DUNMAN SECONDARY SCHOOL

CANDIDATE NAME			
CLASS		**INDEX NUMBER**	

PRELIMINARY EXAMINATION 2024
SECONDARY 4 EXPRESS

CHEMISTRY **6092/02**

Paper 2 **22 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 index 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.

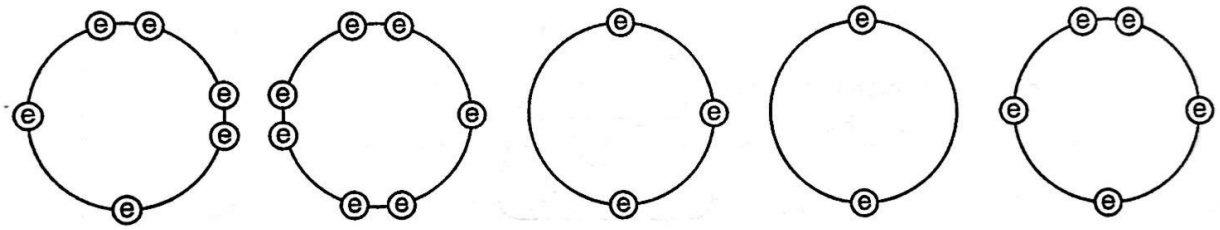
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 28.

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

Section A

Answer **all** questions.

1 These diagrams show the electron arrangement in the outer shells of five elements, A to E. All elements are from Period 2 of the Periodic Table.



A B C D E

Use the letters A to E to answer the following questions.

You may use each letter once, more than once or not at all.

(a) Which elements are most likely to be non-metals?

……..... [1]

(b) Which element has an atomic number of 5?

……..... [1]

(c) What element forms an ion with a charge of 2+?

……..... [1]

(d) Which element will form three covalent bonds when it forms a compound?

……..... [1]

(e) Which two elements will form a compound with the formula of the type YZ_2?

……..... [1]

[Total: 5]

2 Table 2.1 shows the formulae of some oxides of elements from period 3 of the Periodic Table.

Table 2.1

Group						
1	2	13	14	15	16	17
Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_2	Cl_2O

(a) From the table give **one** formula each for acidic oxide, basic oxide and amphoteric oxide.

acidic oxide …….

basic oxide …….

amphoteric oxide ……..... [2]

(b) Draw a 'dot-and-cross' diagram to show the bonding in sulfur dioxide.

Show outer electrons only.

[2]

(c) Explain, in terms of structure and bonding, why the melting point of silicon dioxide is very much higher than that of sulfur dioxide.

……

……

……

……

……

...…… [3]

(d) Dichlorine monoxide melts at -120˚C and boils at 2˚C. Describe the changes in the movement and arrangement of the particles as it is heated from 0˚C to 20˚C.

movement ……

……

arrangement ……

...…… [2]

(e) Dichlorine monoxide dissolves in water to produce hypochlorous acid.

$$Cl_2O\ (g) + H_2O\ (l) \rightleftharpoons 2HOCl\ (aq)$$

Explain why dichlorine monoxide is a poor conductor of electricity, while hypochlorous acid is a good conductor of electricity.

……

……

……

...…… [2]

[Total: 11]

3 The table shows information about the preparation of pure samples of solid salts.

Complete the table by filling in the missing information, including state symbols with any formulae.

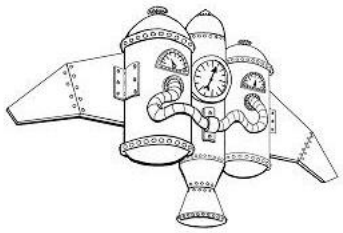
formula of salt	formulae of reagents used	method used
$MgCl_2$ (aq)	…….. HCl (aq)	addition of excess solid to acid filtration evaporation and crystallisation
……..	NH_3 (aq) H_2SO_4 (aq)	……. evaporation and crystallisation
$BaCO_3$ (s)	…… ……	……..… ……..

[5]

[Total: 5]

4 Rocket belts can be used to lift people into the air and transport them over short distances.

The picture below shows a rocket belt, usually strapped onto a person's back.



