Class/ Index Number /	Centre Number/ 'O' Level Index Number /	Name

新加坡海星中学

MARIS STELLA HIGH SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

CHEMISTRY
Paper 2

6092/02
22 August 2025
1 hour 45 minutes

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number, Centre number, O level index number and name in the spaces at the top of this page.
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	
Section A	70
Section B	10
Total	80

Section A

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

1 The structures of some carbon-containing substances, **A**, **B**, **C**, **D**, **E** and **F** are shown in Fig 1.1.

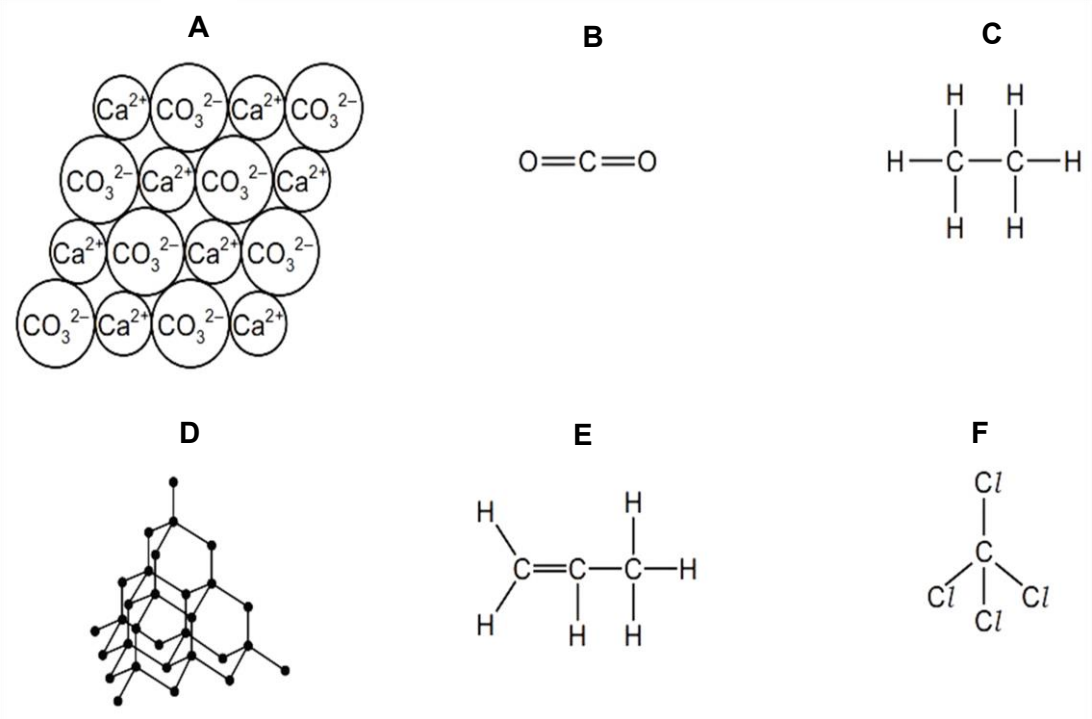

Fig. 1.1

(a) Use the letters **A**, **B**, **C**, **D**, **E** and **F** to answer the following questions.

Each letter may be used once, more than once or not at all.

(i) Which substance is a saturated hydrocarbon?

……..[1]

(ii) Which substance has a giant molecular structure?

……..[1]

(iii) Which substance is a product of respiration?

……..[1]

(iv) Which substance is in the same homologous series as ethene?

……..[1]

(v) Which substance is found in limestone?

……..[1]

(b) Explain why substance **B** in the atmosphere is increasing and why planting more trees is not a long-term solution to the increase in the amount of **B**.

…….....

…….....

…….....[2]

[Total: 7]

2 Lithium is a metal and lithium chloride is a compound. The structure and properties of these substances are very different.

(a) Explain using ideas about bonding and structure, how the particles in lithium and lithium chloride are held together.

……

……

……

……[2]

(b) Table 2.1 below shows the melting and boiling points of lithium and lithium chloride.

