REGENT SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2020
SECONDARY FOUR (EXPRESS)

NAME: _____ INDEX NUMBER: _____

CLASS: _____ SETTER : MS CHEW HC

CHEMISTRY 6092/02

Paper 2 **17 Sep 2020**

1 hour 45 minutes

Candidates answer on the Question Paper
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Index number and name 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 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.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 27.

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

	TARGET
80	
PARENT'S SIGNATURE	

Section A [50 marks]

Answer the following questions in this section in the spaces provided.

A1 **(a)** Use the list of substances below to answer the following questions.

Phosphoric acid	**Copper**	**Sodium iodide**
Sodium hydroxide	**Nitric acid**	**Ammonia**
Nitrogen	**Methane**	**Aluminium**

(i) Which substance is an element that exists as small molecules?

…… [1]

(ii) Which substance forms a positive ion that is more reactive than zinc ion?

…… [1]

(iii) Which acidic substance, in mol/dm^3 of solution, will have the highest pH value?

…… [1]

(iv) Which substance is displaced from its salts under alkaline conditions?

…… [1]

(v) Which substance, when in solution, is used to distinguish between aluminium and lead (II) ions?

…… [1]

(b) Which of the following statements about carbon monoxide is(are) true and which is(are) false?

Put a tick (✓) in one box in each row.

	True	**False**
It is the main reducing agent in iron extraction in the Blast Furnace.		
It is not an acidic oxide		
It is removed in a catalytic converter by reaction with nitrogen.		
It can be detected by smell when incomplete combustion of carbon-containing fuels occurs		

[2]

[Total: 7]

A2 Elements in the same group in the Periodic Table can show different physical properties.

For example, Group VII elements chlorine and bromine exist in different physical states. In another example shown in the table below, the melting points of Group IV elements show a marked change after germanium.

Element	C	Si	Ge	Sn	Pb
Melting point / °C	> 3550	1410	937	232	327

(a) State the melting point trend of the Group VII elements from chlorine to iodine.

…… [1]

(b) Carbon, silicon and germanium each form a solid with the same type of structure.

(i) What type of structure is present in carbon, silicon and germanium?

…… [1]

(ii) Suggest why the melting point of these elements decreases from carbon to germanium.

……..

…… [1]

(iii) State the physical states of bromine and germanium at room temperature.

Explain, in terms of bonding, why the physical states of bromine and germanium are different.

……..

……..

……..

……..

……..

…… [3]

(c) Silicon is able to react with chlorine to form a colourless liquid.

Draw a 'dot and cross' diagram to show the bonding in the colourless liquid, show only the outer electrons.

[2]

(d) Lead is able to form two chlorides, $PbCl_2$ and $PbCl_4$.

(i) State the oxidation states of lead in the two chlorides.

$PbCl_2$ = ……..

$PbCl_4$ = …….. [2]

(ii) When chlorine reacts with a saturated solution of $PbCl_2$ in NH_4Cl (aq), a yellow salt, **X** is formed.

X has the following composition by mass:

Cl 46.7%; H 1.76%; N 6.14%; Pb 45.4%

Calculate the empirical formula of **X**.

[3]

(d) (iii) **X** is ionic with a relative formula mass of 456. It contains ammonium ion and one type of polyatomic anion in the ratio of 2:1.

State the formula of the anion present in **X**.

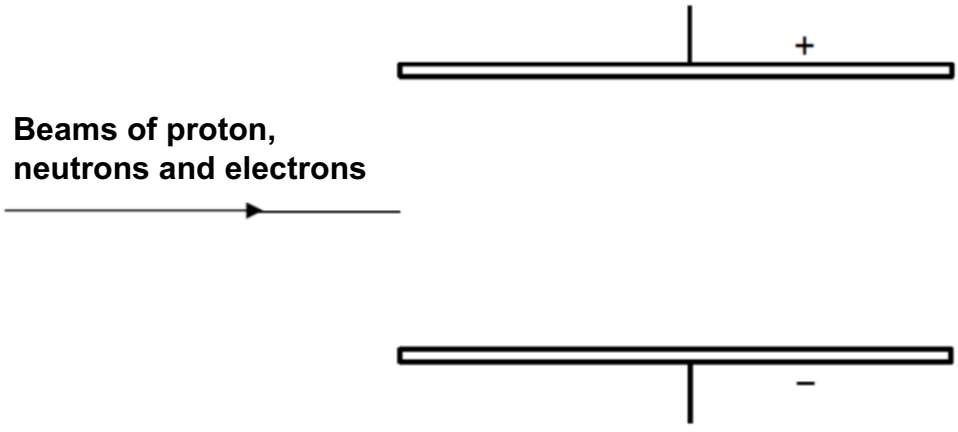
…… [1]

