YUYING SECONDARY SCHOOL
PRELIMINARY EXAMINATION
Secondary 4 Express

NAME			
CLASS		**REG. NO**	

CHEMISTRY 6092/2

Paper 2

28th August 2020

1 hour 45 minutes

Candidates answer on the Question Paper.
Additional Materials: Nil

Setter: Mr Kelvin Goh

READ THESE INSTRUCTIONS FIRST
Write your name, class and register number on this question booklet.
Write in dark blue or black pen on both sides of the paper.
You may use a pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions in the spaces provided on the Question Paper.

Section B
Answer **all** the questions in this section in the spaces provided.
The last question is in the form either/or and only **one** of the alternatives should be attempted.
Write your answers in the spaces provided on the Question Paper.

The use of an approved calculator is expected, where appropriate.
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 21.

For Examiner's Use	
Total	**80**

This document consists of **21** printed pages.

Section A

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

1 The chemical formulae of some reagents are shown below. Use them to answer the questions that follow.

Na_2CO_3	KOH	$CuCl_2$
Zn	$Ba(NO_3)_2$	H_2SO_4
$(NH_4)_2SO_4$	$PbCO_3$	Ag
F_2	NaCl	Br_2

Each reagent can be used once, more than once, or not at all.

Write the formulae of any **two** reagents which, when mixed together,

(a) would produce a green insoluble salt. [1]

_____ and _____

(b) would produce a white precipitate. [1]

_____ and _____

(c) would produce a gas which turns moist red litmus paper blue. [1]

_____ and _____

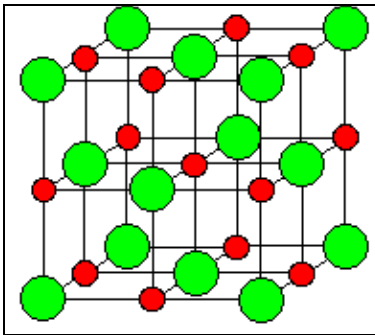
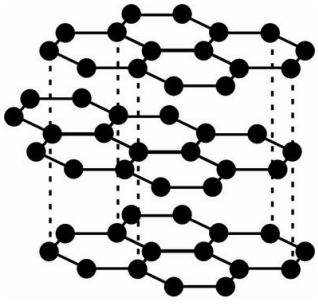
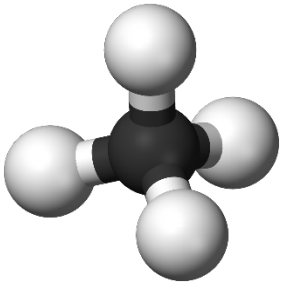
(d) would produce a gas which extinguishes a lighted splint with a ‘pop’ sound. [1]

_____ and _____

(e) would produce a gas which turns blue litmus paper red and bleaches it. [1]

_____ and _____

2 The structures of substances **A**, **B** and **C** are shown below.

		
A	**B**	**C**

With reference to the **structure and bonding** of these substances, state and explain:

(a) which substance is able to conduct electricity in the solid state. [3]

(b) which substance can only conduct electricity in the molten state. [3]

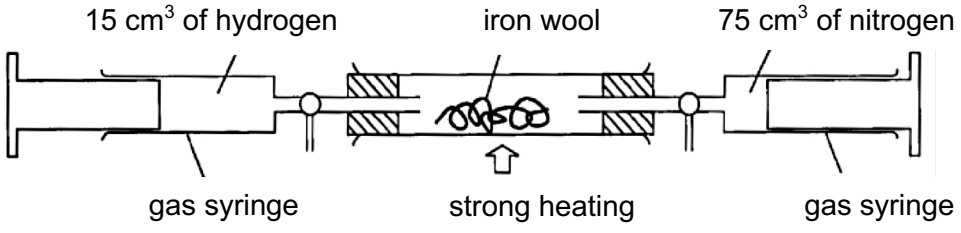
(c) which substance has the lowest melting point. [3]

(d) Suggest possible identities for substances **A** and **C** [1]

A: _____ **C**: _____

(e) Draw the dot-and-cross diagram to show the arrangement of electrons in substance **C**, based on your answer in (d). [2]

3 The reaction to produce ammonia can be demonstrated in the science laboratory by the method shown in the diagram below:



The mixture of nitrogen and hydrogen is passed backwards and forwards over the hot iron wool until there is no further reaction. There must not be any air present in the reaction mixture in order for the reaction to take place.

