NAME:	NO:	CLASS:

ADMIRALTY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2024

SUBJECT	:	Chemistry
CODE/PAPER	:	6092/2
LEVEL/STREAM	:	Secondary 4 Express
DATE	:	21 August 2024
TIME	:	0800h – 0945h
DURATION	:	1 hour 45 minutes

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.

A copy of the Periodic Table is printed on page 22.
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.

For Examiner's Use	
Section A	/ 70
Section B	/ 10
Total	/ 80

DO NOT TURN OVER THIS PAPER UNTIL YOU ARE TOLD TO DO SO.

This question paper consists of **22** printed pages including this cover page.

Section A

Answer all questions.

1 Table 1.1 shows the structures of substances **A**, **B** and **C**.

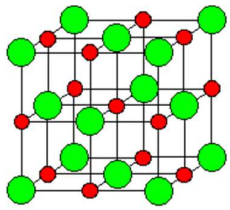
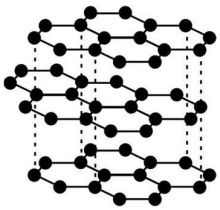
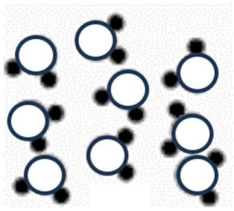
		
A	**B**	**C**

Table 1.1

Use the letters **A, B** and **C** to answer the following. Each compound may be used once, more than once or not at all. Answer the following questions using the structure and bonding of the identified substance.

(a) State the substance that can be used as an electrode in electrolysis.

.....

.....

.....

..... [3]

(b) State the substance that is a liquid at room temperature.

.....

.....

.....

..... [3]

(c) State which substance can be used as a lubricant.

.....

.....

.....

..... [3]

2 The Haber process is the main industrial procedure for the production of ammonia today. In this process, ammonia is made by reacting nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

A smaller scale of this reaction can be performed in the laboratory using the set-up shown in Fig. 2.1.

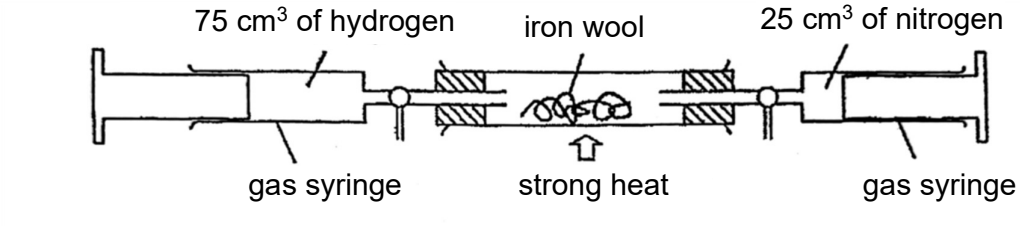


Fig. 2.1.

Nitrogen and hydrogen gas are passed forward and backward over the iron wool until no further reaction is observed.

(a) Suggest a reason why air must **not** be present in the reaction mixture.

.....

..... [1]

(b) Explain the role of the iron wool in this reaction.

.....

..... [1]

(c) Using the information in the set-up shown in Fig. 2.1, suggest the volume of ammonia gas produced. Explain your answer.

.....

.....

.....

..... [3]

(d) In the industry, the standard conditions for the Haber process is a temperature of 450 ^{o}C and a pressure of 200 atm. Certain companies run the Haber process at a higher pressure of 300 atm.

Suggest one advantage and one disadvantage of performing the Haber process at a higher pressure.

advantage……

……

disadvantage...……

…… [2]

3 Zinc sulfite, $ZnSO_3$, is an ionic salt which is insoluble in water.

(a) Given that zinc sulfite can be prepared from sulfurous acid, H_2SO_3. State the chemical that can be reacted with sulfurous acid to prepare zinc sulfite.

…… [1]

(b) Write a balanced equation based on **(a)**, showing state symbols**.**

…… [2]

(c) Suggest the experimental steps required to produce a dry sample of zinc sulfite from sulfurous acid and the chemical mentioned in **(a)**.

