in a chemical bond, Σ, can be calculated by subtracting the smaller electronegativity value from the larger electronegativity value.

Σ gives a good indication of whether a chemical bond formed between two elements is ionic or covalent. The general rule states that if a chemical bond is an ionic bond, the Σ value is greater than 2.0. An example is magnesium fluoride, MgF_2, where Σ = 3.98 – 1.31 = 2.67.

However, there are exceptions to this rule.

Elements and their oxides and chlorides

The formulae and chemical bonding of the oxides and chlorides of some elements are given in Table 9.2. The bonding in aluminium oxide has been intentionally left out.

Table 9.2

element	formula of main oxide	bonding in oxide	formula of main chloride	bonding in chloride
H	H_2O	covalent	HCl	covalent
Mg	MgO	ionic	$MgCl_2$	ionic
Al	Al_2O_3		$AlCl_3$	covalent
P	P_4O_{10}	covalent	PCl_3	covalent
S	SO_2	covalent	S_2Cl_2	covalent

Bond energies

Bond energies give an indication of the strength of the covalent bond. The higher the bond energy, the stronger the covalent bond.

The bond energies of some covalent bonds are given in Table 9.3.

Table 9.3

covalent bond	bond energy / kJ/mol	covalent bond	bond energy / kJ/mol
H – H	432	O = O	494
H – F	562	C ≡ O	1077
H – Cl	431	C = O	799
P – Cl	346	C – O	358

(a) **(i)** Describe and explain the trend in the electronegativity of Group 2 element.

.....

.....

..... [2]

(ii) Predict the electronegativity of sodium.

..... [1]

(b) In Table 9.1, the electronegativity of helium, neon and argon are noted as 'no data'. Suggest why this is so.

.....

..... [2]

(c) Aluminium oxide melts at 2072 °C.

Calculate the electronegativity difference, Σ value for aluminium oxide.

Do the Σ value support the bonding in aluminium oxide?

Explain your answer.

[2]

(d) Two students talk about the information given.

Student 1: 'I think that the electronegativity difference, Σ value, is directly proportional to the bond energy of a single covalent bond between two different atoms.'

Student 2: 'I think that the electronegativity difference, Σ value, can predict the covalent bond strength.'

Does the information in the tables support the ideas of the students?

Student 1:

Student 2:

[3]

(e) Diagrams can be used to represent how particles are chemically bonded.

(i) The 'dot-and-cross' diagram of an ammonia molecule is shown below in Fig. 9.1.

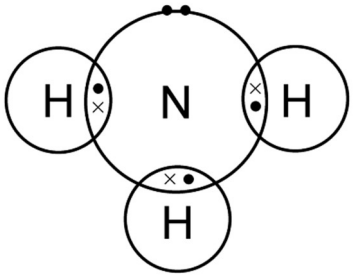


Fig. 9.1

Based on your understanding of electronegativity, suggest why the 'dot-and-cross' diagram is not an accurate representation of the covalent bonds in ammonia.

.....

.....

[1]

(ii) In the space, draw a 'dot-and-cross' diagram for S_2Cl_2.

[1]

[Total: 12]

10 An electrolytic and electrochemical set-up consisting of two cells are shown in the Fig. 10.1 below.

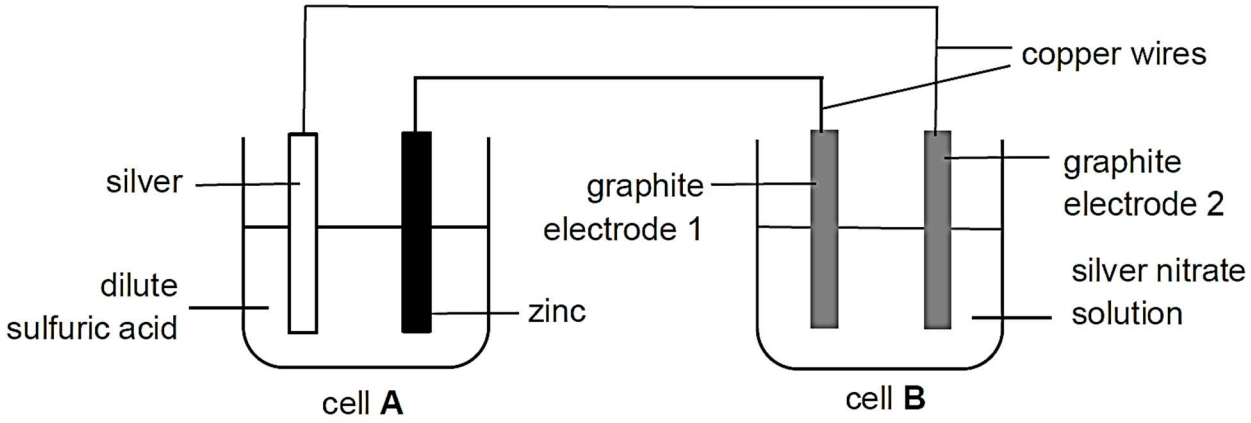


Fig. 10.1

(a) Both cell **A** and cell **B** use electrodes, electrolytes and copper wires for electrical conduction.

Describe how the electrodes, electrolytes and copper wires conduct electricity.

.....

.....

..... [2]

(b) In cell **A**, zinc is the negative electrode.

Write the overall equation for the reaction in cell **A**.

