Candidate Name	Class	Index Number

ST ANDREW'S SECONDARY SCHOOL
MID–YEAR EXAMINATION 2021
SECONDARY 4 EXPRESS

CHEMISTRY 6092/2

Paper 2

Thursday **29 April 2021** **1 hour 45 minutes**

READ THESE INSTRUCTIONS FIRST

Do not open this question paper until you are told to do so.

Write your name, class and index number in the spaces provided on this question paper.
Write in dark blue or black pen.
You may use a pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section B
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions 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 20.

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

FOR EXAMINER'S USE
/ 80

This question paper consists of 20 printed pages.

[Turn over

Section A

Answer **all** questions in this section in the spaces provided.
The total mark for this section is 50.

A1 The positions of the elements in the Periodic Table often reflect their properties.
Fig 1.1 shows the positions of some elements.

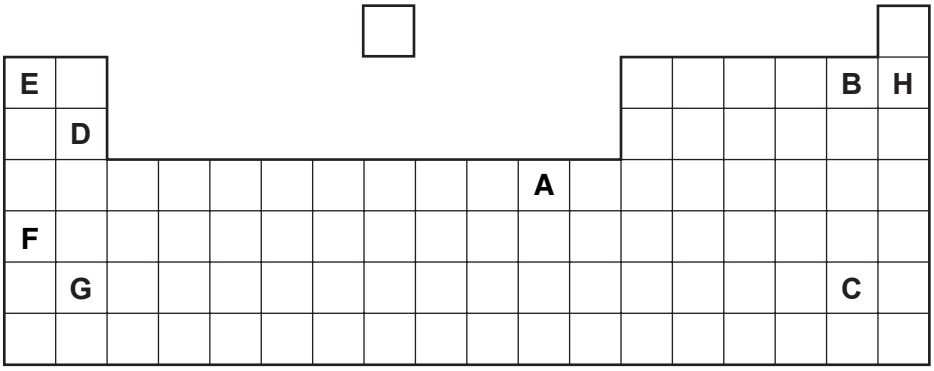


Fig 1.1

Answer the following questions about elements **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H**.
Each element may be used once, more than once or not at all.

(a) Identify the element that

(i) forms an aqueous hydroxide **and** an insoluble sulfate, ... [1]

(ii) has the largest atomic radius **and** a valency of 1, ... [1]

(iii) has the lowest boiling point, ... [1]

(iv) represents the strongest reducing agent. ..... [1]

(b) Equal amounts of two elements were reacted with excess dilute nitric acid in separate test tubes at 25 °C.

Observations made from each test tube are shown in **Fig 1.2**.

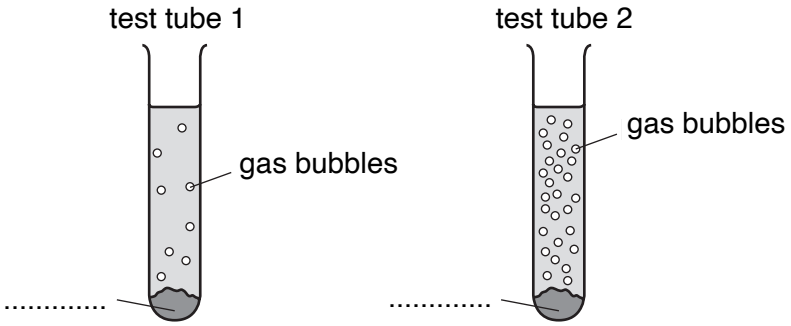


Fig 1.2

Label **Fig 1.2** with the element that has reacted in each test tube. [2]

A2 Sulfur is a non–metallic element.

(a) Sulfur forms numerous allotropes, of which two are illustrated in **Fig 2.1**.

Fig 2.1

(i) What is the meaning of the term *allotropes*?

.....

..... [1]

(ii) Predict, and explain, the allotrope that has a higher melting point.

.....

..... [2]

(b) The relative atomic mass of a sample of sulfur can be calculated using results from the mass analysis of its isotopes. **Fig 2.2** shows the results from the analysis of a sample of sulfur, with percentage composition of each isotope labelled.