Table 2.1

	melting point / °C	boiling point / °C
lithium	180.5	1342
lithium chloride	605.0	1382

Using the information from Table 2.1, explain what can be deduced about the forces of attraction holding the particles together in lithium and lithium chloride.

……

……

……

……[2]

(c) Two students, **A** and **B**, are comparing the properties of lithium and lithium chloride at room temperature. Student **A** states that both lithium and lithium chloride can conduct electricity, but Student **B** states that **only** lithium can conduct electricity.

State whether Student **A**, Student **B**, or neither student is correct. Explain your answer.

……

……

……

……

……[3]

(d) Students **A** and **B** then went on to discuss the bonding in another substance, calcium fluoride. Explain, in terms of electrons, how the bonds in calcium fluoride are formed.

……

……

……

……[2]

[Total: 9]

3 Chlorine dioxide, ClO_2, was the first oxide of chlorine to be discovered. Although unstable as a liquid or gas, it is now produced on a very large scale for the bleaching of wood pulp and water treatment.

Chlorine dioxide has a complex bonding structure. The chlorine atom in the molecule has an unpaired electron, which is not involved in bonding, contributing to its reactivity.

The structure of a chlorine dioxide molecule can be represented as shown.

$$O = Cl = O$$

(a) Draw a 'dot & cross' diagram to show the bonding in a chlorine dioxide molecule. Show outer shell electrons only.

[2]

(b) Chlorine dioxide was first obtained by scientist and inventor, Humphry Davy. It was formed by the hazardous disproportionation reaction of chloric acid, $HClO_3$.

$$3HClO_3 \rightarrow 2ClO_2 + HClO_4 + H_2O$$

Disproportionation is a type of redox reaction in which the same element is both oxidised and reduced.

Which element in the reaction has undergone disproportionation? Explain your answer using oxidation states.

……..

……..

……..[2]

(c) Chlorine dioxide can also be produced by reacting sodium chlorate(III), $NaClO_2$ with chlorine. The other product is sodium chloride.

(i) Write an equation for the reaction.

……[1]

(ii) Which is the oxidising agent? Explain your answer.

……

……[2]

[Total: 7]

4 Sulfuric acid and malonic acid are both dibasic acids.

Malonic acid is a white crystalline solid which is soluble in water. It melts at 135 °C. The structural formula of malonic acid is given below.

$$HOOC–CH_2–COOH$$

(a) **(i)** Write the molecular formula of malonic acid.

……..[1]

(ii) When malonic acid is thermally decomposed, carbon dioxide and a simpler carboxylic acid are formed. Deduce the name and formula of this acid.

……..[2]

(iii) Name the product when the carboxylic acid in **(a)(ii)** is mixed with ethanol and heated in the presence of concentrated sulfuric acid.

……..[1]

(iv) Draw the structural formula of the product formed in **(a)(iii)**.

[1]

(b) Suggest why a solution of malonic acid, of concentration 0.2 mol/dm^3, has a higher pH than sulfuric acid of the same concentration.

…….[1]

[Total: 6]

5 Aqueous hydrogen peroxide is often used in households as a bleaching agent as well as a disinfectant among other uses.

At room temperature, aqueous hydrogen peroxide decomposes very slowly to form water and oxygen. The decomposition of hydrogen peroxide can be represented by the equation below.

(a) Explain in terms of bond making and bond breaking why this reaction is exothermic.

……

……[2]

(b) The decomposition of hydrogen peroxide is speeded up by adding powdered manganese(IV) oxide.

An experiment was carried out with three samples of hydrogen peroxide placed in conical flasks labelled **P**, **Q** and **R**. An equal mass of powdered manganese(IV) oxide was added to each conical flask. The mass of the conical flasks and their contents were measured at regular time intervals, and a graph of mass was plotted against time.

The results are shown in Fig. 5.1.