……

……

……

…… [2]

(d) State whether zinc sulfate, $ZnSO_4$ be prepared using the same method as zinc sulfite, $ZnSO_3$. Explain your answer.

……

…… [1]

4 The Andrussow process is an industrial process for the production of hydrogen cyanide in the presence of platinum as a catalyst.

The structural formulae of all chemicals are shown in the chemical equation below:

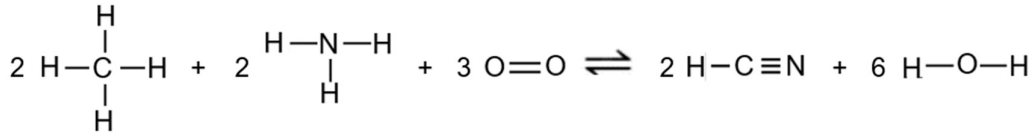


Table 4.1 shows some information about the bonds present in the chemicals.

bond	bond energy/ $kJmol^{-1}$
H – N	390
H – O	464
C ≡ N	891

bond	bond energy/ $kJmol^{-1}$
C – H	413
O = O	498

Table 4.1

(a) Using the information in Table 4.1, calculate the enthalpy change of the chemical equation for Andrussow process.

[3]

(b) Using the ideas about breaking and forming bonds, explain why the enthalpy change for the Andrussow process is negative.

……

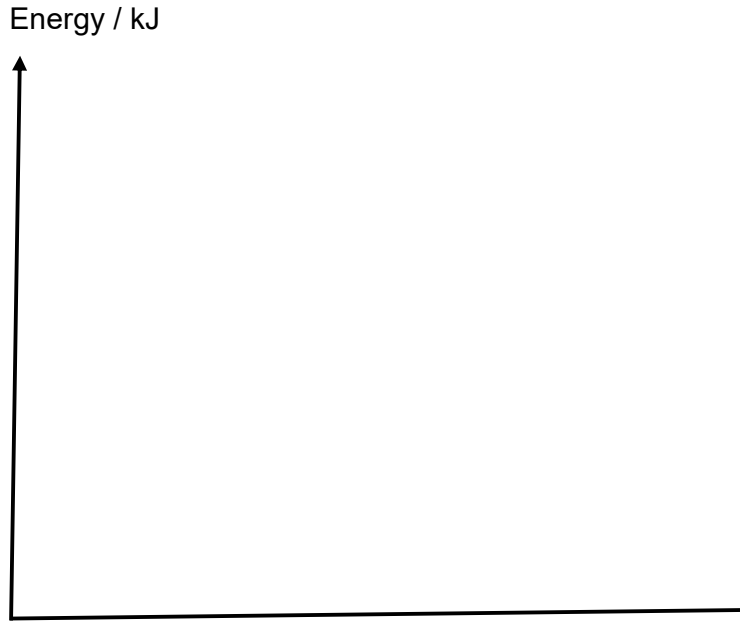
……

……

…… [2]

(c) Draw the energy profile diagram for the Andrussow process. Your diagram should show and label

- reactants and products
- the enthalpy change, ΔH and activation energy, E_a



[3]

(d) To speed up the Andrussow process, a small amount of powdered platinum is added. Use ideas about energy and collisions to explain how powdered platinum speeds up the process.

……

……

…… [3]

5 The body obtains iodine from certain food to make thyroid hormones. When iodine is added to starch solution, a dark blue colour is observed. Aqueous iodine reacts with sodium thiosulfate. The chemical equation of the reaction is shown below.

$$I_2\,(aq) + 2Na_2S_2O_3\,(aq) \rightarrow 2NaI\,(aq) + Na_2S_4O_6\,(aq)$$

The concentration of iodine in an unknown sample can be determined using a known concentration of sodium thiosulfate using titration method.

(a) Explain why starch is added to the analyte containing unknown concentration of iodine during the titration.