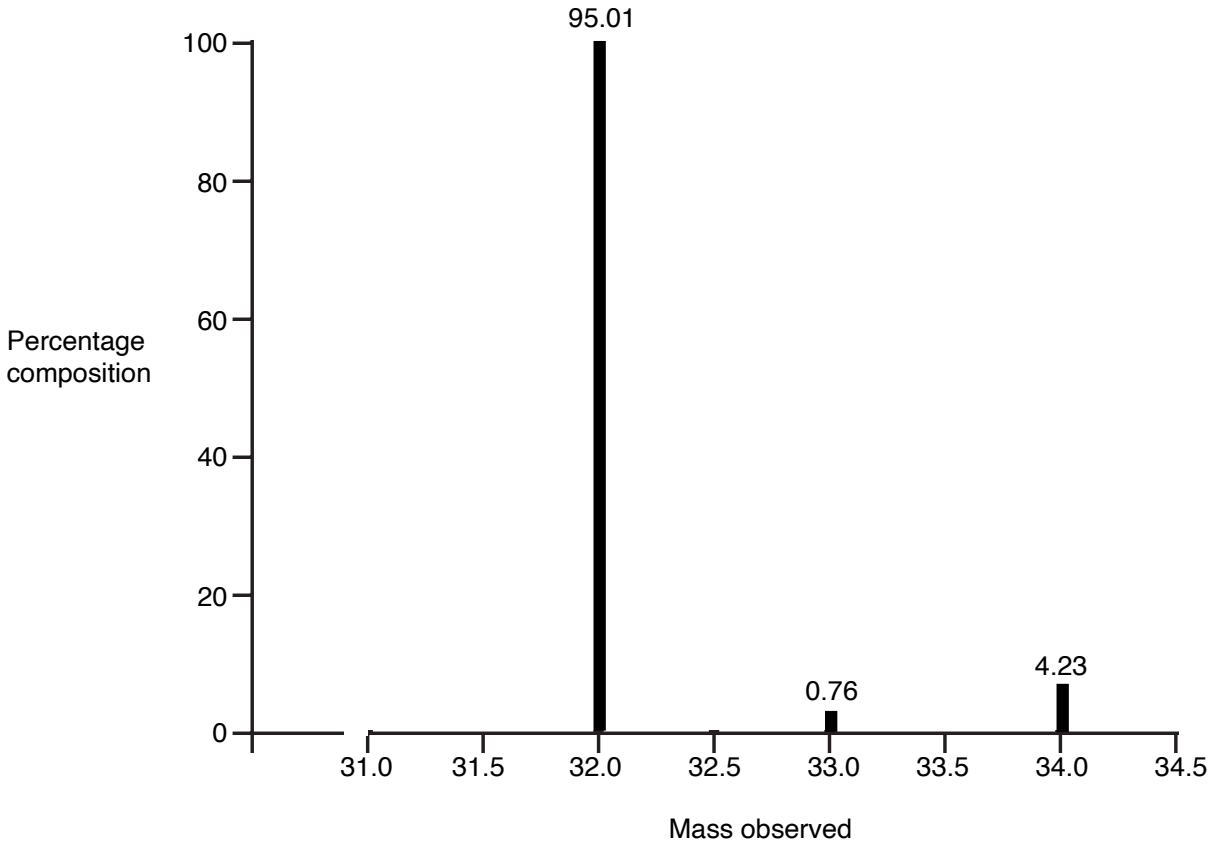


Fig 2.2

(i) Explain why different masses are observed between the isotopes.

..... [1]

(ii) Use **Fig 2.2** to calculate the relative atomic mass of the sample of sulfur.
Give your answer to 4 significant figures.

relative atomic mass of S = ... [2]

(iii) Suggest why the relative atomic mass of sulfur provided in the Periodic Table is slightly different from your answer calculated in **(ii)**.

..... [1]

A3 Hydrogen reacts with other elements to form compounds known as hydrides.

(a) **Fig 3.1** shows the dot-and-cross diagram of a molecule of borane, BH_3.

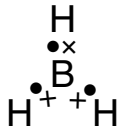


Fig 3.1

(i) Describe **one** feature that is unusual about this BH_3 molecule.

.....

..... [1]

(ii) Predict the physical state of BH_3 at room temperature.
Explain your answer.

.....

..... [2]

(b) The dot-and-cross diagram of magnesium hydride, MgH_2, shown in **Fig 3.2** does not exist.

Fig 3.2

(i) Explain why the bonding in **Fig 3.2** does not exist.

.....

..... [2]

(ii) Draw the dot-and-cross diagram that exists for MgH_2.
Show outer shell electrons only.

[2]

(iii) Use the diagram in **(b)(ii)** to explain why molten MgH_2 is an electrolyte.

.....