[Total: 14]

A3 The English chemist John Dalton proposed the modern atomic theory in 1803, that all elements are composed of atoms which are indivisible and cannot be created or destroyed.

We now know however that an atom is made up of three types of sub-atomic particles: protons, neutrons and electrons.

(a) Beams of protons, neutrons and electrons were fired into an electric field between two oppositely charged plates as shown below.



By considering their relative charges and masses, complete the above diagram to show the path taken by **each** beam of sub-atomic particles between the two charged plates. [2]

(b) The table below shows the number of sub-atomic particles in four species, $\mathbf{V}^{3-}$, **W**, $\mathbf{X}^{2-}$ and $\mathbf{Y}^{+}$.

Species	Number of protons	Number of neutrons	Number of electrons
$\mathbf{V}^{3-}$	15	16	18
W	15	17	15
$\mathbf{X}^{2-}$	16	16	
$\mathbf{Y}^{+}$	19	20	

(i) Write in the above table, the number of electrons for species $\mathbf{X}^{2-}$ and $\mathbf{Y}^{+}$. [1]

(ii) Atoms or ions that contain the same number of protons are called isotopic.
Those that contain the same number of neutrons are called isotonic.
Those that contain the same number of electrons are called isoelectronic.

Which of the species $\mathbf{V}^{3-}$, **W**, $\mathbf{X}^{2-}$ and $\mathbf{Y}^{+}$ are:

Isotopic	
Isotonic	
Isoelectronic	

[3]

[Total: 6]

A4 Limescale is a white deposit of calcium carbonate that is commonly found in kettles, hot water boilers and taps in countries where the water is 'hard' (rich in mineral deposits).

(a) A gas is produced in the reaction between limescale and an acid.

Describe a positive test for the gas produced in this reaction.

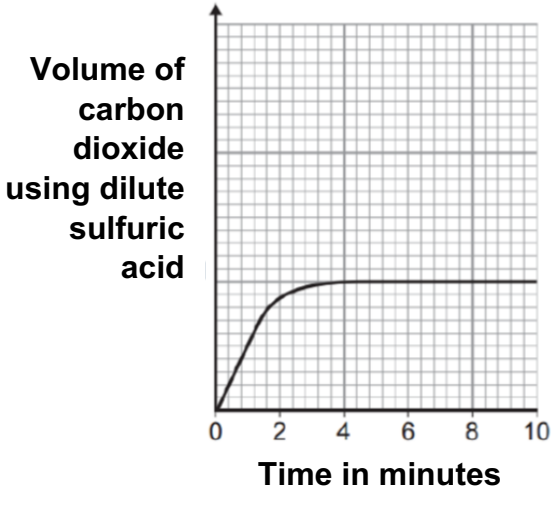
……..

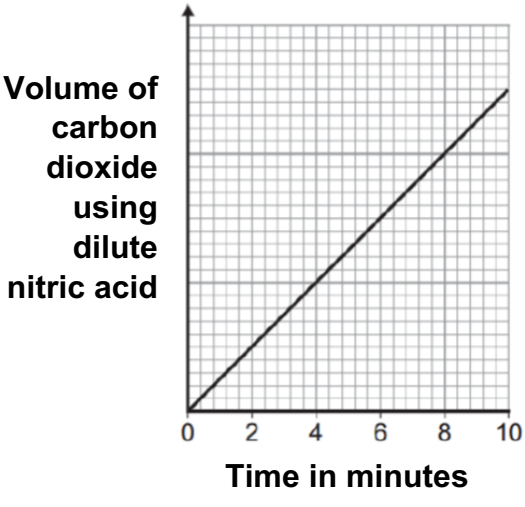
……. [2]

(b) A student wanted to compare the effectiveness of dilute sulfuric acid and dilute nitric acid in removing limescale.