……..

…….. [1]

(b) Calculate the concentration of iodine in a 25.0 cm^3 of sample given that 11.0 cm^3 of 0.12 mol/dm^3 of sodium thiosulfate solution is needed to reach the end point in the titration.

[3]

(c) Draw a 'dot-and-cross' diagram to show the bonding in NaI. Show only the valence electrons.

[2]

6 Fig. 6.1 shows various reactions involving organic compounds, with ethene as the starting materials.

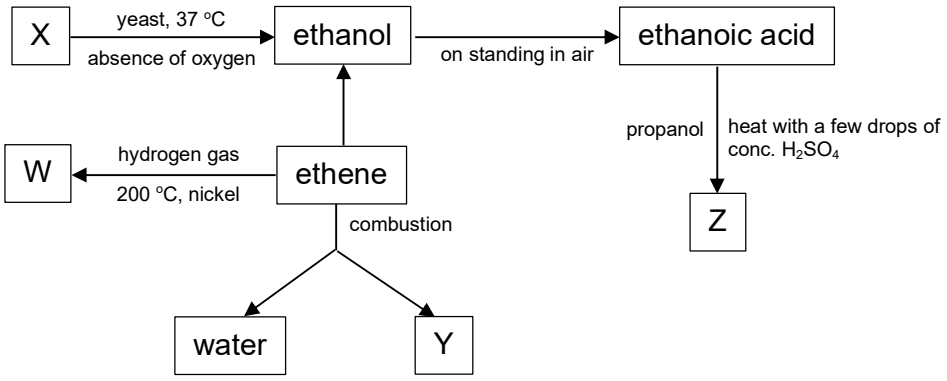


Fig. 6.1

(a) (i) Identify W, X and Y.

W: …… X: ……...

Y: ……

[3]

(ii) Draw the full structural formula of Z.

[1]

(b) Name the following processes.

(i) Ethene is converted to ethanol: ……..…… [1]

(ii) Ethanol is converted to ethanoic acid: …….. [1]

(c) State the reagent and conditions required for conversion of ethene to ethanol.

……

…… [2]

(d) Describe the method to distinguish between a sample of ethanol and ethanoic acid.

……

……

…… [2]

(e) Fig. 6.2 shows the structural formula of fumaric acid.

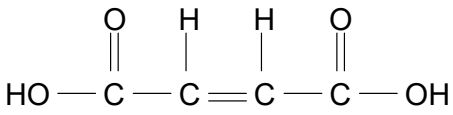


Fig. 6.2

Fumaric acid can also undergo addition polymerisation to form another polymer **N**.

Draw the structure of **N**, showing two repeating units.

[1]

7 In Fig. 7.1, each cell contains a concentrated aqueous salt solution containing chloride and dilute sodium sulfate solution with graphite electrodes and platinum electrodes respectively.

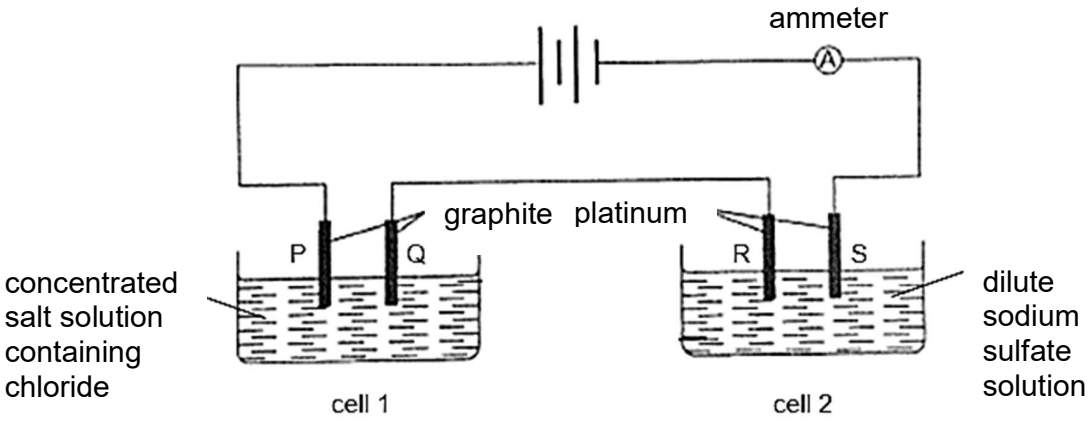


Fig. 7.1

(a) (i) A yellowish-green gas was produced at electrode P in cell 1. Explain how the gas was formed. Include in your answer a half equation to show its formation.