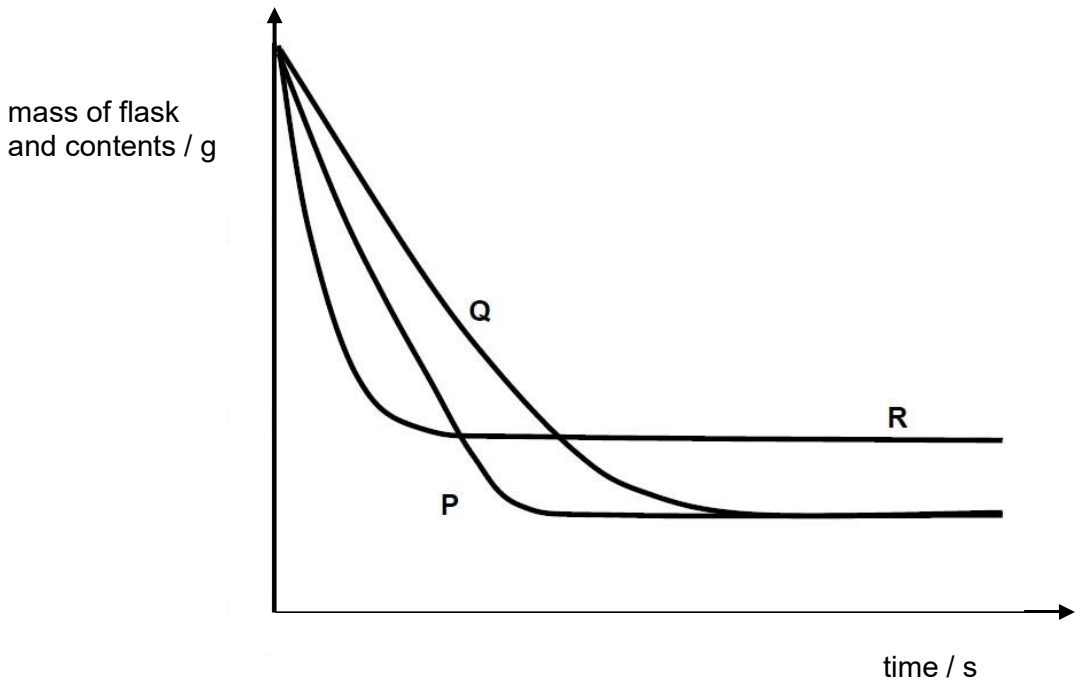

Fig. 5.1

(i) Given that conical flask **P** contained 50 cm^3 of 2.0 mol/dm^3 of hydrogen peroxide and conical flask **Q** contained 80 cm^3 of hydrogen peroxide, calculate the concentration of hydrogen peroxide in conical flask **Q**.

[2]

(ii) Suggest a suitable volume and concentration of hydrogen peroxide in conical flask **R**.

Volume of hydrogen peroxide …….

Concentration of hydrogen peroxide ……[2]

(iii) Suggest another way to speed up the decomposition further, without the use of a catalyst or varying the concentration. Explain your answer in terms of collision theory.

……..

……..

……..

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……..

……..[3]

[Total: 9]