(a) Write the balanced chemical equation, including state symbols, for the formation of ammonia from nitrogen and hydrogen. [2]

_____

(b) Assuming only 15% of the nitrogen and hydrogen react to produce ammonia, calculate the volume of ammonia produced at room temperature and pressure. [3]

(c) In industries, ammonia is manufactured in the Haber Process. The table below shows the percentage yield of ammonia at different temperature and pressures.

temperature (°C)	**percentage yield of ammonia at equilibrium (%)**		
	200 atm	**300 atm**	**400 atm**
350	24	40	48
450	20	23	30
550	10	12	15

(i) Describe the effect of pressure on the yield of ammonia. [1]

_____

_____

(ii) Suggest one advantage and one disadvantage of using a working temperature of 550 °C rather than 350 °C during the industrial manufacturing of ammonia. [2]

advantage: _____

_____

disadvantage: _____

_____

4 Catalytic converters are used in cars to remove pollutants such as nitrogen oxides and carbon monoxide from the combustion engines. When the pollutants pass over a catalyst, they are converted to harmless products. The following chemical equation describes this process:

$$2\ NO\ (g)\ +\ 2\ CO\ (g)\ \rightarrow\ N_2\ (g)\ +\ 2\ CO_2\ (g)$$

(a) Which substance is **oxidised** in the reaction? Explain your answer in terms of oxidation states of the element involved. [2]

_____

_____

_____

(b) Which substance is **reduced** in the reaction? Explain your answer in terms of the gain or loss of oxygen. [2]

_____

_____

_____

(c) Describe a chemical test to confirm the presence of the reducing agent. [2]

test: _____

_____

observation: _____

_____

(d) Explain how pollutants such as nitrogen monoxide and carbon monoxide are produced in the combustion engine of cars. [2]

nitrogen monoxide: _____

_____

carbon monoxide: _____

_____

(e) Describe a harmful effect of nitrogen monoxide. [1]

_____

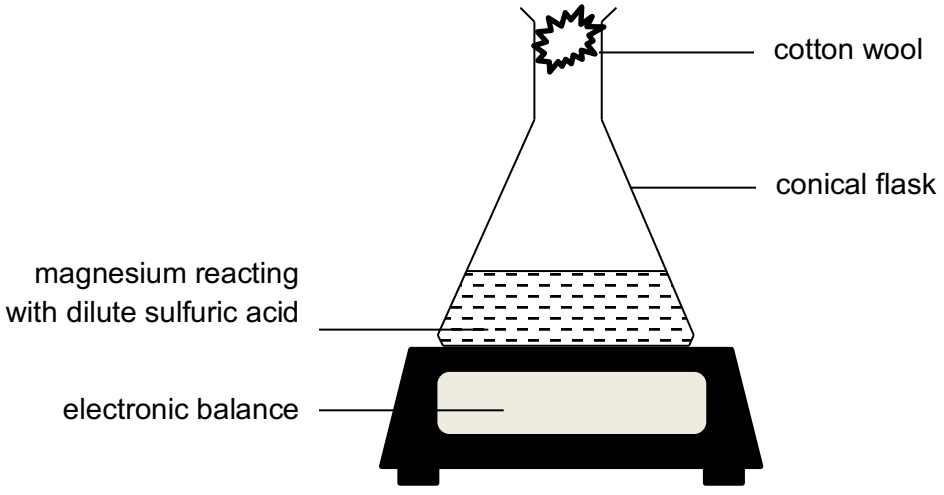
_____

(f) Suggest why the harmless products that leave the catalytic converter could still cause problems for the environment. [1]