……

……

…… [2]

(ii) After 10 min of electrolysis, a white precipitate was seen around electrode Q. A sample of this white precipitate was added to a test-tube containing excess aqueous ammonia. It was noted that the white precipitate dissolves to form a colourless solution.

Name the salt solution used in cell 1.

…… [1]

(iii) State the half equations that happened at electrode R and S.

At R: ……...

At S: …… [2]

(iv) Calculate the mass of oxygen gas produced when 9.6 dm^3 of hydrogen gas is produced in cell 2 at room temperature and pressure.
(One mole of gas occupies 24 dm^3 at room temperature and pressure)

[3]

(v) State one change in observation of cell 2 when the electrolyte is changed to dilute copper sulfate.

……

…… [1]

(b) Fig. 7.2 shows a cross sectional diagram of a dry cell. This cell uses ammonium chloride as a paste electrolyte with only enough moisture to allow current to flow.

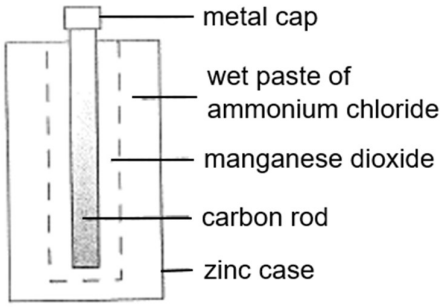


Fig 7.2

The overall reaction occurring in the dry cell can be represented by the equation below:

$$Zn + 2MnO_2 + 2NH_4Cl \rightarrow Mn_2O_3 + H_2O + ZnCl_2 + 2NH_3$$

Using a suitable half-equation, state the direction of the electron flow in this dry cell.

……

……

…… [2]

8 There are several atmospheric pollution problems currently threatening the Earth's general environment. The increased use of fossil fuels has a negative effect on the health of the environment in terms of air and water pollution.

Of all the fossil fuels, coal is the least expensive for its energy content. However, burning coal in electric power plants is a major source of carbon dioxide emissions. It also releases substantial amounts of methane. The U.S. Environmental Protection Agency's Clean Power Plan, as well as the low cost of natural gas, is leading older coal plants to close and reducing interest in new coal plants. Thus, alternative sources of energy used as fuels are constantly sought after to meet the increasing demands of human activities.

Fig. 8.1 below shows the changes in the type of fuel used between 1990 and 2002.

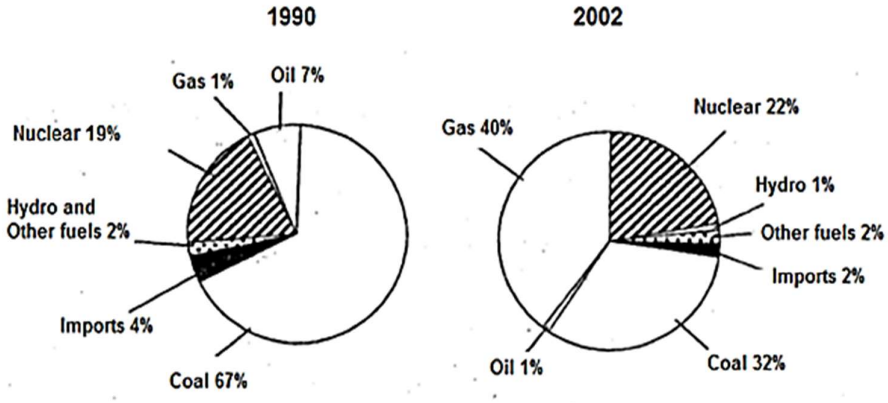


Fig 8.1

The air : fuel ratios for a few types of fuel as shown in Table 8.2.