Rocket belts contain concentrated hydrogen peroxide solution as a fuel. An exothermic change occurs when the hydrogen peroxide decomposes rapidly to form oxygen and water.

The reaction is shown below:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The rapid releases of oxygen from the jetpack lifts the person off the ground.

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

……

……

……

..... [2]

(b) The decomposition of hydrogen peroxide is very slow at room temperature.

In a rocket belt, silver powder is present to make the decomposition reaction much faster.

The silver powder remains unchanged at the end of the reaction.

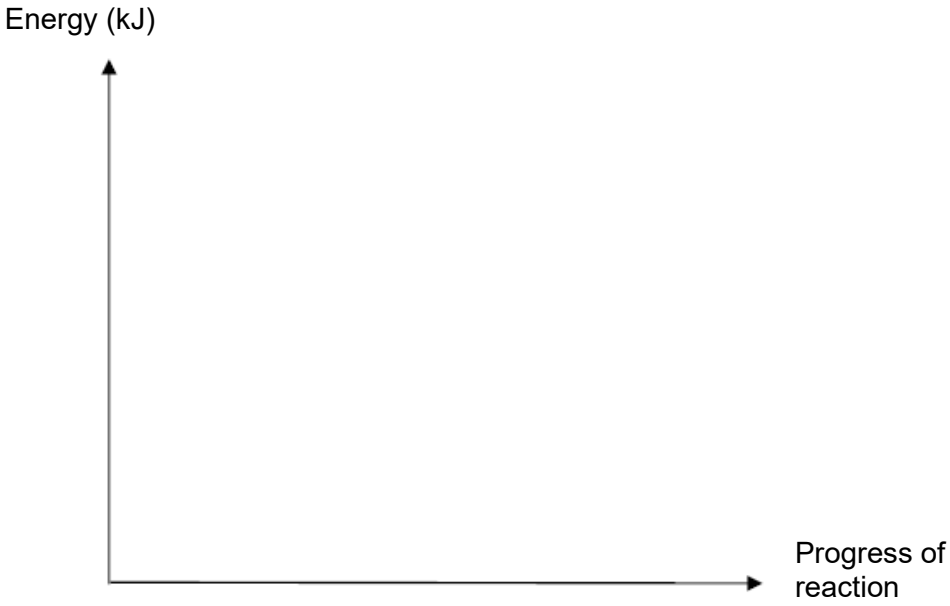
(i) State the role of silver powder in the decomposition of hydrogen peroxide.

…… [1]

(ii) Complete the energy profile diagram to show the effect of silver powder on the decomposition of hydrogen peroxide.

Your diagram should include:

- reactants and products,
- the activation energy for the reactions with and without silver powder,
- the enthalpy change of the reaction.



[3]

[Total: 6]

5 Sodium sulfite (Na_2SO_3) is often added to preserve food. The amount of sodium sulfite in a piece of meat can be determined through a series of tests shown below.

Step 1: Boil the meat with hydrochloric acid to form sodium chloride, water and sulfur dioxide.

Step 2: Collect gas produced and bubble it through 100 cm^3 of water to dissolve sulfur dioxide.

Step 3: Titrate the solution obtained against iodine according to the following reaction.

SO_2 (g) + $2H_2O$ (l) + I_2 (aq) → $4H^+$ (aq) + SO_4^{2-} (aq) + $2I^-$ (aq)

(a) Describe a chemical test to determine if there is any sulfur dioxide remaining after the gas has been bubbled through water in step 2.

……

……

……

..…… [2]

(b) It was noted that 12.00 cm^3 of 0.025 mol/dm^3 of iodine was required for complete reaction in the titration. Assume all the gas has dissolved in water.

(i) Calculate the volume of SO_2 produced in step 2. Show your working.

[2]

(ii) Explain, in terms of oxidation states, why the titration in step 3 involves a redox reaction.

……..

……..

……..

…… [2]

[Total: 6]

6 ‘Lean burn’ engines are a type of car engine.

Table 6.1 shows some information about learn burn engines compared to normal car engines.

Table 6.1

type of engine	amount of air mixed with petrol	operating temperature
normal	less air	higher
lean	more air	lower

The amount of air that is mixed with petrol and the operating temperature of the car engines affect the amount of pollutant gases that form.