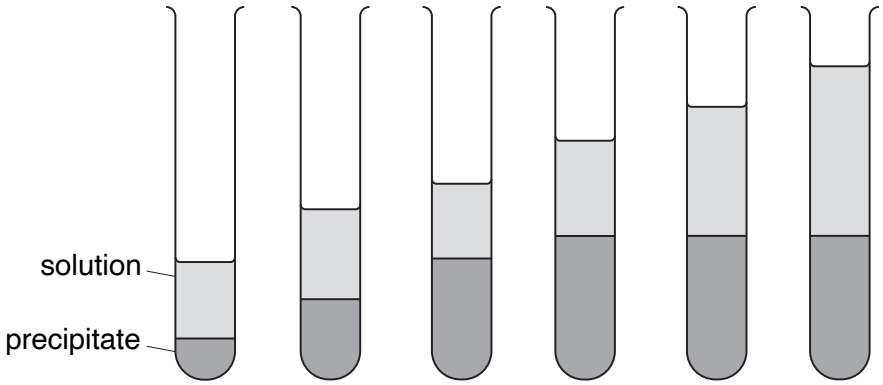
..... [1]

A4 **Q** is a 0.100 mol/dm^3 solution of potassium iodide.
T is a 0.100 mol/dm^3 colourless solution of a metal nitrate.

A student conducted the experiment described below to identify the metal nitrate in **T**.

step 1	8.0 cm^3 of **Q** was measured using a 10.0 cm^3 measuring cylinder and added into each of the six test tubes labelled 1 – 6.
step 2	A burette was filled with **T**.
step 3	1.0 cm^3 of **T** was added into test tube 1.
step 4	2.0 cm^3 of **T** was added into test tube 2.
step 5	3.0 cm^3 of **T** was added into test tube 3.
step 6	4.0 cm^3 of **T** was added into test tube 4.
step 7	5.0 cm^3 of **T** was added into test tube 5.
step 8	6.0 cm^3 of **T** was added into test tube 6.
step 9	When the precipitate in each test tube had completely settled, its height was measured and recorded.

Results of the experiment are presented in **Fig 4.1**.



test tube	1	2	3	4	5	6
volume of **T** / cm^3	1.0	2.0	3.0	4.0	5.0	6.0
height of precipitate / mm	6.0	12.0	18.5	24.0	24.5	24.0

Fig 4.1

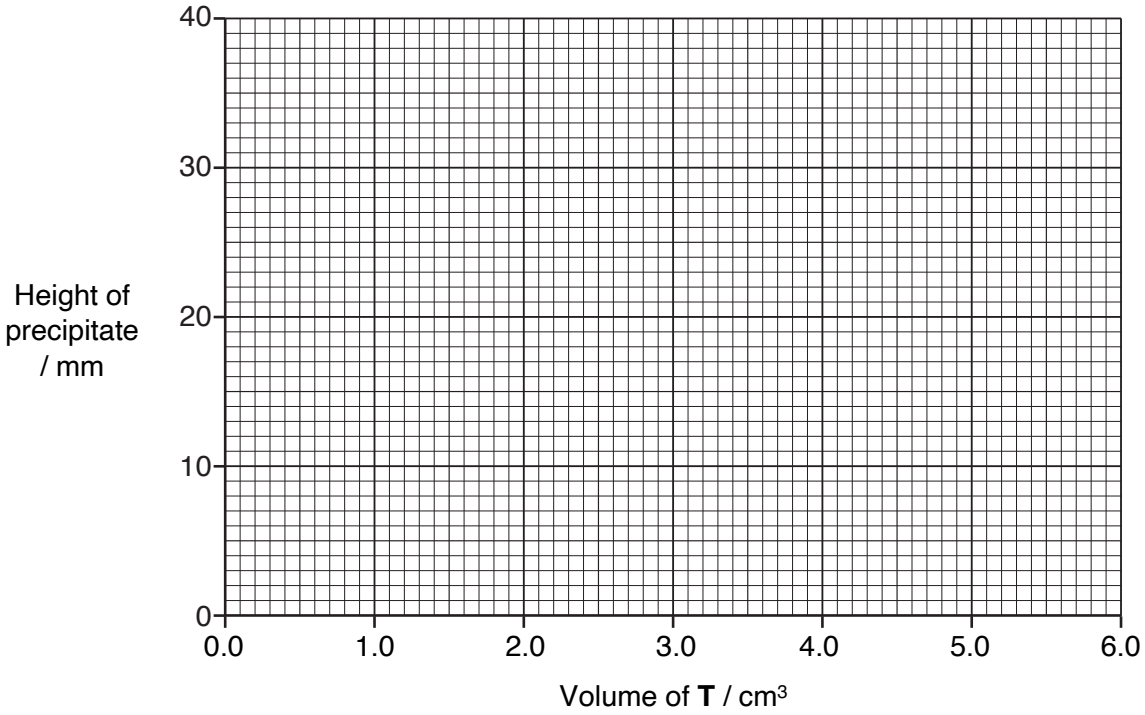
(a) Before conducting the experiment, the student concluded that it is not possible for **T** to contain Cu^{2+}, Fe^{2+} or Fe^{3+}.