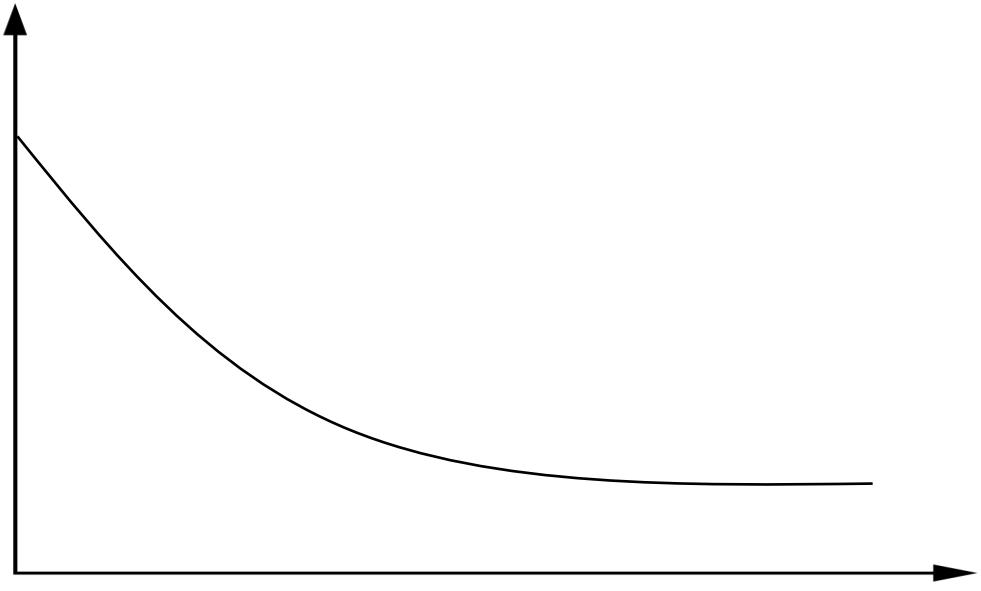
_____

_____

5 An experiment to determine the rate of reaction between a piece of magnesium ribbon and excess dilute sulfuric acid was carried out using the following apparatus.



The results of the experiment were then shown on the graph below:



(a) Label the axes on the graph. [1]

(b) Sketch on the same graph to show the rate of reaction if the experiment was repeated: [2]

(i) at a higher temperature, with all other conditions remaining constant. Label this graph '**A**'.

(ii) using half the mass of magnesium ribbon, with all other conditions remaining constant. Label this graph '**B**'

(c) Using ideas about collision theory, describe what happens to the rate of reaction when a higher concentration of dilute sulfuric acid is used. [2]

_____

_____

_____

_____

_____

(d) Suggest another method to determine the speed of reaction for the reaction between magnesium and dilute sulfuric acid. [1]

_____

_____

6 Three methods of preparing salts are described below.

no.	method
1	use a burette, pipette and an indicator
2	mix two solutions and obtain the salt by precipitation
3	add an excess of a base or a metal to a dilute acid and remove the excess insoluble reactant by filtration

For each of the following salts, choose the correct number of the method of preparation from above and state the reagents required. Write the balanced chemical equation for the reaction as well.

(a) zinc sulfate [3]

method: _____

reagents: _____

balanced chemical equation:

_____

(b) potassium chloride [3]

method: _____

reagents: _____

balanced chemical equation:

_____

(c) lead(II) iodide [3]

method: _____

reagents: _____

balanced chemical equation:

_____

Section B

Answer **all** the questions in this section in the spaces provided.
The last question is in the form either/or and only **one** of the alternatives should be attempted.
The total mark for this section is 30.

7 A fuel cell is a chemical cell in which reactants are continuously supplied to produce electricity.

Two such cells are the **Alkaline Fuel Cell (AFC)** and the **Proton Exchange Membrane Fuel Cell (PEMFC)**.

Alkaline Fuel Cell (AFC)

AFCs use an alkaline electrolyte such as potassium hydroxide in water and are generally fuelled with pure hydrogen. Typical operating temperatures are around 70 ºC.

As a result of the low operating temperature, a variety of non-precious metals can be used as catalysts to speed up the reactions occurring at the anode and cathode.

AFC cell type is easily poisoned by carbon dioxide (CO_2). In fact, even the small amount of CO_2 in the air can affect this cell's operation, making it necessary to purify both the hydrogen and oxygen used in the cell. This purification process is costly.