Two major pollutant gases are carbon monoxide (CO) and nitrogen monoxide (NO).

(a) Complete the table to show how carbon monoxide and nitrogen monoxide are formed in a car engine.

pollutant gas	how it is formed
carbon monoxide	
nitrogen monoxide	

[2]

(b) Describe and explain how a lean burn engine affects the amount of carbon monoxide and nitrogen monoxide formed compared to a normal car engine.

……..

……..

……..

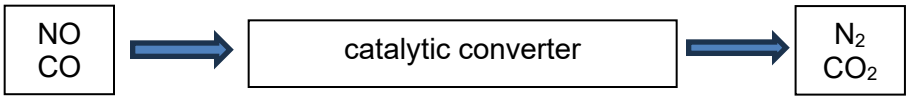
……..

……..

……..... [3]

(c) Catalytic converters are fitted to cars to reduce the problems caused by the exhaust gases such as carbon monoxide and nitrogen monoxide.

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



Explain why the converter does not remove all the environmental problems caused by the exhaust gases.

……..

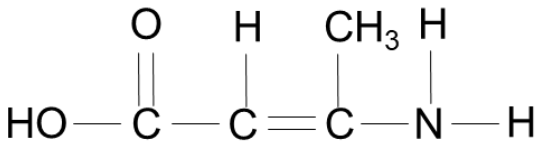
……..

……..

……..... [2]

[Total: 7]

7 An organic compound T has the structural formula:



(a) Describe what you would observe when a few drops of aqueous bromine is added to the compound T. State the type of reaction that has occurred.

……..

…..……...[2]

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

(i) Name the functional group in compound T that was involved in this reaction.

…..……[1]

(ii) Draw the full structural formula of the compound that gave the sweet smell.

[1]

(c) Compound T can undergo addition and condensation polymerization.

(i) Draw the structure of the polymer showing two repeating units when compound T undergoes addition polymerization.

[1]

(ii) State one difference in physical property between compound T and the polymer formed in (c)(i).

……..

…..……..…….……[1]

(d) State how condensation polymerization differs from addition polymerization.

……..

……..

……..

……..…… [2]

(e) Poly(ethene) is another addition polymer.

Describe one physical method and one chemical method used to recycle poly(ethene).

physical method ……

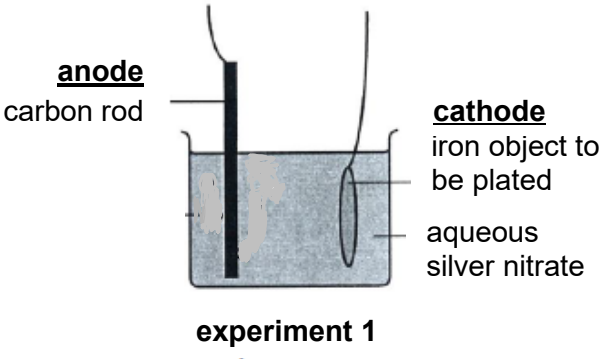
……..

chemical method ……..

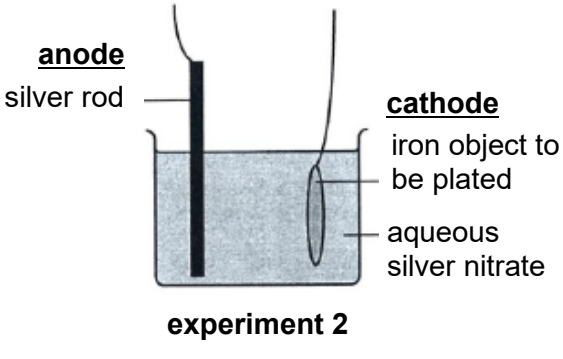
…… [2]

[Total: 10]

8 A student sets up two different experiments for electroplating an iron object with silver.



experiment 1



experiment 2

(a) Predict and explain the expected observations at the anode for each experiment. Include half-equations for your answer.

……..

……..

……..

……..

……..

…… [3]

(b) After some time, the student observes that no more silver is being deposited on the object in experiment 1 but more silver is still being deposited on the object in experiment 2.

(i) Suggest a reason for this observation.

……..