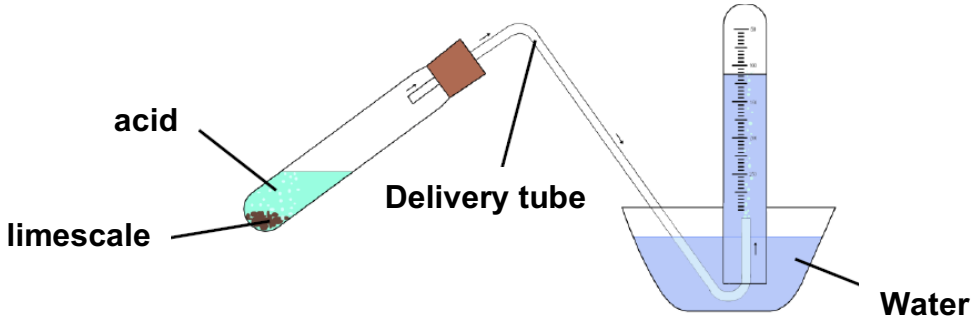
The student measured the volume of carbon dioxide produced each minute for a total of 10 minutes. He did this first for the reaction between dilute sulfuric acid and a fixed mass of limescale. The student then repeated the experiment using dilute nitric acid in place of the dilute sulfuric acid. All other variables were kept the same.

The results are shown below.





(b) **(i)** The student used the following apparatus for the collection of carbon dioxide.



Name this method of gas collection and state with a reason, why the measured volume of carbon dioxide is likely to be inaccurate.

……..

…… [2]

(ii) Write down the chemical equations, with state symbols, for the reactions between calcium carbonate and sulfuric acid and between calcium carbonate and nitric acid.

Reaction between calcium carbonate and sulfuric acid

……..

Reaction between calcium carbonate and nitric acid

……..

[3]

(iii) Describe how the results for the reaction of calcium carbonate with sulfuric acid and with nitric acid are different. Use your equations in **(b)(ii)** to explain this difference.

……..

……..

……..

……..

…… [3]

(c) Calcium carbonate can be used to reduce the effect of acid rain and in flue gas desulfurisation.

(i) Write a balanced chemical equation to represent the use of calcium carbonate in flue gas desulfurisation.

…… [1]

(ii) Unlike calcium hydroxide, calcium carbonate can be safely added to soils containing fertilisers such as ammonium nitrate to reduce soil acidity.

Explain why it is important **not** to use calcium hydroxide to treat soils containing ammonium nitrate fertilisers.

……..

…… [1]

(d) A technology known as carbon capture and storage is currently used to reduce emissions of carbon dioxide to the atmosphere.

One method of carbon capture and storage involves the use of calcium oxide and calcium carbonate, and is known as calcium looping.

The first step of calcium looping involves the use of calcium oxide to remove carbon dioxide from industrial waste gas emissions.

Step 1 : $CaO\ (s) + CO_2\ (g) \rightarrow CaCO_3\ (s)$

In the second step, solid calcium carbonate is converted to calcium oxide and carbon dioxide. The carbon dioxide is then removed and purified so that it is suitable for storage.

Step 2 : $CaCO_3\ (s) \rightarrow CaO\ (s) + CO_2\ (g)$

(i) Explain why there is a need to reduce emissions of carbon dioxide to the atmosphere.

……..

…… [1]

(d) (ii) Which statements about the reactions involved in calcium looping are **true** and which are **false**?

Pick a tick (✓) in one box in each row.

	True	**False**
The reaction in Step 1 is exothermic.		
A high pressure should be used to increase the speed of reaction in Step 1.		
The enthalpy change for the reaction in Step 2 is positive.		
Both the reactions in Step 1 and Step 2 are redox reactions.		

