Name:	Register Number:	Class:

BEDOK GREEN SECONDARY SCHOOL

4E 4E

Preliminary Examination 2020

CHEMISTRY 6092/1

Paper 1 16 September 2020

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class on the multiple choice answer sheet provided.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**. Choose the one you consider correct and record your choice in soft pencil on the multiple choice answer sheet.

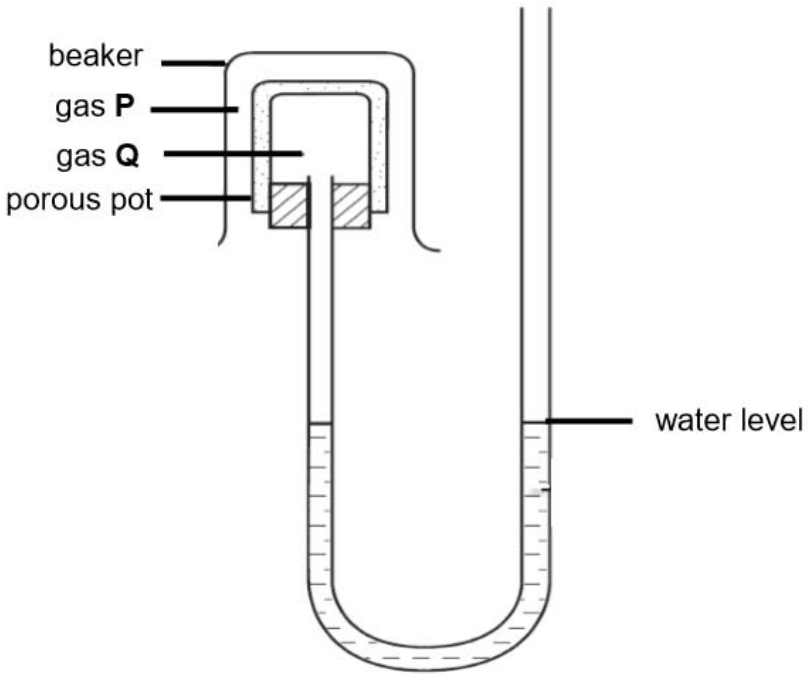
Read the instructions on the multiple choice answer sheet very carefully.

INFORMATION FOR CANDIDATES
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

A copy of the Periodic Table is on page 18.

Answer **all** questions on the multiple choice answer sheet.

1 A beaker of gas **P** is inverted over a porous pot containing gas **Q** as shown.



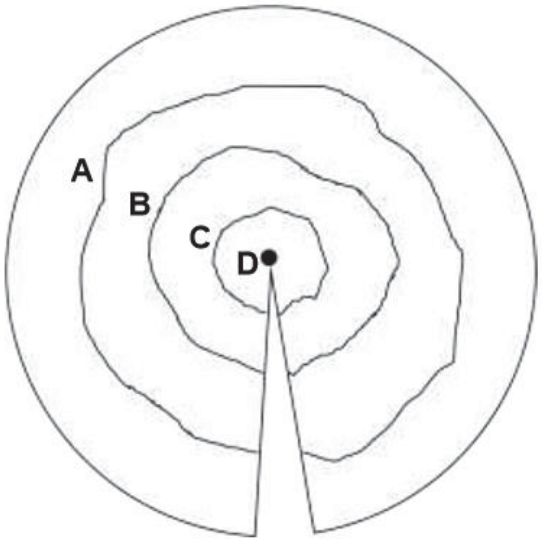
Which pair of gases will result in the water level remaining unchanged?

	P	Q
A	CH_4	N_2
B	C_2H_4	CO
C	C_2H_6	CO_2
D	C_3H_8	O_2

2 Paper chromatography was used to separate an ink which is comprised of several dyes. In the experiment, a few drops of solvent was added to the centre and allowed to spread out.

The diagram below shows the chromatogram obtained from the experiment.

Which dye has the greatest solubility in the solvent used?



3 Which piece of apparatus is **not** required to obtain water from a can of green tea?

A white tile
B condenser
C distillation flask
D fractionating column

4 An alloy reacts with hot dilute hydrochloric acid to evolve a gas which extinguishes a lighted splint with a 'pop' sound. A reddish brown solid residue remains, which turns into a black solid when heated in air.

Which two metals are present in the alloy?