type of fuel	air : fuel ratio (by volume)
gas	14.2 – 14.6
coal	120 –140
oil	170 –195

Table 8.2

Air pollution is caused by solid particles and poisonous gases in the air. These substances are called air pollutants, which include carbon monoxide and unburnt hydrocarbons.

(a) Using information provided in Fig. 8.1, state one main change in the type of fuel used over 12 years from 1990 to 2002.

……

…… [1]

Fig. 8.2 shows the relationship between the air : fuel ratio and the production of air pollutants by the vehicle engines.

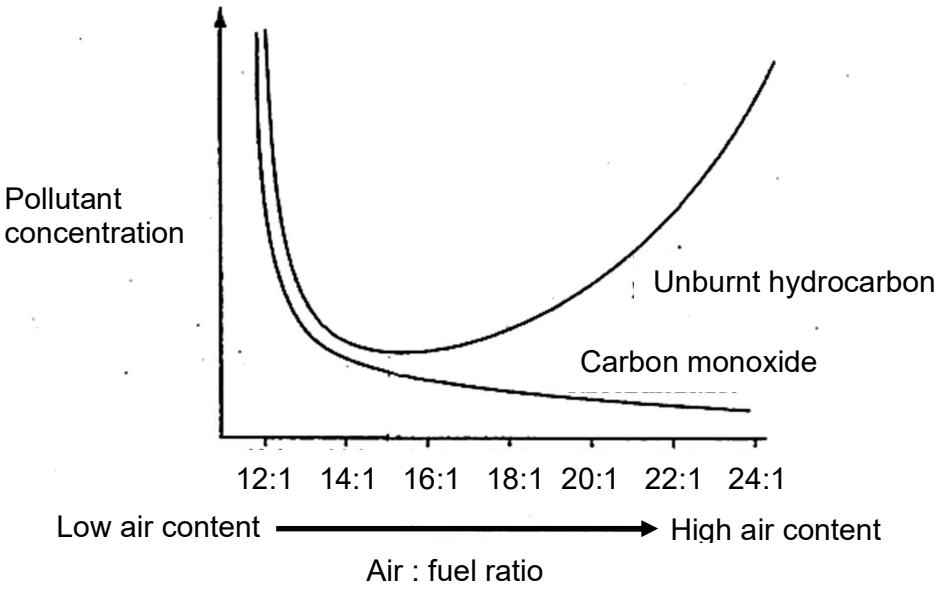


Fig. 8.2

(b) Drawing references from the data, suggest how the change in type of fuel impacts the environment.

.....

.....

..... [3]

(c) The graph in Fig. 8.3 shows how the average temperature at the Earth's surface has changed over the last 150 thousand years. The graph in Fig. 8.4 shows how the percentage of carbon dioxide in the atmosphere has changed over the last 150 thousand years.