Explain why.

.....

..... [1]

(b) Plot the results in **Fig 4.1** on the grid below and draw two intersecting lines through the points.



[2]

(c) Use your graph in **(b)** and deduce the chemical formula of **T**.
Describe briefly how you derived at this answer.

chemical formula .....

.....

..... [3]

(d) Suggest **one** improvement made to the experiment that could improve the accuracy of the results.

.....

..... [1]

A5 Nitrous oxide, N_2O, is a colourless gas widely used as a propellant in aerosol cans of whipped cream.

(a) Ammonium nitrate, NH_4NO_3, is heated gently to produce N_2O.
4.40 g of NH_4NO_3 was used in a reaction.

(i) Calculate the mass of N_2O produced in this reaction.

mass of N_2O produced = ... g [2]

(ii) Determine the percent yield of this reaction if 2.50 g of N_2O was produced.

yield of reaction = ... % [1]

(iii) Provide an explanation for the yield determined in **(a)(ii)**.

.....

..... [1]

(b) N_2O is occasionally injected into the engines of racing cars to give more power for short bursts of acceleration. N_2O decomposes exothermically to N_2 and O_2.

Propose **two** ways how the introduction of N_2O provides the extra boost to engine.

1 .....

2 ..... [2]

A6 Chlorofluorocarbons, or CFCs, are the group of compounds widely used as coolants in refrigerators that have been released into the atmosphere within the last few decades. Scientists discovered that the presence of CFCs in the atmosphere have resulted in the depletion of the ozone layer.

(a) What is the role of the ozone layer?

.....

..... [1]

(b) How CFCs in the atmosphere have resulted in the depletion of the ozone layer?

.....

..... [2]

(c) State **one** environmental effect of the presence of CFCs in the atmosphere.

..... [1]

Fig 6.1 is a graph showing the relative amount of CFCs recorded over a number of years.

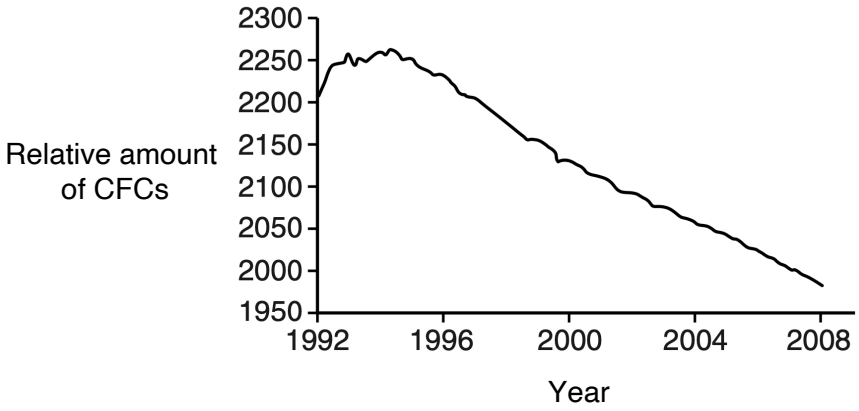
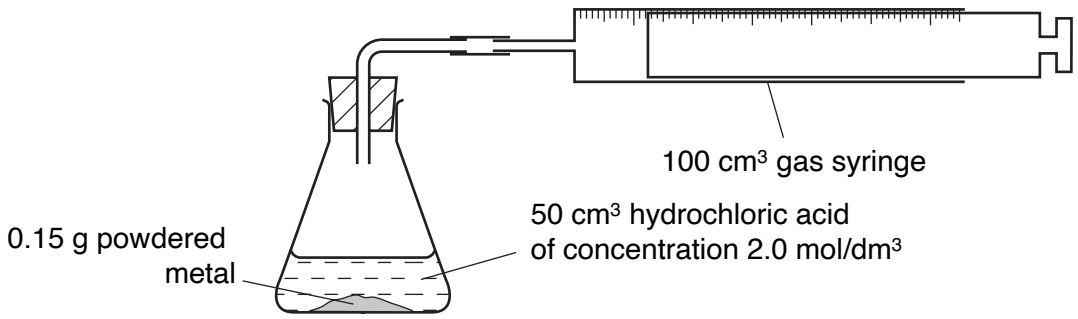


Fig 6.1

(d) With reference to **Fig 6.1**, state the unique characteristics of CFCs.