A silver and zinc
B silver and copper
C iron and copper
D iron and aluminium

5 Some information on two substances **P** and **Q** are given below.

substance	**P**	**Q**
arrangement of particles	close and not orderly	regularly arranged and very close
movement of particles	sliding around randomly	vibrating about their fixed positions

Four substances are given below.

substance	description
1	copper at 100^{o}C
2	ethanol at 25 ^{o}C
3	oxygen at 10 ^{o}C
4	water at 200 ^{o}C

Which of the substances are **P** and **Q**?

	P	**Q**
A	1	2
B	2	1
C	3	4
D	4	1

6 Three different exeriments with colour changes are carried out.

1. Sulfur dioxide is tested with acidified potassium manganate(VII) solution.
2. Universal Indicator solution is added to a solution of a weak acid.
3. Aqueous potassium iodide and dilute nitric acid are mixed. Then aqueous silver nitrate is added.

Which row correctly identifies the experiments that correspond to the colour changes?

	colourless solution to a yellow precipitate	purple to colourless	green to orange
A	1	2	3
B	2	1	3
C	3	2	1
D	3	1	2

7 A substance has a high melting point. When solid, it does not conduct electricity but when molten, it does conduct.

Which type of structure does the substance have?

A metallic

B polymeric

C giant ionic lattice

D simple molecular

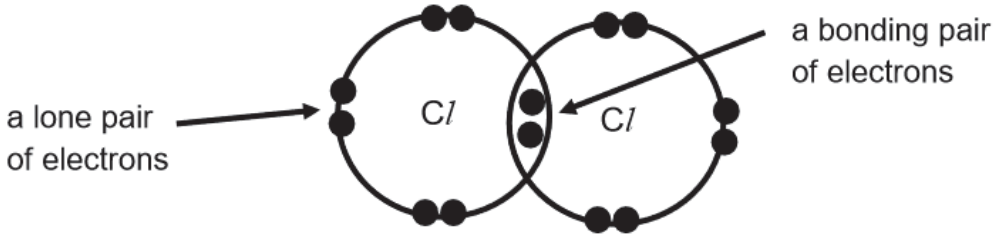
8 Elements **J**, **E** and **G** have atomic numbers 3, 8 and 17 respectively. Each of them combines with hydrogen.

Which set of formulae is correct?

	element **J**	element **E**	element **G**
A	**J**H	H**E**	H$\mathbf{G}_7$
B	**J**H	H_2**E**	H**G**
C	**J**H_2	H$\mathbf{E}_2$	H**G**
D	**J**H_3	H_6**E**	H_7**G**

9 A lone pair electrons is an electron pair in the valence shell of a single atom or in the atoms of a molecule that is not used in covalent bonding.

For example, Cl_2 has 6 lone pairs of electrons and 1 bonding pair of electrons.



How many lone pair(s) is/are found in a molecule of ammonia, NH_3?

A 1

B 2

C 3

D 4

10 The equation shows the reaction between a hydroxide of the metallic element **M** and dilute nitric acid.

$$\mathbf{M}(OH)_2(aq) + 2HNO_3(aq) \rightarrow M(NO_3)_2(aq) + 2H_2O(l)$$

Which particles are responsible for the electrical conductivity in **M**, $\mathbf{M}(OH)_2$ and $\mathbf{M}(NO_3)_2$?

	M	$\mathbf{M}(OH)_2$	$\mathbf{M}(NO_3)_2$
A	electrons	cations	cations
B	electrons	cations and anions	cations and anions
C	cations	electrons	electrons
D	cations	cations and anions	cations

11 The pH of an aqueous solution of sulfuric acid is 2.

What is the pH of the acid after adding 10 g of lead(II) chloride?

A 1

B 2

C 7

D 9

12 When the metal bismuth (Bi) is added to copper(II) nitrate, bismuth(III) nitrate and copper are formed.

What is the ionic equation of this reaction?

A $Bi(s) + Cu^{2+}(aq) \rightarrow Bi^{3+}(aq) + Cu(s)$

B $2Bi(s) + 3Cu^{2+}(aq) \rightarrow 2Bi^{3+}(aq) + 3Cu(s)$

C $Bi(s) + Cu(NO_3)_2(aq) \rightarrow Bi(NO_3)_3(aq) + Cu(s)$

D $Bi^{3+}(aq) + 3NO_3^-(aq) \rightarrow Bi(NO_3)_3(aq)$

13 A solution containing hydroxide ions was separately titrated with hydrochloric acid, HC*l*, and ethanoic acid, CH_3COOH. The results are shown in the table.

type of acid	concentration of acid	volume of acid required for complete reaction
hydrochloric acid	0.1 mol/dm^3	20.0 cm^3
ethanoic acid	0.2 mol/dm^3	?