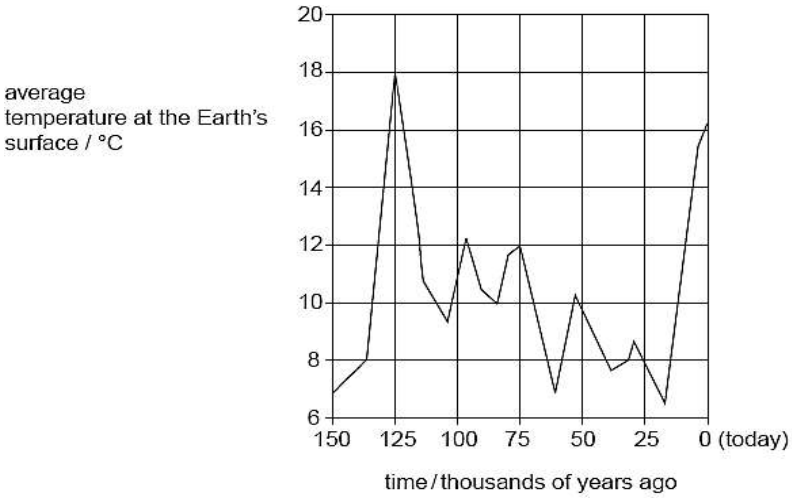


Fig. 8.3

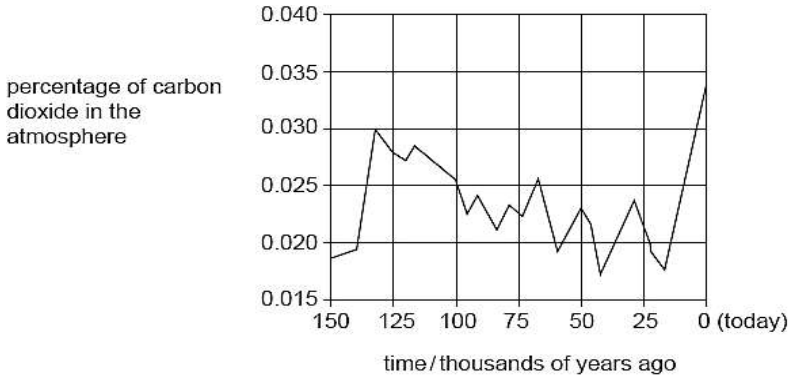


Fig. 8.4

Using Fig. 8.3 and Fig. 8.4, describe the general relationship between the percentage of carbon dioxide in the atmosphere and the average temperature at the Earth's surface.

……

…… [1]

Carbon dioxide can be isolated form dry air. Dry air is essential for industrial use. Table 8.5 below some properties of gases in dry air.

gas in dry air	density/ kg/m^3	melting point/ °C	boiling point/ °C	percentage in air/ %
Nitrogen	1.2506	−210	−196	78.06
Oxygen	1.4290	−219	−183	20.95
Carbon dioxide	1.977	−57	−55	0.033
Argon	1.7837	−189	−186	0.934
Krypton	3.74	−157	−153	0.00011

Table 8.5

(d) (i) The individual gases in dry air are useful raw materials in many different industrial processes. State a suitable technique to separate the different gases in dry air.

…… [1]

(ii) Dry air can be liquified at −196 °C at atmospheric pressure. Two gases are not able to be collected individually when the liquefied air is allowed to warm up. State these two gases and use the data to support your answer.

……

…… [2]

(iii) Using the knowledge of electronic structure, explain why the noble gases are able to provide inert environments for high-temperature chemical processes.

……

…… [1]

Section B

Answer one question.

9 The ionic radius of an ion can be taken to be the distance between the nucleus and the electron in the outermost shell of an ion. Table 9.1 shows the ionic radii of some Group 1 and Group 17 ions.

Group 1 ion	ionic radius/ pm	Group 17 ion	ionic radius/ pm
lithium	70	fluorine	126
sodium	95	chlorine	181
potassium	133	bromine	195

Table 9.1

The melting point of an ionic compound is related to its ionic charges and radii. Table 9.2 shows the melting points and the lattice enthalpies of some ionic compounds.

ionic compound	melting point/ °C	magnitude of product of ionic charges	sum of ionic radii/ pm
lithium fluoride	848	1	196
sodium chloride	801	1	276
sodium bromide	747	1	
potassium bromide	734	1	

Table 9.2

(a) Explain why the magnitudes of product of ionic charges of the ionic compounds shown in Table 9.2 are 1.

……..

……..

…….. [2]

(b) Complete Table 9.2 by calculating the sum of ionic radii for sodium bromide and potassium bromide [1]

(c) (i) State the relationship between the melting points and the sums of ionic radii of the ionic compounds.

……..

…….. [1]

(ii) Using your knowledge on the bonding of ionic compounds, explain the relationship stated in **(c)(i)**.