..... [1]

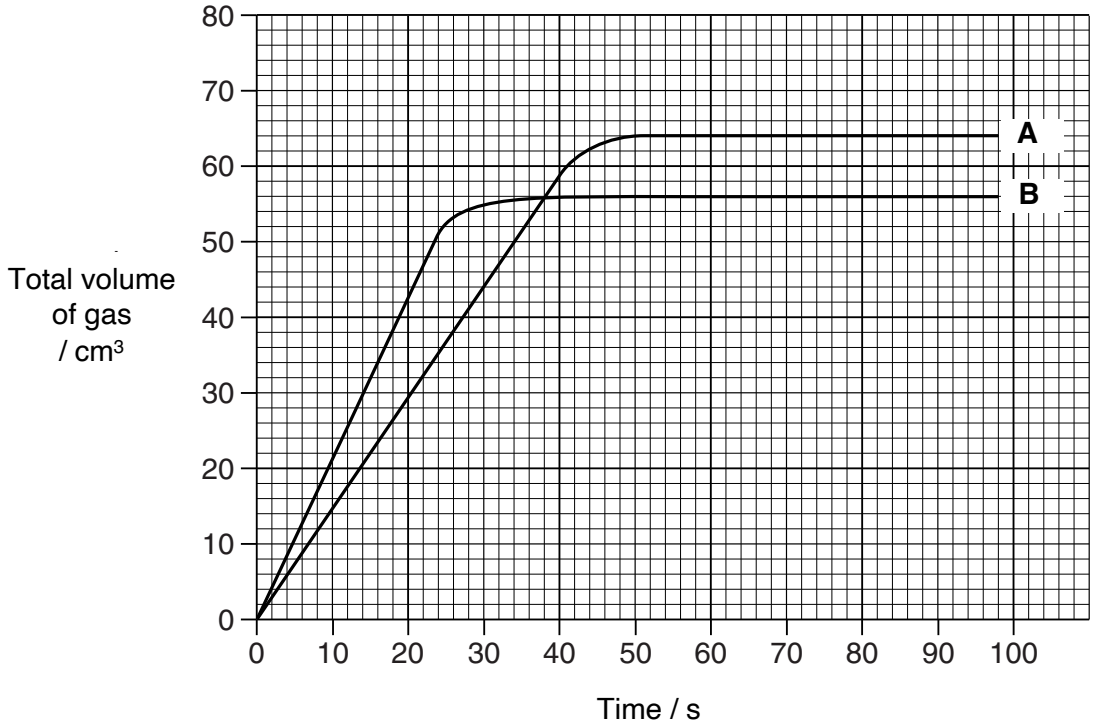
A7 The following apparatus is used to investigate the reaction between hydrochloric acid and two different metals, iron and zinc.



In each experiment,

- 0.15 g powdered metal was added into a conical flask containing 50 cm^3 hydrochloric acid of concentration 2.0 mol/dm^3.
- the volume of gas produced was measured every 10 seconds using the gas syringe.

The graphs below show the results obtained.



(a) Name the gas produced.
Suggest a suitable chemical used to confirm the identity of this gas.

name .....

.....

..... [3]

(b) Explain why a difference in the volume of gas produced even though the metal used in each experiment has a same mass.

.....

..... [1]

(c) **(i)** Identify the metal used for each graph produced.

A ..... **B** ..... [1]

(ii) Describe how you derived at the answer in **(c)(i)**.

.....

..... [2]

(d) State and explain, using ideas about bond breaking and bond forming, if the reaction is endothermic or exothermic.

.....

..... [2]

(e) Deduce, by way of calculations, if the limiting reactant in this reaction is the metals or the hydrochloric acid.

limiting reactant ..... [2]

Section B

Answer all **three** questions in this section.
The last question is in the form of an either/or and only one of the alternatives should be attempted.

The total mark for this section is 30.

B8 A chemist performed an electrolysis that involved 2.0 dm^3 aqueous silver nitrate solution using inert electrodes as shown in **Fig 8.1**.