…..……[1]

(ii) Describe how the student could use aqueous sodium chloride to find out if his reasoning is correct.

……..

……..

……..

…..……[2]

(c) Magnesium can also be used to prevent iron object from rusting.

Explain how magnesium protects the iron object from rusting and include an ionic equation to support your explanation.

……..

……..

……..

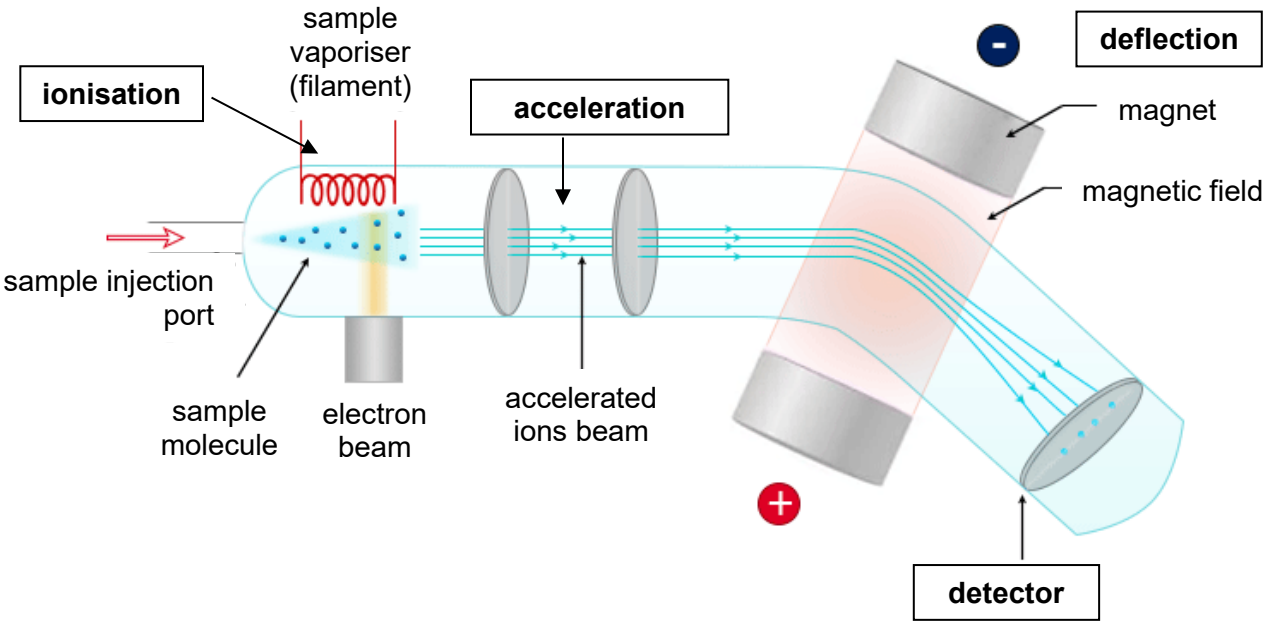
…… [2]

[Total: 8]

9 Introduction to Mass Spectrometry

Mass spectrometry is an analytical method used to identify the unknown compounds within a sample, and to provide information about the structure, chemical properties of different molecules. The process involves the conversion of the sample into gaseous ions, with or without fragmentation, which can then be characterized by their **mass-to-charge ratio (m/z)** and **relative abundances.**

Working of the mass spectrometer



Step 1 : Ionisation

The sample is vaporised. The atom or molecule is ionized by knocking one or more electrons off to give a positive ion. If enough energy is supplied, some bonds of molecules are broken and smaller positive ions are formed. Most of the positive ions formed will carry a charge of 1+. Mass spectrometers always work with positive ions.

Step 2 : Acceleration

The ions are accelerated so that they all have the same kinetic energy.

Step 3: Deflection

The ions are then deflected by a magnetic field according to their masses. The lighter (the smaller mass-to-charge ratio) they are, the more they are deflected.

For example, if an ion had a mass of 28 and a charge of 1+, its mass/charge ratio would be 28.

Step 4 : Detection

The beam of ions passing through the machine is detected electrically.

Step 5 : Mass Spectrum (Data Output)

The mass spectrum records the mass-to-charge ratio, m/z and relative abundance of all ions in the form of “stick diagram”.