..... [1]

(c) **(i)** Write an ionic equation for the reaction at the graphite electrode 1 in cell **B**.

..... [1]

(ii) Describe and explain the change in pH, if any, of the electrolyte in cell **B**.

.....

.....

..... [2]

(d) The electrolyte in cell **B** is replaced with molten aluminium oxide.

After a long period of time, one of the graphite electrodes in cell **B** reduces in size and needs to be replaced.

Explain why this graphite electrode needs to be replaced.

.....

.....

..... [2]

[Total: 8]

Section B [10 marks]

Answer **one** question from this section.

11 Spider silk is a compound with a long chain mainly made up of amide linkages.

Amino acids are molecules with two key functional groups. Each amino acid molecule consists of an amine group on one side, and a carboxyl group on the other, which allows them to polymerise into long chains known as “polypeptides”.

Fig. 11.1 shows the structural formula of the three main amino acids, glycine, alanine and serine, found in spider silk.

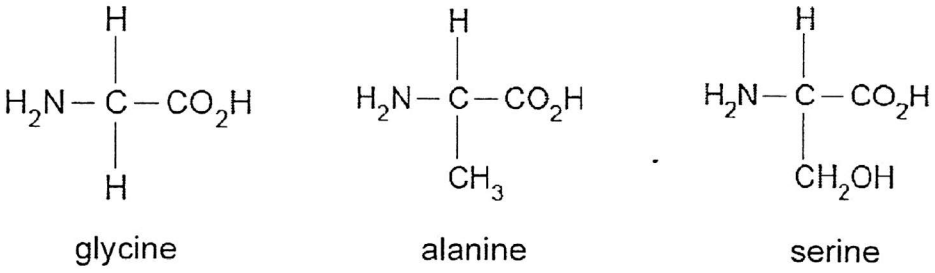


Fig. 11.1

(a) **(i)** Assume spider silk is made from repetitive sequences of

—glycine—alanine—serine—

In the space below, draw the structural formula of the repeating unit of this polypeptide.

[2]

(ii) State the type of polymerisation reaction that the amino acids undergo to form this polypeptide.

Explain your answer.

.....

.....

.....

[2]

(iii) The M_r of each polypeptide is about 600 000.

Assuming the polypeptide is made from the same repeating unit in **(a)(i)**, calculate the average number of amino acids monomers in this polypeptide.

[2]

(b) Nylon is also a polyamide. It is a synthetic fibre that is non-biodegradable. Part of the structure of nylon is shown in Fig 11.2 below.

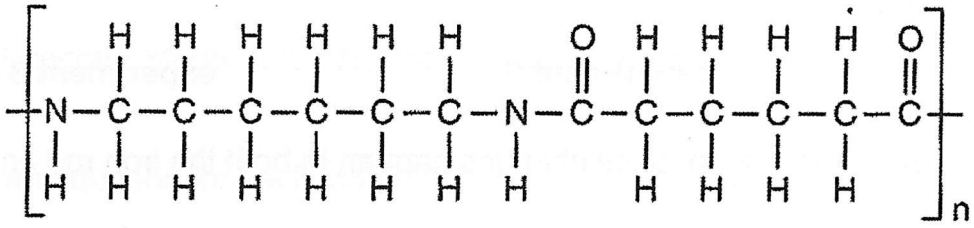


Fig 11.2

(i) In the space below, draw the full structural formula of the two monomers that react to form this nylon.

[2]

(ii) A chemical method of recycling nylon involves depolymerisation. Describe what depolymerisation is and state the conditions required.

.....

.....

.....

[2]

[Total: 10]

12 Production of electric cars has been increasing in the recent years.

This result in the increasing demand for light-weight materials such as aluminium-silicon alloys.

Silicon is extracted from sand, primarily composed of silicon dioxide, by heating it to 2000 °C with carbon in a furnace. This process produces silicon and carbon monoxide as shown in the reaction:

$$SiO_2 + 2C \rightarrow Si + 2CO$$

However, sand also contains small amounts of aluminium oxide, which remains in the silicon after the reaction with carbon. Further purification steps are required to remove this aluminium oxide impurity.

(a) What conclusions can you make from this information about relative reactivity of carbon, silicon and aluminium?

Use ideas about reduction to explain your answer.

.....

.....

..... [2]

(b) Table 12.1 shows information about some oxides of carbon, silicon and aluminium.

Table 12.1

oxide	melting point / °C	boiling point / °C	density at room temperature and pressure in g/cm^3	electrical conductivity
carbon monoxide	-205	-192	0.002	does not conduct in any state
silicon dioxide	1600	2230	2.65	does not conduct in any state
aluminium oxide	2000	2980	3.99	conduct when molten

Use ideas about bonding and structure to explain the differences between the properties of the oxides of carbon, silicon and aluminium.

[5]

(c) Aluminium-silicon alloys contain aluminium mixed with silicon and other elements.

Table 12.2 shows information about the composition of some aluminium-silicon alloys.

Table 12.2

alloy	percentage by mass of silicon	percentage by mass of elements other than silicon and aluminium
X	< 16	7
Y	16 - 19	8
Z	22 - 24	6

100 g of an aluminium-silicon alloy is analysed and found to contain 2.8 mol of aluminium.

Identify the alloy, X, Y and Z, using the information in Table 12.2.

Show your working.

[3]

[Total: 10]

END OF PAPER

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