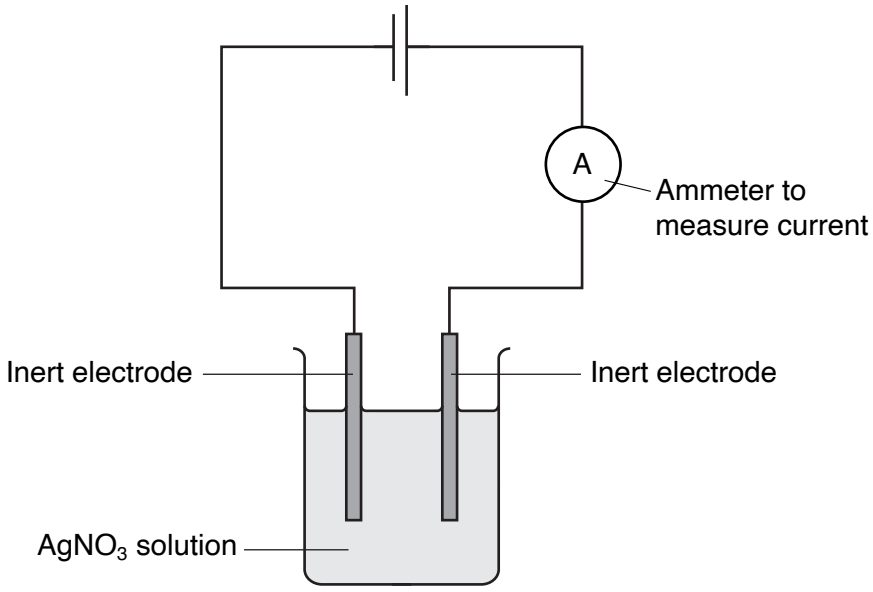


Fig 8.1

In this electrolysis, a current of 1.0 A was passed and the increase in the mass of the cathode was determined every 5 minutes for a duration of 50 minutes, and then recorded in **Table 8.1**. Thereafter, he repeated the electrolysis using a current of 1.2 A instead.

Table 8.1

Time / min		5	10	15	20	25	30	35	40	45	50
Increase in mass of cathode / g	**Current of 1.0 A**	0.34	0.67	1.01	1.34	1.68	2.01	2.35	2.68	2.68	2.68
	Current of 1.2 A	0.40	0.81	1.21	1.61	2.01	2.41	2.68	2.68	2.68	2.68