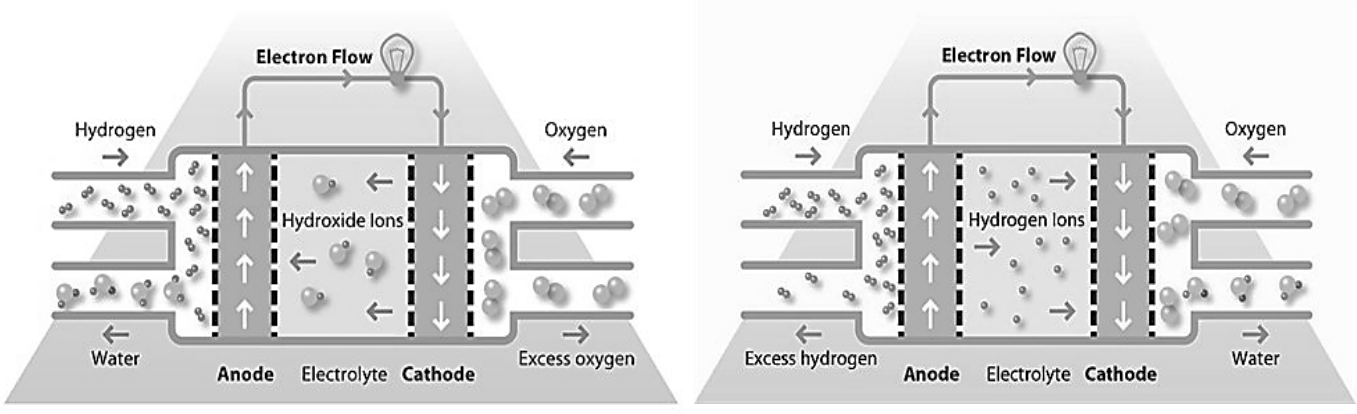
Proton Exchange Membrane Fuel Cell (PEMFC)

The **PEMFC** uses a water-based, acidic polymer membrane as its electrolyte, with platinum-based electrodes. PEMFC cells operate at relatively low temperatures (below 100 ºC).

Due to the relatively low temperatures and the use of precious metal-based electrodes, these cells must operate on pure hydrogen.

Hydrogen fuel is processed at the anode where electrons are separated from protons on the surface of a platinum-based catalyst. The protons pass through the membrane to the cathode side of the cell while the electrons travel in an external circuit, generating the electrical output of the cell.

On the cathode side, another precious metal electrode combines the protons and electrons with oxygen to produce water, which is expelled as the only waste product.



[Source: http://www.fuelcelltoday.com/about-fuel-cells/introduction]

(a) Both the **AFC** and **PEMFC** are hydrogen fuel cells. Explain how hydrogen fuel cells generate electricity. [1]

(b) Why is the **AFC** is used to produce electricity and water aboard space shuttles, even though the purification process for both hydrogen and oxygen used in the cell is costly? [2]

(c) State one reason why the operation of **AFC** is more economical than that of **PEMFC**. [1]

(d) In the **PEMFC**, the ionic half equation at the anode is: [2]

$$2\ H_2\ (g) \rightarrow 4\ H^+\ (aq) + 4\ e^-$$

Write the ionic half equation, including state symbols, for the reaction occurring at the cathode.

(e) Some people think that using hydrogen fuel cells eliminate the production of greenhouse gases. However, there are other people that argue that this is incorrect. Explain why. [1]

(f) Most of the hydrogen produced today is made via steam-methane reforming. In this process, high temperature steam reacts with methane, in the presence of a catalyst to produce hydrogen and carbon monoxide.

(i) Write the balanced chemical equation for the reaction. [1]

_____

(ii) Given that a certain source of natural gas constitutes 95% by volume of methane, calculate the minimum volume of natural gas required to produce 1 kg of hydrogen. [3]

8 Small pieces of different metals were added to chloride solutions containing different metal ions. The results are summarised in the table below.

'✓' represents that a reaction is observed while 'x' represents that no reaction took place.

metal / chloride solution	copper	nickel	iron	scandium	zinc
copper(II)		✓	✓	✓	✓
nickel(II)	x		✓	✓	✓
iron(II)	x	x		✓	✓
scandium(III)	x	x	x		x
zinc	x	x	x	✓	

(a) Place the five metals in **decreasing** order of reactivity. [1]

_____

(b) Write the balanced chemical equation, including state symbols, for the reaction of zinc metal with copper(II) chloride solution. [2]

_____

(c) State **two** expected observations when excess zinc is added to iron(II) chloride solution. [2]

1. _____

2. _____

(d) Suggest a method that can be used to extract scandium from its ore. [1]

_____

(e) Iron is a metal in high demand because of its many important uses. It is extracted in the blast furnace from haematite. [3]
Write the essential balanced chemical equations for the extraction of iron in the blast furnace, excluding the equations involved in the removal of acidic impurities.