What volume of ethanoic acid is required for complete reaction?

A 10.0 cm^3

B 15.0 cm^3

C 20.0 cm^3

D 40.0 cm^3

14 Group I and Group II ionic hydrides react with water to form hydroxide ions and hydrogen gas.
In an experiment, 1 g of samples of each of the following four ionic hydrides are treated with an excess of water.

Which sample produces the greatest mass of hydrogen?

A CaH_2

B LiH

C MgH_2

D NaH

15 Fibre glass can be considered to be a mixture of ionic oxides and giant covalent oxides. Which of the following is **not** a constituent of fibre glass?

A Al_2O_3

B SiO_2

C Na_2O

D P_4O_{10}

16 The table shows the possible oxidation states of transition elements in the Periodic Table. (The elements are represented by letters which are not their symbols)

element	possible oxidation numbers						
P			3				
Q		2	3	4			
R	1	2	3	4	5		
T		2		4	5	6	7

Which of the following ions is likely to exist?

A $\mathbf{P}O_2^+$

B $\mathbf{Q}O_3^-$

C $\mathbf{R}O_4^{2-}$

D $\mathbf{T}O_2^{2+}$

17 Which of the following oxides is **unlikely** to dissolve in aqueous sodium hydroxide?

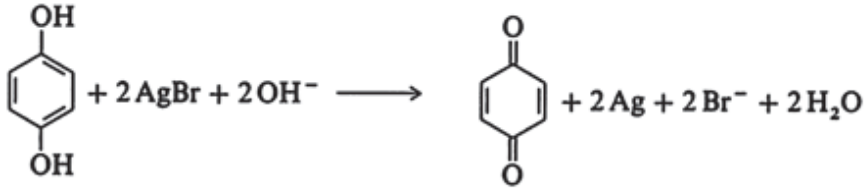
A Al_2O_3

B MgO

C Cl_2O

D SiO_2

18 When exposed film from a camera is developed, one step involves reacting the light-activated silver bromide crystals with aqueous alkaline hydroquinone.



Which of the following best describes the role of hydroquinone?

A an acid

B an oxidizing agent

C an acid and reducing agent

D a base and oxidizing agent

19 Graphite can be used as a lubricant; diamond cannot. This is because graphite has

A free moving ions.

B delocalized electrons.

C a hexagonal arrangement of atoms in the layers.

D weak intermolecular forces of attraction between the layers of atoms.

20 To identify an oxide of nitrogen, 0.10 mol of the oxide is mixed with an excess of hydrogen and passed over a catalyst at a suitable temperature.

$$N_xO_y + H_2 \xrightarrow{catalyst} xNH_3 + yH_2O$$

The water produced weighs 7.20g. The ammonia produced is neutralized by 200 cm^3 of 1.0 mol/dm^3 HC*l*.

What is the formula of the oxide of nitrogen?

A N_2O

B NO

C NO_2

D N_2O_4

21 In an electrolysis experiment, the same amount of charge deposited 16 g of copper and 6g of titanium. The charge on the copper ion was +2.

What was the charge on the titanium ion?

A +1

B +2

C +3

D +4

22 Dichloroethane, $C_2H_4Cl_2$, can be made from gaseous ethene using the reaction shown.

$$C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$$

In an experiment, $1dm^3$ of gaseous ethene at room temperature and pressure produced 2.68g of dichloroethane.

What is the percentage yield of dichloroethane?