6 Fig. 6.1 shows the electrolysis of a concentrated solution of sodium chloride in the laboratory.

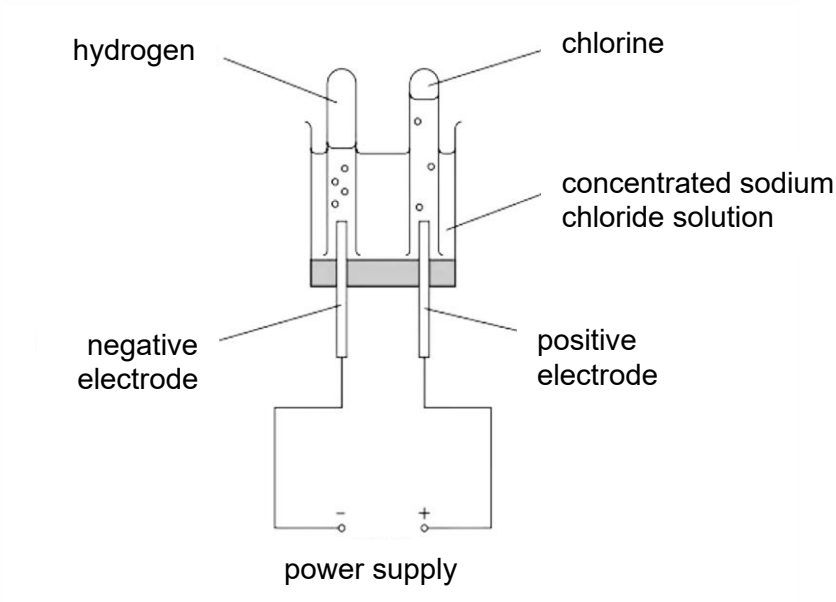


Fig. 6.1

(a) **(i)** Explain, with the use of ionic equations, why the volume of chlorine collected should be the same as the volume of hydrogen collected.

……..

……..

……..

……..[2]

(ii) Suggest why the volume of chlorine collected is always less than the volume of hydrogen collected.

……..[1]

(b) In the chemical industry, chlorine can be produced by the electrolysis of molten sodium chloride. The overall equation for this reaction is shown below.

$$2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$$

Calculate the maximum volume, in dm^3, of chlorine gas that can be obtained from 23.4 tonnes of molten sodium chloride.

(1 tonne = 1000 kg)

[3]

(c) Nuclear submarines can stay underwater for months without needing to come to the surface.

Oxygen for the crew to breathe is produced using an equipment called an automated electrolytic oxygen generator.

Many people assume that seawater is used directly and electrolysed to produce oxygen.

Explain why the assumption is incorrect and potentially hazardous, and how seawater can be processed to obtain oxygen.

……..

……..

……..

……..

……..

…….[3]

[Total : 9]

7 Ethanol can be manufactured by two different methods. Table 7.1 gives some information about the two methods.

Table 7.1

	hydration of ethene	fermentation of glucose
raw material	crude oil	sugar cane
rate of reaction	fast	slow
purity of ethanol	pure	impure
operating temperature	300 °C	30 °C
operating pressure	60 – 70 atmospheres	1 atmospheres
catalyst	phosphoric acid	enzymes in yeast

Use the information given in Table 7.1 to discuss the advantages and disadvantages of these two methods.

……..

……..

……..

……..

……..

……..

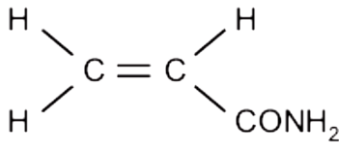
……..

……..[4]

[Total: 4]

8 **(a)** Researchers have found the presence of acrylamide in certain foods that were heated to temperature above 120 °C. Potato chips and french fries were found to contain high levels of acrylamide.

Acrylamide is thought to be harmful to human health and has the following structure.



(i) Acrylamide readily polymerises to form poly(acrylamide). Draw the structure of poly(acrylamide).

[1]

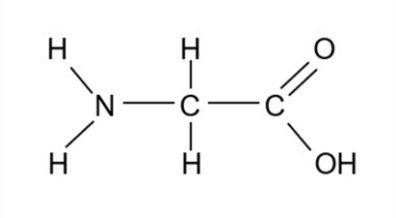
(ii) Acrylamide reacts with water to form acrylic acid and ammonium ions. Describe the test for ammonium ion.

……..

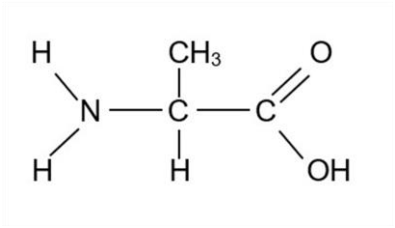
……..

……..[2]

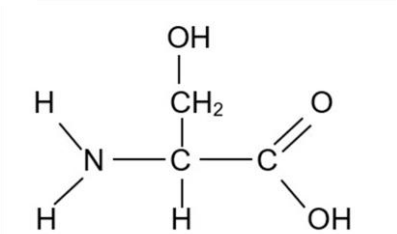
(b) A silk protein is made of many identical protein chains, which are made mainly from equal number of three amino acid monomers, glycine, alanine and serine.



glycine

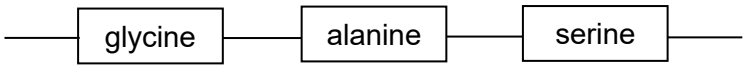


alanine



serine

One possible structure of the silk protein is shown below.