……

……

……

…… [2]

(d) Copper can react with either chlorine or bromine to form copper(II) halide.

$$Cu + Cl_2 \rightarrow CuCl_2$$

$$Cu + Br_2 \rightarrow CuBr_2$$

(i) State and explain, which of the above reaction will take place at a faster rate.

……

…… [1]

(ii) State the observation when chlorine gas is bubbled into aqueous $CuBr_2$ solution. With the help of an ionic equation, explain your prediction.

……

……

……

…… [3]

10 Atomic radius is defined as the distance measured from the center of the nucleus to the valence electron shell in the atom. Fig. 10.1 shows the atomic radii of some elements in Period 1 to Period 3 of the Periodic Table.

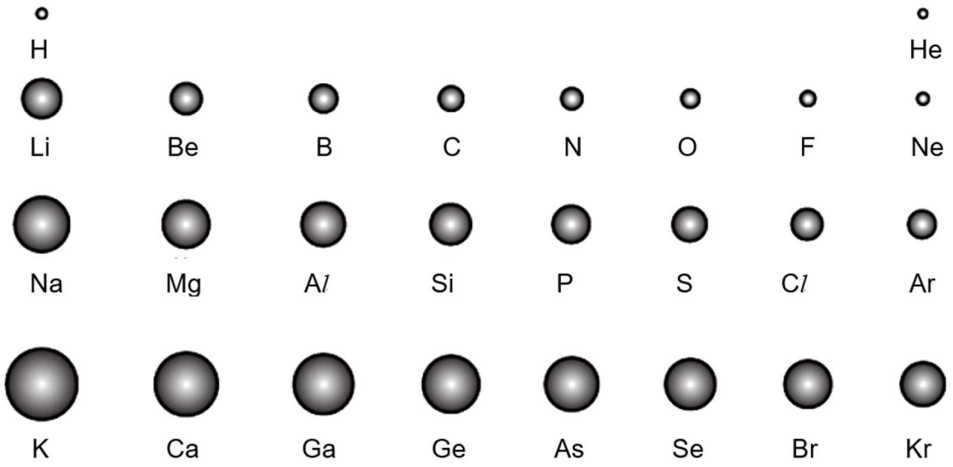


Fig. 10.1

(a) (i) Two students talk about the data presented.

Student 1: 'I think that whether or not an element undergo oxidation reduction is linked to its position on the Periodic Table.'

Student 2: 'I think that whether or not an element undergo oxidation reduction is linked to the size of the atoms.'

Does the data presented support the students' statements? Explain your reasoning.

……

……

……

…… [2]

(ii) Using your knowledge of halogens, state the relationship between atomic radius and its reactivity.

……

…… [1]

(b) A student carried out some experiments involving four metals found in Table 10.1, namely A/(aluminum), Ca (calcium), Mg (magnesium) and Na (sodium). Table 10.2 shows the results.

Key ✓ shows a reaction happened
× shows no reaction happened
− shows the experiment was not performed

	metal W	**metal X**	**metal Y**	**metal Z**
solution of **W** nitrate	–	×	×	×
solution of **X** nitrate	–	–	✓	✓
solution of **Y** nitrate	–	×	–	✓
solution of **Z** nitrate	–	×	×	–

Table 10.2

(i) Due to safety reasons, the reactions between metal **W** with the various solutions are not performed. Metal **W** is a shiny solid that can be cut with a knife and has a density of 0.971 g/cm^3. Suggest the identity of metal **W**.

……

…… [1]

(ii) Under a controlled environment, a small piece of metal **W** is dropped into a basin water. State the observations.

……

……

…… [2]

(iii) Suggest the identities of metal **X**, **Y** and **Z**. Explain your answer.

……

……

…… [3]

(iv) Using the identities in **(iii),** write a balanced equation of the reaction between solution of **Y** nitrate and metal **Z**.

……

…… [1]

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 x 10^{23} mol^{-1}