A 45%

B 54%

C 65%

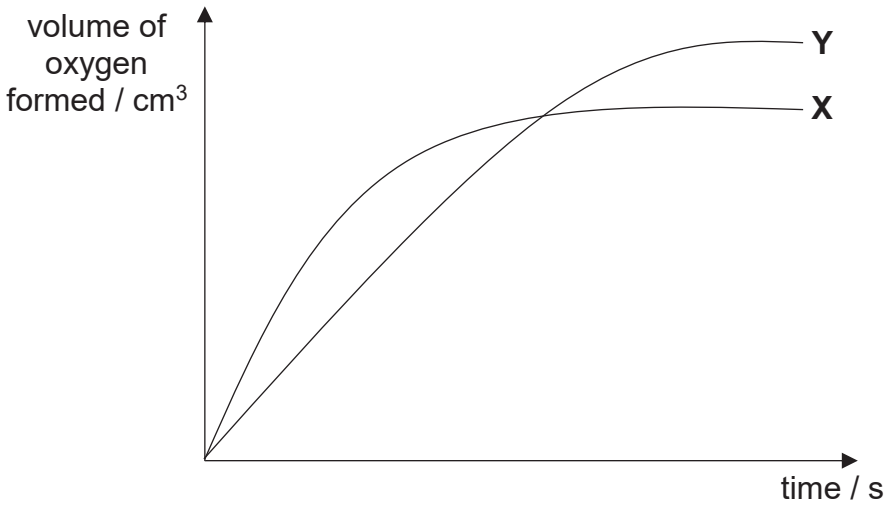
D 83%

23 Dilute aqueous potassium chloride and concentrated aqueous potassium chloride are electrolyzed using inert electrodes in separate experiments.

Which row shows the products of these experiments?

	dilute potassium chloride		concentrated potassium chloride	
	anode	cathode	anode	cathode
A	chlorine	hydrogen	chlorine	potassium
B	chlorine	oxygen	oxygen	hydrogen
C	oxygen	hydrogen	chlorine	hydrogen
D	oxygen	hydrogen	hydrogen	chlorine

24 In the diagram, curve **X** was obtained by observing the decomposition of 100 cm^3 of 1.0 mol/dm^3 hydrogen peroxide, catalyzed by manganese(IV) oxide.



Which alteration to the original experiment conditions would produce curve **Y**?

A adding water

B lowering the temperature

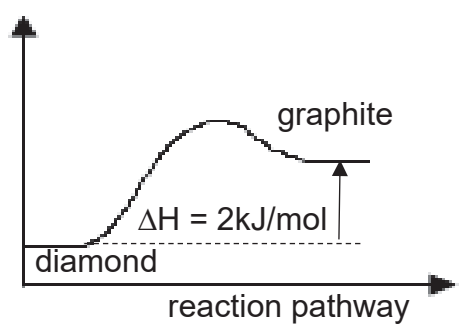
C using less manganese(IV) oxide

D adding some 0.1 mol/dm^3 hydrogen peroxide

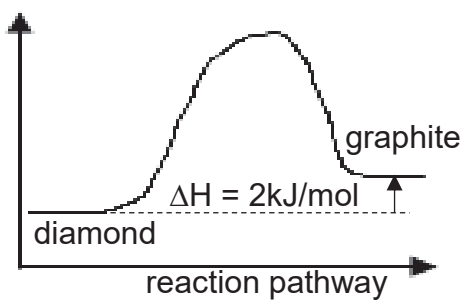
25 The conversion of diamond into graphite is exothermic by 2 kJ/mol. Diamond does not readily change into graphite.

Which reaction pathway correctly represents this conversion?

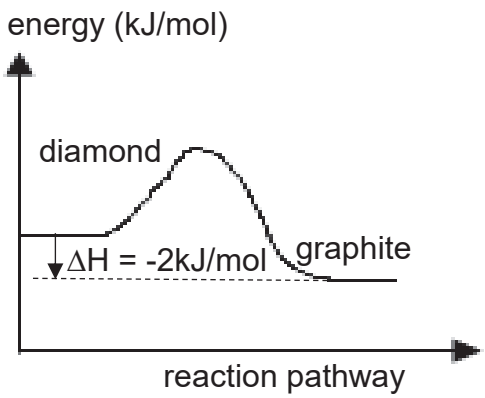
A



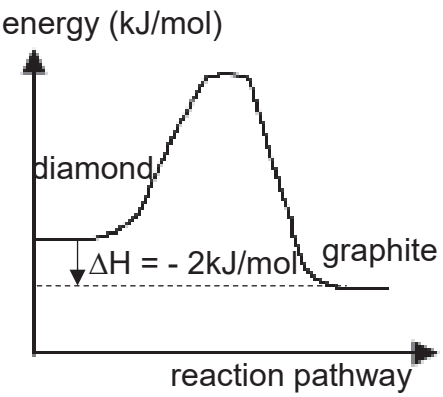
C



B



D



26 Hydrogen reacts with fluorine according to the following equation.

$$H_2 + F_2 \rightarrow 2HF \quad \Delta H \text{ has a negative value}$$

The table below shows the related bond energies.

Bond	F – F	H – H	H – F
Bond energy / kJmol^{-1}	158	436	556

Which statement is true based only on the information given?

A Hydrogen fluoride is the least stable substance.

B The intermolecular force in fluorine are the weakest.