(i) Name the type of polymerisation when the amino acid monomers polymerise.

……..[1]

(ii) Draw the structural formula of the repeat unit for the silk protein, containing the three amino acids.

[1]

(c) Outline two differences between the polymerisation of acrylamide in **(a)(i)** and the amino acid monomers in **(b)(i)**.

……

……

……

……..[2]

[Total: 7]

9 Principles of Chromatography

Chromatography makes use of the principle that components in a mixture when dissolved in a liquid or gas (mobile phase), will flow through another substance (stationary phase) at varying rates.

The rate of separation depends on how the components in the mixture interact with the stationary phase (their retention) and how soluble they are in the mobile phase.

Gas-Liquid Chromatography

Gas-liquid chromatography is used for analysing gases, volatile liquids and solids in their vapour form. This method uses a column with a non-volatile liquid as a stationary phase. An inert carrier gas such as helium or nitrogen moves the sample molecules through the stationary phase.

The sample is injected into the column and the vapour formed is carried through the stationary phase using the inert-gas mobile phase.

Retention time is the time taken for a component to travel through the column and it is recorded on a chromatogram. The position of the peaks shows the retention time of each component in the analysed sample.

The relative sizes of the peaks are related to how much each component is present in the mixture.

Fig. 9.1 shows the chromatogram of mixture **X**, with four components, **A, B, C and D.**

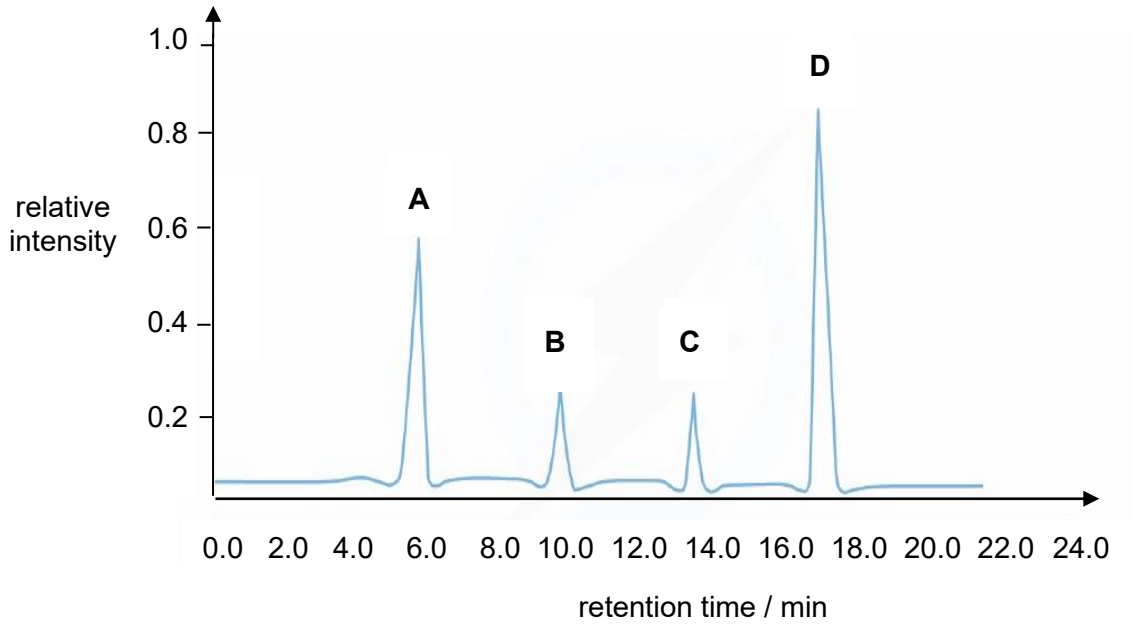


Fig. 9.1

Gas-liquid chromatography is often carried out with mass spectrometry to analyse each component as it exits the chromatography column. The molecular mass of each component in the mixture can be determined and matched with the time it took for the sample to move through the column.