(a) Write the half-cell equation, with state symbols, for the reaction at the

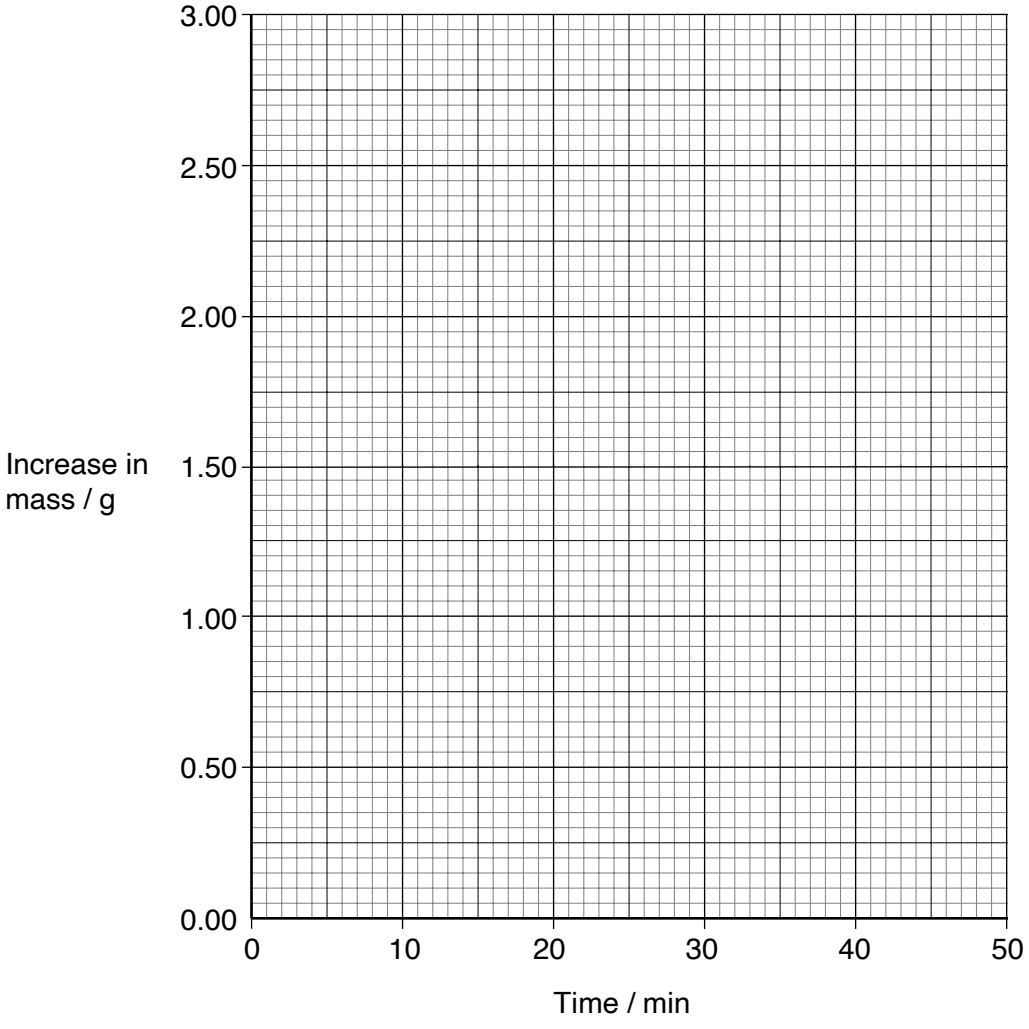
(i) anode,

..... [1]

(ii) cathode.

..... [1]

(b) Use the data from **Table 8.1** to plot two graphs on the grid below to show how the increase in mass of the cathode changes with time when different currents were used.
Label both graphs clearly.



[3]

(c) Compare and comment on the two graphs provided in **(b)**.

.....

..... [2]

(d) Determine the concentration, in mol/dm^3, of the aqueous silver nitrate solution used in both electrolysis.

[2]

(e) The chemist performed another electrolysis using aqueous iron(III) nitrate solution and a current of 1.0 A.

What would be the change in mass of the cathode, if any, at the end of 10 minutes?

[1]

(f) The chemist commented that graphite should **not** be used in both electrolysis.

(i) Provide a possible explanation for his comment.

.....

..... [1]

(ii) Name a suitable material that he could use as electrodes.

..... [1]

B9 Over the past 150 years, three different methods have been utilised in the extraction of bromine from potassium bromide. The methods are described below.

method 1
By reacting potassium bromide with MnO_2 and H_2SO_4:

$$2KBr\ (aq) + MnO_2\ (s) + 2H_2SO_4\ (aq) \rightarrow MnSO_4\ (aq) + K_2SO_4\ (aq) + 2H_2O\ (l) + Br_2\ (l)$$

method 2
By reacting potassium bromide with concentrated H_2SO_4:

$$2KBr\ (aq) + 2H_2SO_4\ (l) \rightarrow K_2SO_4\ (aq) + SO_2\ (g) + 2H_2O\ (l) + Br_2\ (l)$$

method 3
By bubbling chlorine gas into potassium bromide:

$$2KBr\ (aq) + Cl_2\ (aq) \rightarrow 2KCl\ (aq) + Br_2\ (l)$$

(a) Identify the reducing agent in all three methods.
Support your answer in terms of the change in oxidation states.

.....

..... [2]

(b) Method 3 is described an example of a displacement reaction.

(i) Describe the observations made in method 3.

.....

..... [1]

(ii) Explain how the observations described in **(b)(i)** relate to the relative oxidising strength of the elements, chlorine and bromine.

.....

.....

..... [2]

(c) Suggest **one** reason why method 3 is preferred over the other two methods in the extraction of bromine today.

.....

..... [1]

(d) Bromine can be used to treat swimming pools when added into water, according to the chemical equation:

$$Br_2 + H_2O \rightarrow HBrO + HBr$$

Br_2 is said to undergo *disproportionation*.

By comparing **changes** in its oxidation states, explain the meaning of the term *disproportionation*.

.....

.....

..... [2]

B10 Either

Iron is one of the most important metals used in our everyday lives.

(a) **Fig 10.1** shows the structure of iron.