C The covalent bonds in the hydrogen fluoride molecules are the strongest.

D The energy level of hydrogen fluoride is higher than the energy level of hydrogen and fluorine.

27 The table gives some statements about acids and bases and explanations for these statements.

Which row shows both a correct statement and a correct explanation for the statement?

	statement	explanation
A	Hydrogen can be made by reacting magnesium with hydrochloric acid.	The hydrogen ion acts as a acid and reduces magnesium to magnesium ion.
B	The pH of a weak acid is higher than the pH of a strong acid of the same concentration.	The pH shows the extent of ionization – the more ionized the acid is, the lower the pH.
C	Calcium hydroxide can be used to control the pH in soils.	Metal hydroxides are acidic and can reduce excess alkalinity.
D	When an acid reacts with a metal, the metal is reduced.	Reduction is gain of electrons.

28 Three chemicals, **P**, **Q** and **R**, were each dissolved in water. The table shows some of the reactions of these solutions.

solution	reaction when solid sodium carbonate is added	reaction when heated with solid ammonium chloride
P	gas evolved	no reaction
Q	no reaction	gas evolved
R	no reaction	no reaction

What are the correct pH values of these solutions?

	P	**Q**	**R**
A	2	7	13
B	2	13	7
C	7	2	13
D	13	7	2

29 What ions are present in dilute aqueous ammonia?

A NH_4^+, OH^-

B H^+ and OH^-

C NH_4^+, H^+, OH^-

D NH_4^+, H^+, Cl^-, OH^-

30 Three electric cells are set up using zinc metal and three unknown metals, **U**, **V** and **W** as electrodes.
The potential differences between the metals are given in the table below.

electric cell	metals used	voltage / V	positive electrode
1	Zn, **U**	-0.45	Zn
2	Zn, **V**	+2.71	**V**
3	Zn, **W**	+1.11	**W**

From these results, deduce which arrangement correctly lists the metals in the order of decreasing reactivity.

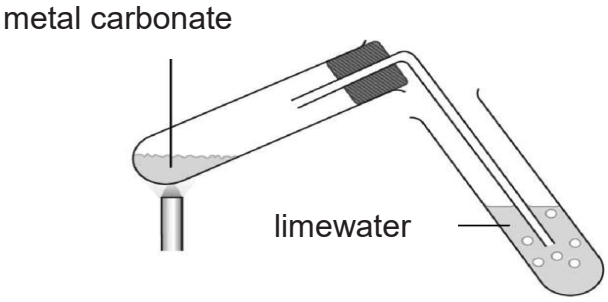
A **U**, Zn, **V**, **W**

B **U**, Zn, **W**, **V**

C **V**, **W**, Zn, **U**

D **V**, Zn, **W**, **U**

31 Three metal carbonates **X**CO_3, **Y**CO_3 and **Z**CO_3, were each heated using the setup shown below.



On mild heating of **Y**CO_3, white precipitate was observed in the limewater. Heating more strongly gave the same observation for **X**CO_3 but not for **Z**CO_3.

Which is the correct order for the reactivity of metals **X**, **Y** and **Z**?

	least reactive ⟶		most reactive
A	**Z**	**Y**	**X**
B	**Z**	**X**	**Y**
C	**X**	**Y**	**Z**
D	**Y**	**X**	**Z**

32 Which property best describes a metal which is found at the top of the reactivity series?

A readily loses electron

B burns to form an oxide

C always forms an unstable compound

D forms an oxide which is easy to reduce with carbon

33 Stainless steel is an alloy of iron, carbon and small amount of chromium. It does not rust easily. It is known that chromium is more difficult to extract than iron.

How does chromium protect iron from rusting in stainless steel?

A Chromium is preferentially reduced to iron to prevent rusting.

B Chromium forms an oxide layer which forms a protective layer.

C Chromium reacts with water first to prevent iron from reacting with water.

D Chromium reacts with iron to form an alloy which is impervious to water and air.

34 Which of the following substances could be used to reduce atmospheric pollution caused by flue gases?

A calcium oxide and ammonium sulfate

B calcium carbonate and calcium oxide

C ammonium sulfate and calcium carbonate

D ammonium carbonate and ammonium sulfate

35 Which molecule has the greatest ozone-depleting potential?

A CH_4

B $CFCl_3$

C CH_2F_2

D $CFClBr$

36 When nickel is placed in copper(II) nitrate solution, the solution gradually turns green.

Which statement is true about the reaction?

A Copper is more reactive than nickel.