[2]

[Total: 15]

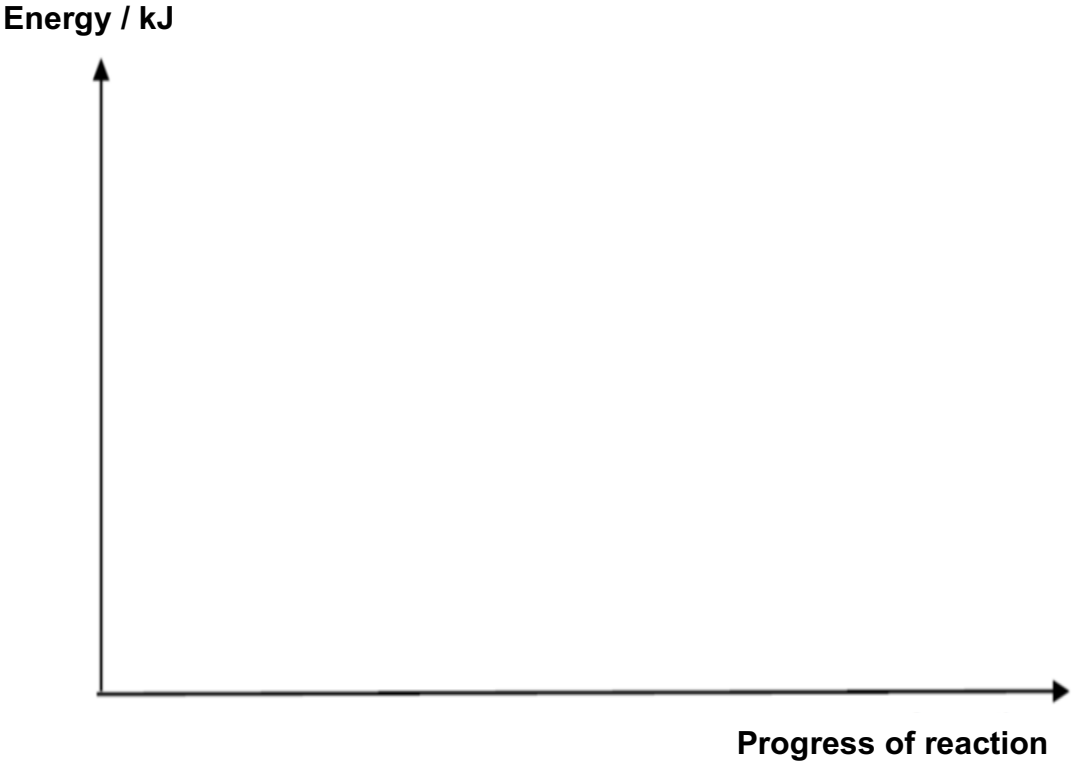
A5 The combustion of ethane gas can be represented by the following equation.

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O \qquad \Delta H = -2868 \text{ kJ}$$

Some bond energy values are given in Table 3.

Bond	Bond energy / kJmol^{-1}
C – H	410
O = O	496
C = O	805
O – H	460

(a) Draw an energy profile diagram for the combustion of ethane. Your diagram should indicate the activation energy and the enthalpy change of reaction, ΔH.



[3]

(b) Calculate the bond energy for the C – C bond.

[3]

(c) Calculate the energy released by the complete combustion of 48.0 dm^3 of ethane.

[2]

[Total: 8]

Section B [30 marks]

Answer all **three** questions from this section.

The last question is in the form of either/or and only one of the alternatives should be attempted.

B6 The transition metals are a block of elements in the centre of the Periodic Table. Some information about the properties of the metals in Period 4 are shown in the tables below.

Element	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Density (g/dm^3)	2.99	4.50	5.96	7.20	7.20	7.86	8.90	8.90	8.92	7.14
Melting point (^oC)	1541	1660	1890	1857	1244	1535	1495	1455	1083	420

Table 6.1

Element	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Common oxidation states that occur in compounds					+7					
				+6	+6	+6				
			+5	+5	+5	+5	+5			
		+4	+4	+4	+4	+4	+4	+4		
	+3	+3	+3	+3	+3	+3	+3	+3	+3	
		+2	+2	+2	+2	+2	+2	+2	+2	+2

Table 6.2

(a) Across Period 4 of the Periodic Table, describe the trend in the number of oxidation states formed by the metals above in their compounds.