Figure 9.1 shows the mass spectrum of a pure sample of lithium.

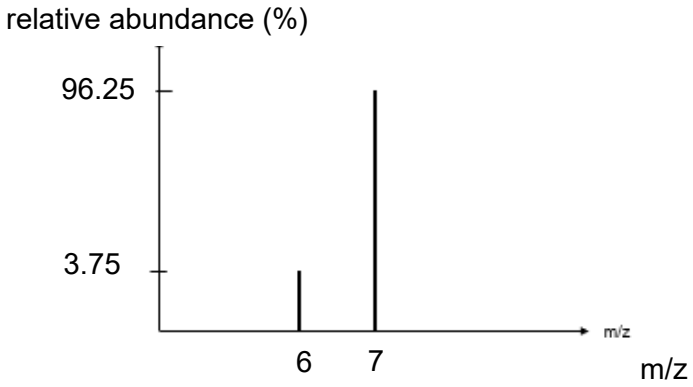


Fig. 9.1

Figure 9.2 shows the mass spectrum of a pure sample of chlorine.

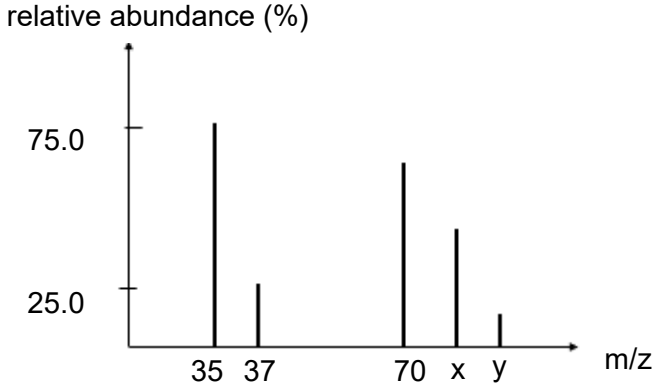


Fig. 9.2

Figure 9.3 shows the mass spectrum of a pure sample of an unknown hydrocarbon.

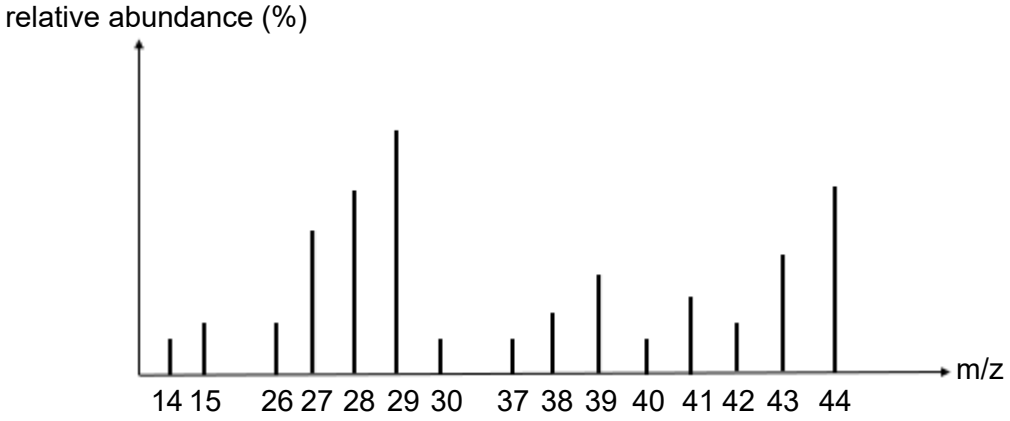


Fig. 9.3

Adapted from :
https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Introduction_to_Organic_Spectroscopy/02%3A_Mass_Spectrometry/2.02%3A_Instrumentation

With reference to Fig. 9.1,

(a) **(i)** Explain how the data in Fig. 9.1 shows that there are two isotopes of lithium.

……..

……..

……..

……..…[2]

(ii) With appropriate working, show that the average atomic mass of lithium is 6.96, correct to 3 significant figures.

[1]

With reference to Fig. 9.2,

(b) **(i)** State the values of x and y.

x = …… ; y = …… [2]

(ii) Suggest why there are 3 additional peaks of 70, x and y on the mass spectrum of chlorine.