B Nickel is more reactive than copper.

C Copper reacts with water in the solution to form a green solution.

D Nickel reacts with water in the solution to form a green solution.

37 Which reaction is **not** a step in the production of iron from haematite in the blast furnace?

A iron reacting with limestone to produce slag

B carbon (coke) burning in air to produce carbon dioxide

C iron(III) oxide reacting with carbon monoxide to form iron

D carbon reacting with carbon dioxide to produce carbon monoxide

38 Which one of the following could be used to change MnO_4^- to MnO_2?

A chlorine

B iron(III) chloride

C carbon monoxide

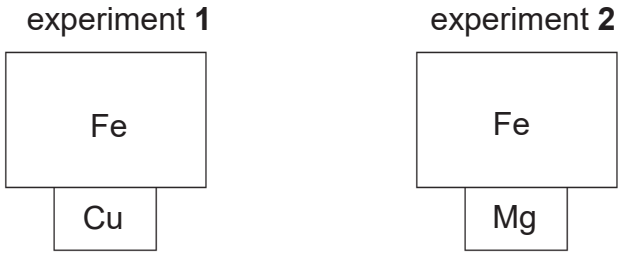
D acidified potassium dichromate(VI)

39 Aqueous sodium fluoride and aqueous sodium bromide are placed into two separate boiling tubes. Chlorine gas was bubbled into both boiling tubes.

Which are the equations for the reactions that would take place in both boiling tubes?

	boiling tube containing sodium fluoride	boiling tube containing sodium bromide
A	$F^- + Cl_2 \rightarrow F_2 + Cl^-$	$Br^- + Cl_2 \rightarrow Br_2 + Cl^-$
B	$F^- + Cl_2 \rightarrow F_2 + Cl^-$	no reaction
C	no reaction	$Br^- + Cl_2 \rightarrow Br_2 + Cl^-$
D	no reaction	no reaction

40 Two large pieces of iron are placed in water. In experiment **1**, a small piece of copper is attached to the iron. In experiment **2**, a small piece of magnesium is attached to the iron.



After 1 week, the iron in experiment **1** had rusted while the iron in experiment **2** did not rust.

Which statement best explains this observation?

A Copper acts as a cathode as it is loses electrons more readily than iron.

B Copper acts as an anode as it is loses electrons more readily than iron.

C Magnesium acts as an anode as it is loses electrons more readily than iron.

D Magnesium acts as a cathode as it is loses electrons more readily than iron.

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											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 90	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 112	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lathanoids	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

lanthaoids	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 89	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.).

Name:	Register Number:	Class:

4E

BEDOK GREEN SECONDARY SCHOOL

Preliminary Examination 2020

4E

CHEMISTRY **6092/02**

Paper 2 Theory 28 Aug 2020

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class on all the work you hand in.
You may use an HB pencil for any diagrams, graphs, tables or rough working.
Write in dark blue or black pen.
Do not use staples, paper clips, glue or correction fluid.

You may lose marks if you do not show your working or if you do not use appropriate units.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

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 brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 21.

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

For Examiner's Use	
Section A [50 marks]	
Section B [30 marks]	
Total [80 marks]	

Section A

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

A1 (a) There are three common methods of preparing salts.

- method **A**: adding excess solid to an acid
- method **B**: precipitation
- method **C**: titration

Complete the table below by stating the method (**A**, **B** or **C**) and name suitable reactants to produce each of the following salts.

name of salt	method	name of reactant 1	name of reactant 2
barium sulfate			sulfuric acid
magnesium chloride			
potassium nitrate			

[4]

(b) Briefly describe how a sample of pure and dry barium sulfate can be produced in the laboratory.

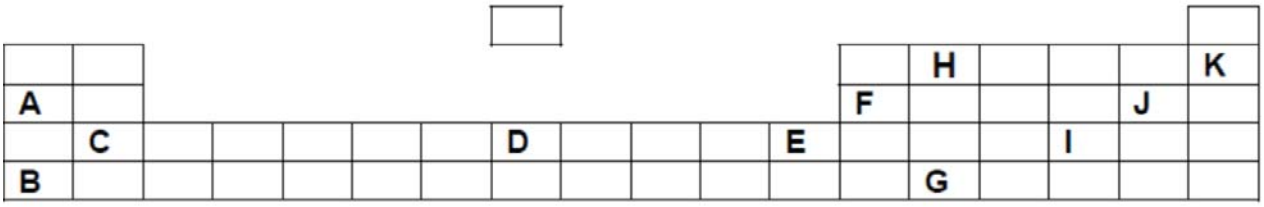
……..