Mass Spectrometry

Mass spectrometry is an analytical technique used to identify particles of different relative mass. It involves vaporising atoms or molecules and bombarding the vapourised particles with electrons to generate a beam of positive ions.

The number of different positive ion particles produced are then separated and counted. The resulting data from the detector is called a mass spectrum. It provides accurate data on the relative masses as well as the relative abundance of all the positive ions generated from individual atoms, molecules and fragments of molecules.

Each peak in the mass spectrum corresponds to a certain fragment with a particular mass to charge ratio (m/z) value. The peak with the highest m/z value is the molecular ion which corresponds to the molecular mass of the component. The molecular ion is the entire molecule that has lost one electron when bombarded with a beam of electrons.

Gas chromatography is carried out on an organic mixture. Two of the compounds in the mixture are hydrocarbons with similar retention times.

The mass spectra of the two compounds reveals that they have the same molecular formula but with subtle differences, indicating they are isomers. Both isomers are tested with aqueous bromine, which remains orange.

The mass spectrum of one of the isomers**, Y** is shown in Fig. 9.2.

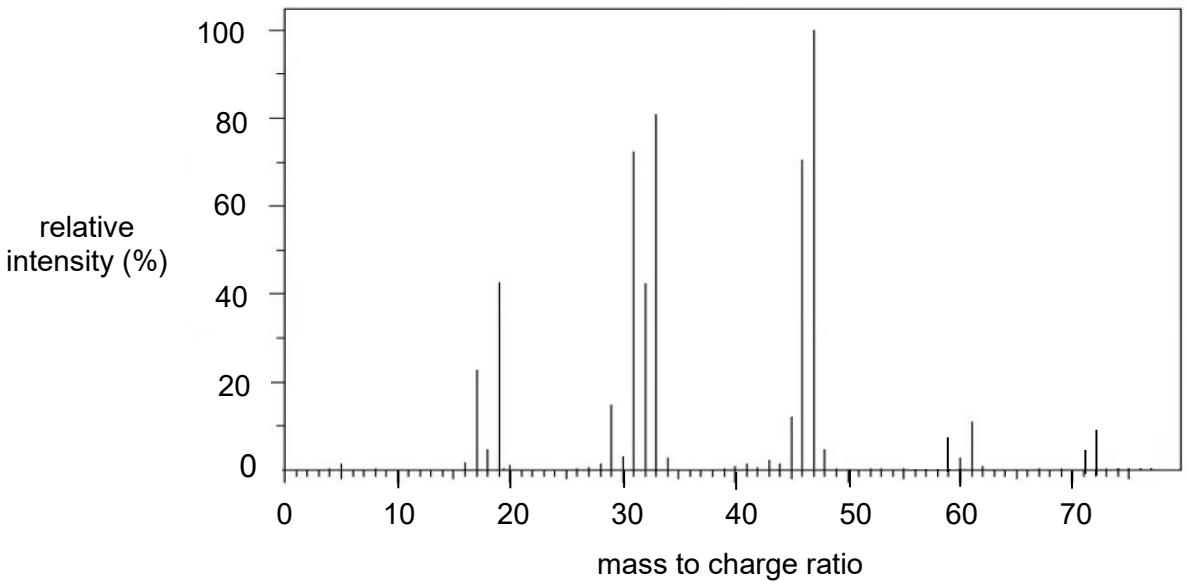


Fig. 9.2

(a) Complete Table 9.1 to show the stationary and mobile phase of paper chromatography.

Table 9.1

chromatography technique	stationary phase	mobile phase
gas-liquid chromatography	column with liquid	inert carrier gas
paper chromatography		

[2]

(b) **(i)** Which component in **X** is present in the greatest quantiy?

……..[1]

(ii) Which components in **X** were present in equal amounts?