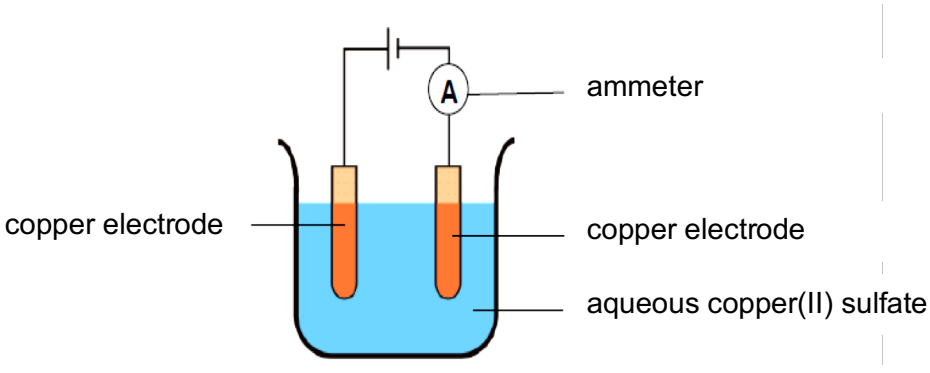
_____

_____

_____

EITHER

9 A student carried out a series of electrolysis experiments using aqueous copper(II) sulfate as shown in the diagram below.



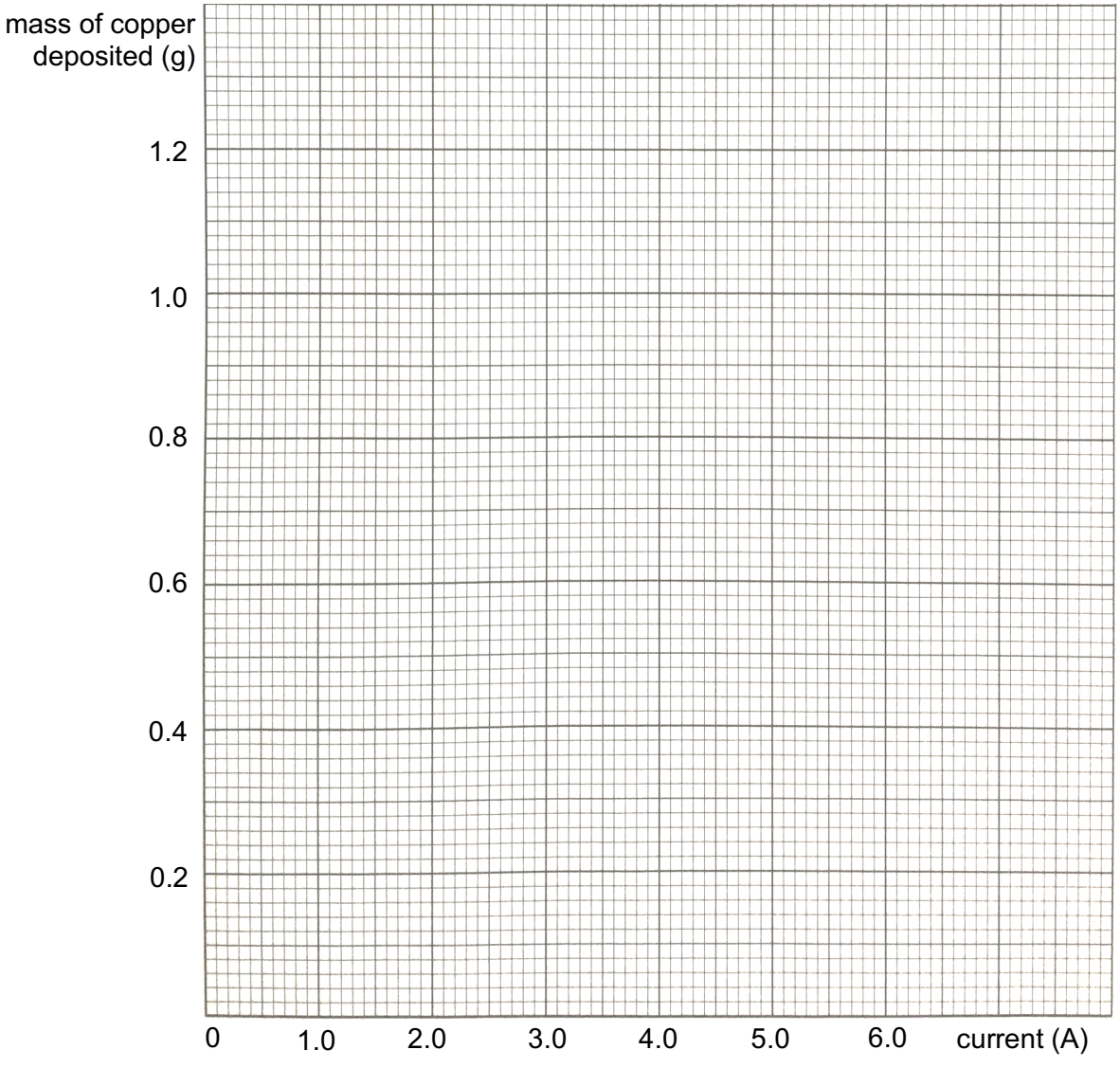
He used the same concentration of aqueous copper(II) sulfate each time, but changed the current that passed through the solution. He consistently performed each electrolysis for 10 minutes. The student weighed one of the selected electrodes before and after each experiment and thus worked out the mass of copper deposited.