……..

……..

…..……[2]

A2 In the Periodic Table below, the letters **A** to **K** represent some elements but not the symbols of the respective elements.



Use the letters to identify and answer the following questions. You may use the letter once, more than once, or not at all.

(a) an element that has a stable electronic structure

…… [1]

(b) an element that has oxidation states of +2 and +3

…… [1]

(c) a metal that floats in water and reacts quickly in water

…… [1]

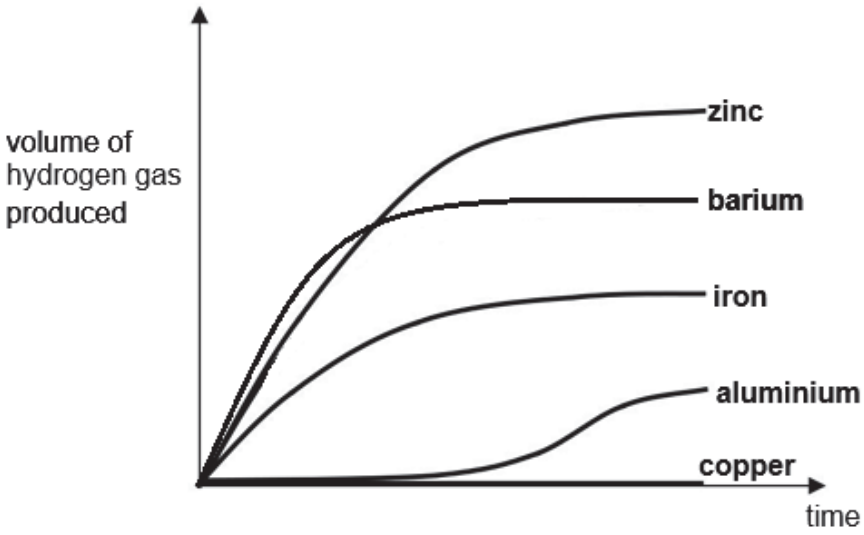
(d) an element used as a protective coating in food cans

…… [1]

(e) an element that forms an acidic oxide

…… [1]

A3 A student attempted to determine the reactivity of five metals by adding 10 g of each of the metals to excess hydrochloric acid and measuring the volume of hydrogen gas collected. The results were plotted into a graph as shown below.



(a) Write the equation for the reaction between iron and hydrochloric acid.
One of the product has metal ion with oxidation state of +2.

……[1]

(b) Although aluminium is more reactive than iron and zinc, explain why little volume of hydrogen is collected from the reaction between aluminium and hydrochloric acid at the start of the reaction.

……..

……..

……..

……[2]

(c) Explain why the graph for the reaction between copper and hydrochloric acid is a straight line on the 'time' axis.

……..

……[1]

(d) The experiment is not a fair test.
Suggest and explain how the procedure can be modified to accurately reflect the order of reactivity of the metals correctly.

……..

……..

……..

……..[2]

(e) Iron, zinc and copper are all metals from the transition metal block in the Periodic Table.
Give two reasons why zinc is **not** a typical transition metal.

……..

……..

……..

……..[2]

A4 The Haber process is an artificial nitrogen fixation process and is the main industrial procedure for the production of ammonia today. The formation of ammonia is made by reacting nitrogen and hydrogen in a reversible reaction as shown in the equation below.

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

(a) The reaction to produce ammonia can be demonstrated in the laboratory by the method shown in Fig 4. 1.

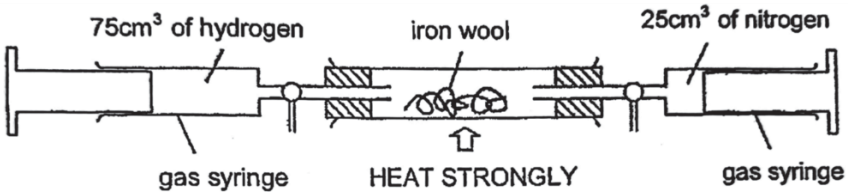


Fig 4.1

The mixture of nitrogen and hydrogen is passed backwards and forwards over the hot iron wool until there is no further reaction.

(i) Suggest why air must **not** be present in the above reaction.

……..

……..[1]

(ii) Using ideas of collision theory, explain the role of iron wool in the reaction above and how it affects the speed of reaction.

……..

……..

……..