……..[1]

(iii) Which component in **X** has the strongest interaction with the stationary phase?

……..[1]

(c) **(i)** What is the molecular mass of isomer **Y**?

……..[1]

(ii) Deduce the molecular formula of **Y**. Explain your answer.

……..

……..[2]

(iii) Write a balanced equation for the reaction of **Y** with excess oxygen.

……..[2]

(iv) Draw the full structural formula of two isomers of **Y**.

[2]

[Total: 12]

Section B

Answer **one** question from this section.

10 A student conducted three experiments to investigate the chemical properties of four different metals, **J**, **K**, **L** and **M**. The results of the three experiments are recorded as shown in Table 10.1.

Table 10.1

no	experiment	**J**	**K**	**L**	**M**
1	passing steam through the metal	a colourless gas is evolved	a colourless gas is evolved	no observable change	reacts very vigorously and a colourless gas is evolved
2	placing metal in silver nitrate	shiny silver crystals form on the surface of the metal	shiny silver crystals form on the surface of the metal	shiny silver crystals form on the surface of the metal	reacts very vigorously and a colourless gas is evolved
3	heating metal oxide with carbon at 1500°C	no observable change	formation of a silvery solid and a colourless gas is evolved	formation of a red-brown solid and a colourless gas is evolved	no observable change

(a) **(i)** Write down the order of increasing reactivity of **J**, **K**, **L** and **M**.

……..[1]

(ii) Explain the formation of the colourless gas when **M** is placed in the silver nitrate solution.

……..[1]

(iii) Suggest the identity of **L**.
Write an ionic equation with state symbols for the reaction between **L** and silver nitrate solution.

……..

……..[2]

(b) The student conducted a fourth experiment to determine the position of hydrogen in the list of metals **J**, **K**, **L** and **M** in their order of reactivity.

Dry hydrogen gas was passed over heated oxides of the metals separately. The results are shown in Table 10.2.

Table 10.2

metal oxide	observation
oxide of metal **J**	remains white
oxide of metal **K**	white to yellow when hot, turns back to white when cold
oxide of metal **L**	colour turns from black to red-brown
oxide of metal **M**	remains white

(i) Use the experimental results in Table 10.2 to explain the position of hydrogen.

……..

……..

……..

……..

……..[3]

(ii) Which one of the four metals **J**, **K, L** and **M**, will cause iron to corrode faster when iron is in contact with it?
Explain your answer.

……..

……..

……..

……..

……..[3]

[Total: 10]

11 Zamak is an alloy of zinc with magnesium, aluminium and copper. It is widely used to make die-cast toys. Magnesium and aluminium are adjacent elements in the third Period of the Periodic Table. Zinc and copper are next to each other in the first set of transition elements.

Table 11.1 shows the densities of the four metals present in Zamak.

Table 11.1

metal	metal 1	metal 2	metal 3	metal 4
density (g/cm^3)	1.74	2.70	7.13	8.96

(a) Suggest the identities of metals 3 and 4 present in Zamak.

……..[1]

(b) **(i)** When finely powdered Zamak is shaken with cold dilute hydrochloric acid, three of the metals dissolved and one remains as a solid residue. Name the solid residue.

……[1]

(ii) Explain, in terms of collision theory, why finely powdered Zamak is used in the reaction.

……..

……..

……..

……[2]

(c) Using ideas of arrangement of atoms in Zamak alloy, explain why Zamak is harder than pure zinc.

……

……

……[2]

(d) Mobile phones are made from many different substances. Table 11.2 shows the composition of substances used to make a typical mobile phone.

Table 11.2

substance	percentage by mass in a typical mobile phone (%)
plastics	56
ceramics	16
copper	15
iron	3
other materials	10

(i) Plastic is a non-biodegradable material.

Explain why being non-biodegradable is both an advantage and a disadvantage.

……..

……..

……..[2]

(ii) The iron used in a mobile phone must not rust.

Suggest one way to prevent the iron from rusting and explain how this method of rust prevention works.

……..

……..

……..[2]

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