……..

……. [1]

(b) Scientists do **not** consider two of the metals found in Period 4 as 'transition metals.'

(i) Name the two metals.

…… [1]

(ii) Using your knowledge about transition metals and the information provided from Tables 1 and 2, explain your answers in **(b)(i)**.

……..

……..

……..

……..

……..

…… [3]

(c) Two equations showing the displacement reactions between metals in Period 4 are as follows.

Equation 1 : $Zn + Co(NO_3)_2 \rightarrow Zn(NO_3)_2 + Co$

Equation 2 : $Co + Ni(NO_3)_2 \rightarrow Co(NO_3)_2 + Ni$

A student wrote in his notes, 'the greater the number of oxidation states exhibited by a metal in its compound, the higher the reactivity of that metal.'

Do you agree with the student? Explain your reasoning.

……

……

……

…….. [2]

(d) Vanadium is a transition metal which forms coloured compounds in different oxidation states.

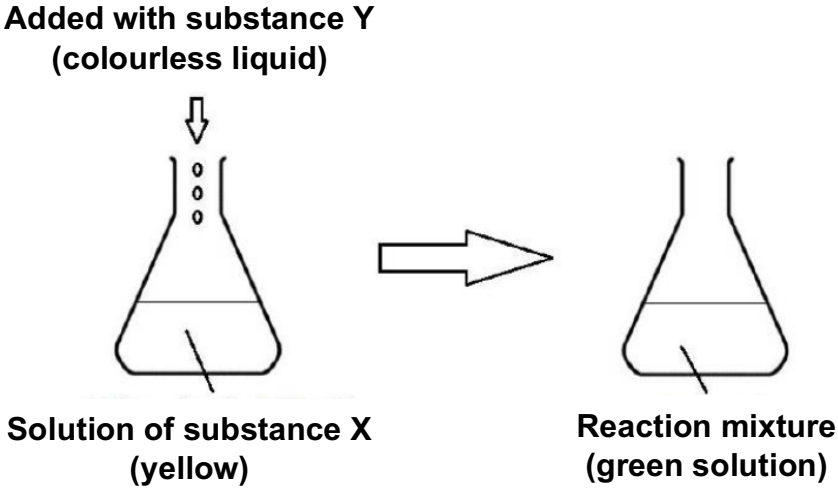
Complete Table 6.3 below by filling in the missing oxidation states.

Substance	Colour	Oxidation state of vanadium
$V(H_2O)_6^{3+}$	Green	+3
VO^{2+}	Yellow	+5
$V(H_2O)_6^{2+}$	Violet	
VO^{2+}	Blue	

[1]

Table 6.3

(e) Substance **X** is a compound containing vanadium. When dissolved in water, substance **X** forms a yellow solution. When a colourless liquid, substance **Y**, is added to an aqueous solution of substance **X**, a green solution is obtained.



Two students, Abu and Mark, attempted to explain the observation.

Abu : 'I think substance **Y** acts as an oxidising agent in the reaction.'

Mark : 'I think substance **Y** acts as a reducing agent in the reaction.'

Identify which student is correct and explain your reasoning.

……

……

……

…… [2]

[Total: 10]

B7 Ammonia is a compound of nitrogen and hydrogen with the formula NH_3.
Ammonia exists in nature as a colourless gas with a characteristic pungent smell.
The undesirable smell is commonly associated with toilets as ammonia gas is given off from urine.

The nitrogen-containing substance in urine is urea, $CO(NH_2)_2$ which undergoes hydrolysis with water to form ammonia and a colourless acidic gas.

(a) Construct a chemical equation, including state symbols, for the hydrolysis of aqueous urea.

……..…….. [2]

In the past, ammonia was obtained via the distillation of camel dung.
Nowadays, ammonia is obtained via the Haber Process.

(b) State the **three** operating conditions of the Haber Process.

……..…….. [2]

(c) In addition, ammonia burns in **pure oxygen** according to the equation given below.

$$4NH_3\,(g) + 2O_2\,(g) \rightarrow 2N_2\,(g) + 6H_2O\,(l)$$

(i) Explain whether the reaction stated in **(c)** is a redox reaction in terms of oxidation states.