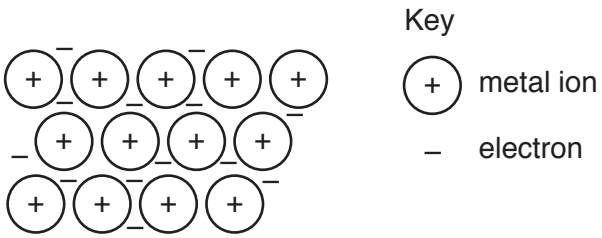


Fig 10.1

Refer to the structure in **Fig 10.1** to explain why

(i) iron is malleable,

.....

..... [2]

(ii) iron is a good conductor of electricity.

.....

..... [1]

(b) Iron is often alloyed with other elements to resist corrosion.

Name one element may be used, and suggest how this element helps iron to resist corrosion.

.....

..... [2]

(c) In an investigation of the rate of reaction between sulfuric acid and iron, the curve in **Fig 10.2** was obtained.

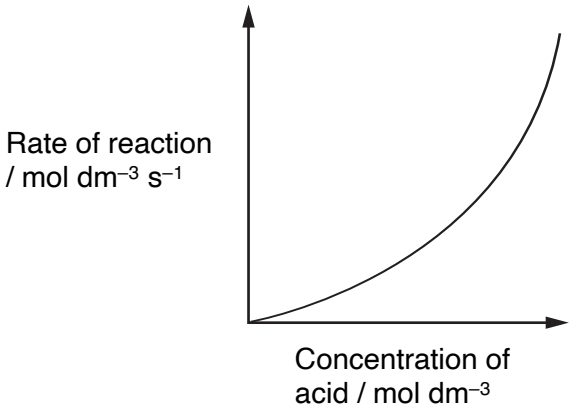


Fig 10.2

(i) Use your understanding of collision theory to explain the shape of the curve in **Fig 10.2**.

.....

.....

.....

..... [2]

(ii) Describe how the rate of reaction is determined experimentally.

.....

.....

.....

.....

.....

..... [3]

B10 OR

Iron is a transition metal.

(a) (i) Suggest one **physical** property of iron that is typical of a transition metal.

..... [1]

(ii) Suggest one **chemical** property of iron compounds that is typical of compounds of transition metals.

..... [1]

(b) Iron needs to be alloyed into steel before being used to make underground water pipes.

With the aid of a labelled diagram, explain why the need to alloy iron into steel used to make underground water pipes.

.....

.....

.....

..... [2]

(c) **Fig 10.3** shows a blast furnace used to extract iron from its ore at high temperatures.

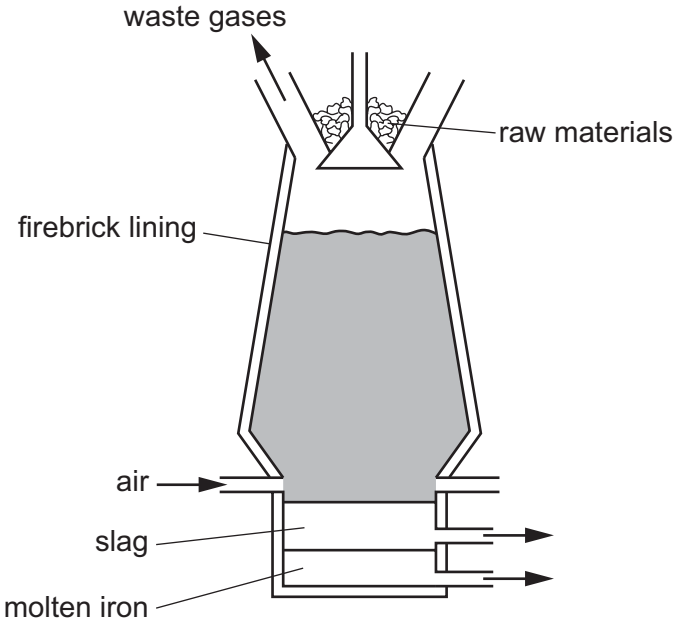


Fig 10.3

(i) State the name of the iron ore added into the blast furnace.
Explain how iron is extracted from this ore.

.....

.....

.....

.....

.....

..... [3]

(ii) The height of a typical blast furnace is approximately 30 m.

Use your understanding of collision theory to explain how high temperatures in the blast furnace ensures the successful extraction of iron from its ore within 30 m.

.....

.....

.....

..... [2]

(iii) Magnesium oxide is a good material used to make the firebrick lining of a blast furnace.

Give **one** reason why.

.....

..... [1]

END OF PAPER

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							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											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 –		114 Fl flerovium –		116 Lv livermorium –		

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.).