……..

……..

……..

……..…[2]

With reference to Fig. 9.3,

(c) **(i)** A student commented that the unknown hydrocarbon is propane.

Do you agree with the student? Justify your answer.

……..

……..

……..

……..…[1]

(ii) Suggest the formula of the ion which has a m/z value of 14.

……..…[1]

(iii) Butane is a flammable gas that is commonly used in portable stoves. Another mass spectrometry analysis was carried out on a sample of butane.

Suggest two differences on how the results of the mass spectrum of butane would differ from propane.

1. ……

……..

2. ……

……..…[2]

(d) Suggest why after ionization, almost all the positive ions detected had a charge of +1, only a small percentage of ions carrying a higher charge.

……..

…… [1]

[Total: 12]

Candidate Name:	Class:	Index No:

Section B

Answer **one** question in this section.

10 A student investigated the rate of reaction when dilute sulfuric acid reacts with excess zinc granules.

He used the same volume of acid each time. He measured the time taken to collect 15 cm^3 of gas at room temperature and pressure. He also measured the total volume of gas at the end of the experiment at room temperature and pressure.

The table shows his results.

Table 10.1

experiment	concentration in mol/dm^3	temperature /˚C	time taken to collect 15 cm^3 of gas / s	total volume of gas / cm^3
1	0.5	20	21	150
2	1.0	20	12	300
3	0.5	40	11	150

(a) Give the formula of the salt formed from the reaction.

…… [1]

(b) Use ideas about collisions between particles to explain why changing the conditions shown in Table 10.1 changes the time taken to collect 15 cm^3 of gas.

……

……

……

……

……

……

……

…… [4]

(c) The student carried out another experiment at room temperature and pressure using 1.0mol/dm^3 ethanoic acid.

He used the same volume of acids as in the previous experiments with excess zinc granules.

Complete the table to predict what results he should expect and explain how you arrived at your answers.

experiment	concentration in mol/dm^3	temperature /˚C	time taken to collect 15 cm^3 of gas / s	total volume of gas / cm^3
4	1.0	20		

……

……

……

……

…… [3]

(d) When calcium metal is reacted instead, the initial production of gas is faster, but the reaction quickly stops.

Explain why this happens.

……

……

……

…… [2]

[Total: 10]

11 A student carried out some experiments to place four metals, copper, magnesium, cobalt and nickel in order of reactivity.

She added metals to salt solutions. The table shows the results.

Table 11.1

	copper	magnesium	cobalt	nickel
copper(II) sulfate		brown solid forms in colourless solution	brown solid forms in pink solution	brown solid forms in colourless solution
magnesium sulfate	solution remains colourless		solution remains colourless	solution remains colourless
cobalt(II) sulfate	solution remains pink	grey solid forms in colourless solution		solution remains pink
nickel(II) sulfate	solution remains green	silvery solid forms in colourless solution	silvery solid forms in pink solution	

(a) Place the metals in order of reactivity, starting with the most reactive.

……..……..…..... [1]

(b) Other than copper, use information in Table 11.1, identify which other metal is also a transition metal and explain your reasoning.

……...…….....

……...…….....[1]

(c) The student carried out further experiment to place iron in nickel(II) sulfate. Iron is more reactive than cobalt.

Predict her observation.

……...…….....[1]

(d) **(i)** A student comments 'Higher temperature is needed to extract a more reactive metal from its ore'.

Do you agree with the statement?

……...…….....

……...……..... [1]

(ii) In two separate experiments, hydrogen was passed over heated zinc oxide and heated copper(II) oxide.

Describe the changes, if any, you would expect to see in each experiment.

Explain your reasoning.

observations ……

……...…….....

……...…….....

reasons ……

……...…….....

……...……..... [3]

(iii) Suggest a method to extract magnesium and zinc from its ore.

magnesium ……...…….....

zinc ……...……..... [2]

(iv) Some metal ores contain gold mixed with impurities which include compounds of lead. The lead compounds can be removed from the gold by reacting the ore with dilute nitric acid.

Explain why gold does not react with dilute nitric acid.

……...…….....

……..……..... [1]

[Total: 10]

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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}