……..

……..

…… [3]

(ii) State the reducing agent in reaction **(c)**.

…… [1]

(c) **(iii)** Given that 40 cm^3 of ammonia gas was completely reacted, calculate the minimum volume of **air** required.

[2]

[Total: 10]

EITHER

B8 Magnesium is found in solution in seawater, at concentrations of 1.35 g/dm^3 in a typical seawater sample. Next to sodium, it is the second most common metal found in solution in seawater.

To convert the magnesium in solution to magnesium chloride, minerals are added and several other processes take place.

Magnesium can be extracted from magnesium chloride by electrolysis. Nearly 70% of the world production of magnesium is used to make alloys.

(a) Draw a clearly labelled diagram to show how magnesium can be extracted from magnesium chloride.

Include ionic equations, with state symbols, for the changes at the electrodes.

Equation at anode : ……..

Equation at cathode : ……..

[4]

EITHER

(b) To improve corrosion resistance in magnesium, the surface of the metal is covered with a thick protective oxide coating. This oxide layer can be produced by the electrolysis process called anodising.

Magnesium metal is made the anode in the electrolysis process by using a suitable electrolyte. The oxygen gas produced forms on the surface of the magnesium emtal and reacts with the metal to forma thick oxide layer.

Suggest a suitable electrolyte for anodisong magnesium metal and write the equation that occurs at the anode.

Electrolyte : ……..

Equation : …… [2]

(c) One of the chemical reactions that occur during the conversion of magnesium from seawater to magnesium chloride is

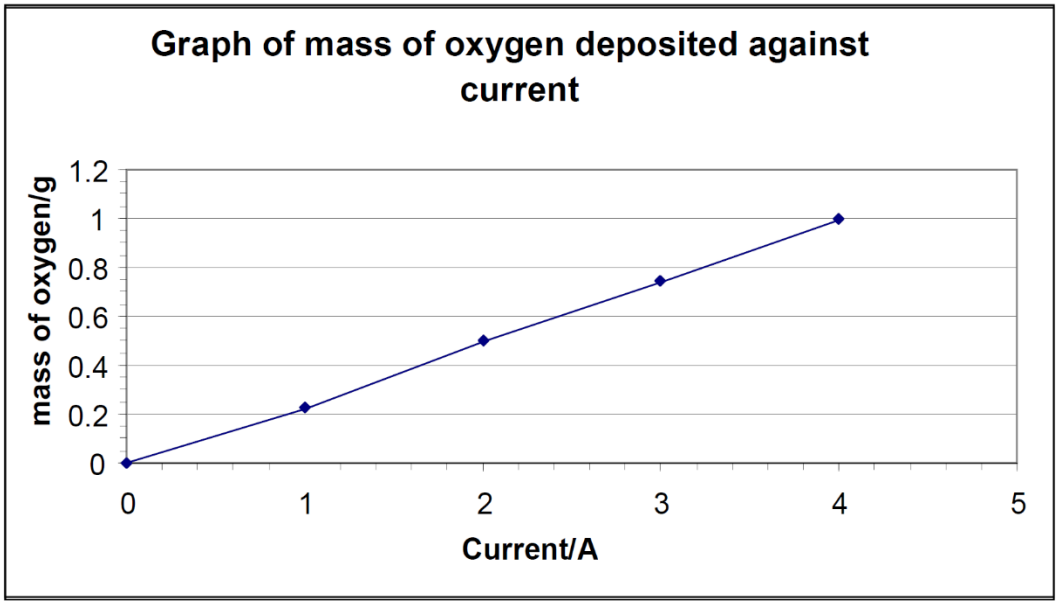
$$2MgO + C + Cl_2 \rightarrow 2MgCl_2 + CO_2.$$

Calculate the mass of carbon needed to produce 152 kg of magnesium chloride.

[2]

EITHER

(d) The graph below shows the results of the experiment on the relationship between the current and the mass of oxygen deposited in 5 minutes.



(i) From the graph, describe the relationship between the current and the mass of oxygen deposited.

……..