Table 1 shows the results of his experiments.

experiment	time (min)	current (A)	mass of copper deposited (g)
A	10	1.0	0.21
B	10	2.0	0.40
C	10	3.0	0.58
D	10	4.0	0.81
E	10	6.0	1.22

Table 1

(a) Using **Table 1**, plot a graph of mass of copper deposited against current on the graph below. [2]



(b) Describe the relationship between the mass of the copper deposited and current as shown by your graph in (a). [1]

_____

_____

(c) The student carried out another experiment by passing a current of 5.0 A through the solution of copper(II) sulfate for 10 minutes. [1]
Using the graph from (a) and the information above, predict the mass of copper that would form in the experiment.

_____

(d) Describe the observations seen in the electrolysis set-up after a period of time. [2]

_____

_____

_____

_____

(e) With reference to the above electrolysis, suggest the modifications that can be made to the copper electrodes in the industrial purification of impure copper. [2]

_____

_____

(f) The student carried out another electrolysis experiment using aqueous silver nitrate and silver electrodes. His results are shown in the table below.

electrolye	**time (min)**	**current (A)**	**mass of silver deposited (g)**
aqueous silver nitrate	10	4.0	2.7

Write the ionic half equations, with state symbols, for the reactions that occur at the negative and positive electrodes. [2]

negative electrode: _____

positive electrode: _____

OR

9 Astronauts carry lithium hydroxide canisters in their spacesuits in order to create breathable air during space flights. Air is pumped through a filter containing lithium hydroxide. Inside the filter, carbon dioxide is removed from the air when it reacts with lithium hydroxide to produce only lithium carbonate and water.

Table 1 below shows information about lithium hydroxide.

relative molecular mass of LiOH	**enthalpy change of reaction between lithium hydroxide and carbon dioxide (kJ/mol)**	**price of lithium hydroxide per tonne ($)**
24	-89.0	5000

Table 1

(a) Draw an energy profile diagram for the reaction above on the axes provided. [4]
Indicate clearly, the

- reactants and products,
- labelling on both axes,
- enthalpy change, ΔH , for the reaction and
- activation energy, Ea

(b) After the flights, the lithium carbonate formed is reacted with dilute hydrochloric acid.

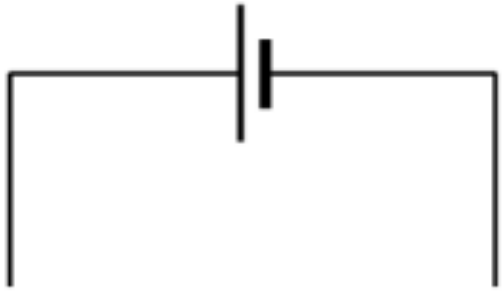
(i) Write the balanced chemical equation of the reaction between lithium carbonate and dilute hydrochloric acid. [2]

_____

(ii) This resulting solution from (b)(i) can be electrolysed to regenerate lithium hydroxide solution. [2]

Complete the diagram for the electrolysis carried out to regenerate lithium hydroxide solution. You should label the :

- cathode
- anode
- the materials used for both the electrodes
- the substance used as the electrolyte.



(c) It has been suggested that sodium hydroxide is an alternative to lithium hydroxide in the removal of carbon dioxide. Table 2 below gives information about sodium hydroxide.

relative molecular mass of NaOH	**enthalpy change of reaction between sodium hydroxide and carbon dioxide (kJ/mol)**	**price of sodium hydroxide per tonne ($)**
40	-102.0	4000

Table 2

Comparing **Table 1** and **Table 2**, suggest one advantage and one disadvantage of using sodium hydroxide on space flights, if the same mass of both sodium hydroxide and lithium hydroxide are used. [2]

advantage: _____

_____

_____

disadvantage: _____

_____

_____

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.).