……. [1]

(ii) An experiment was carried out that passes an electric current of 2.4 amperes for 10 minutes. Using the graph and the information above, predict the mass of oxygen that would be deposited in the experiment.

……. [1]

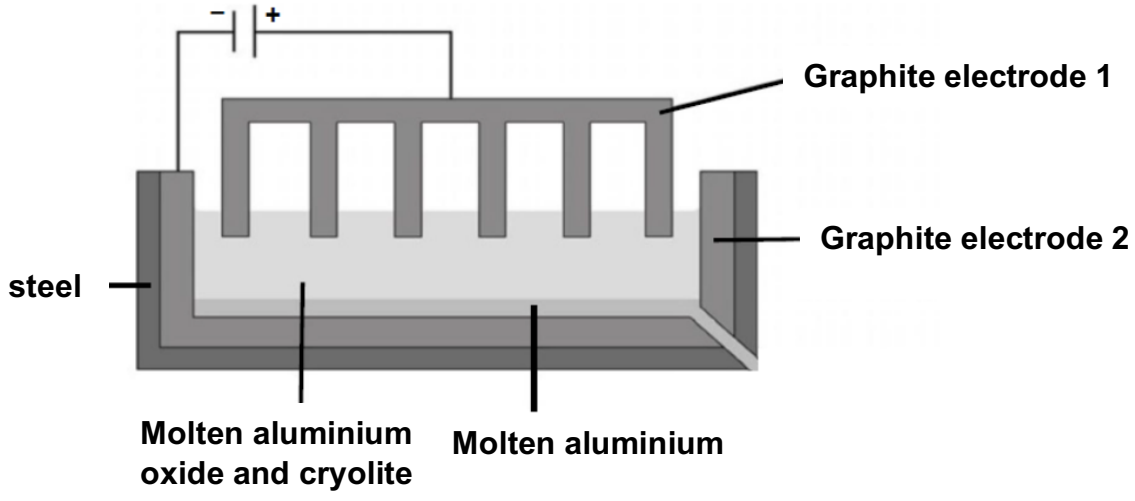
[Total: 10]

OR

B8 Aluminium is a useful metal that can be extracted from bauxite by electrolysis.

Bauxite is broken up and concentrated sodium hydroxide is added to it to dissolve the aluminium oxide. This will separate aluminium oxide from insoluble metal oxide impurities.

Aluminium oxide (melting point of 2072°C) is then added to an ionic compound cryolite, Na_3AlF_6 (melting point 1012°C) into the electrolytic cell below.



(a) Write ionic equations for the reactions at graphite electrode 1 and 2.

Graphite electrode 1

……..

Graphite electrode 2

……..

[2]

(b) Suggest why adding cryolite to aluminium oxide makes the process cheaper to run.

……..……

……..…….. [1]

OR

(c) One of the graphite electrodes needs to be replaced over a long period of electrolysis.

State the graphite electrode that needs to be replaced. Explain your answer.

……..……

……..…….. [2]

(d) Pure aluminium is a reactive metal.

A student carried out some experiments to investigate the displacement reactions of four metals, copper, aluminium, manganese and chromium.

He added metals to salt solutions. The table shows his observations.

Metal	**Copper (II) sulfate**	**Aluminium sulfate**	**Manganese (II) sulfate**	**Chromium (II) sulfate**
Copper		No change, solution remains colourless	No change, solution remains pink	No change, solution remains green
Aluminium	Brown solid forms in colourless solution		Grey solid forms in colourless solution	Grey solid forms in colourless solution
Manganese	Brown solid forms in pink solution	No change, solution remains colourless		Grey solid forms in pink solution
Chromium	Brown solid forms in green solution	No change, solution remains colourless	No change, solution remains pink	

(i) What is the order of reactivity for the four metals?

Most reactive ……

……

……

Least reactive ……

[1]

OR

(d) **(ii)** State the colour of chromium (III) sulfate solution.

..…….. [1]

(e) Pure aluminium is not used for aircraft parts. A mixture of a small quantity of magnesium in aluminium is used for aircraft parts instead.

Explain how the presence of magnesium affects one physical property of aluminium so that it can be used for aircraft parts.

……..……

……..……

……..…….. [3]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							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											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 –		

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.).