……..[2]

(b) In the industry, ammonia is manufactured in a plant. The yield of ammonia can vary, depending on the temperature and pressure. Table 4.1 shows the percentage yield of ammonia at different temperatures and pressures.

Table 4.1

temperature/ ^{o}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

(**Note:** The standard atmosphere (symbol: atm) is a unit of pressure.)

(i) State the main source of the following reactants.

nitrogen ……..[1]

hydrogen ……..[1]

(ii) Suggest one advantage and one disadvantage of using 300 atm as the working pressure rather than 200 atm.

advantage: ..……...

……

disadvantage: ……..

……..……..[2]

(c) In the industry, after hydrogen and nitrogen are mixed in the reactor, the reaction mixture is cooled in the cooling chamber so that ammonia liquefies. Fig. 4.2 shows the reactor and the cooling chamber.

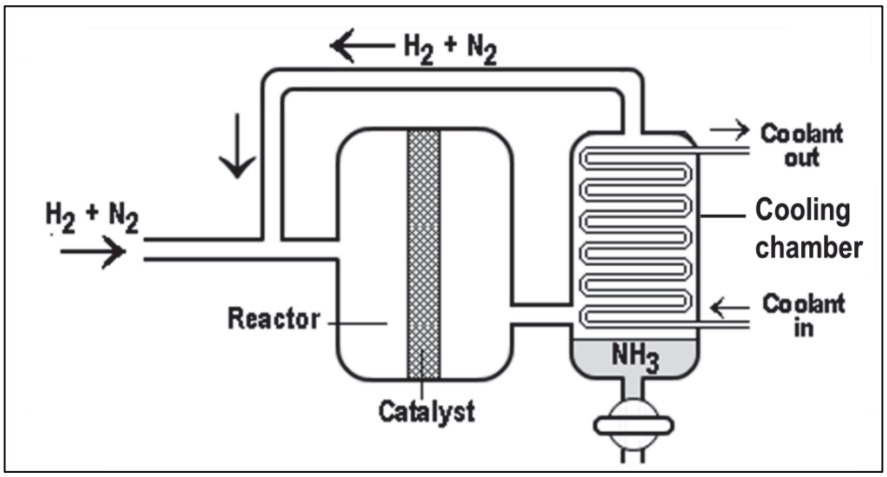


Fig. 4.2

The boiling points of nitrogen, hydrogen and ammonia are shown in Table 4.2.

Table 4.2

gas	boiling point / °C
nitrogen	-196
hydrogen	-253
ammonia	-33

Suggest a suitable temperature of the cooling chamber for it to achieve its function effectively.

……..……..[1]

A5 Small pieces of a grey coloured metal, **X**, were added to concentrated nitric acid.

A brown gas, **Z**, and a colourless solution containing salt **Y** were formed.

Analysis of a 0.0915 mol sample of **Z** showed it contained 1.28g of nitrogen and 2.93g of oxygen.

The small sample of the colourless solution was diluted with water and then divided into two portions.

- To one portion, aqueous sodium hydroxide was added drop by drop until it was in excess. A white precipitate, **W**, was formed that it is soluble in excess sodium hydroxide.
- To the other portion, aqueous ammonia was added drop by drop until it was in excess. A white precipitate, **W**, was formed that is soluble in excess aqueous ammonia.

(a) Identify

(i) white precipitate, **W**: ……..

(ii) metal **X**: ……..

(iii) salt **Y**: …….. [3]

(b) **(i)** Calculate the relative molecular mass, M_r, for gas **Z**.

[2]

(ii) Determine the molecular formula for gas **Z**.

[4]

(c) Describe a simple test to confirm that gas **Z** is acidic in nature.

……..

……..[1]

A6 Oxides of nitrogen contribute to the formation of acid rain. Chemical factories and car engines are common sources of oxides of nitrogen. One way to reduce the amount of oxides of nitrogen and carbon monoxides found in air is the use of catalytic converter.

(a) State the source and impact on the environment or human of carbon monoxide.

……

……

……[2]

(b) In a catalytic converter, the oxides of nitrogen and carbon monoxide in air passes through a ceramic material that is coated with catalysts.

State the names of the catalysts.

……[1]

(c) Describe how a catalytic converter reduces the emission of harmful gases.

……

……

……

……

……[2]

(d) Suggest an issue that may still arise after the harmful gases have passed through a catalytic converter.

……[1]

A7 An oxyacid is a compound that contains hydrogen, oxygen and at least one other element. Iodine forms several types of oxyacids and their names and chemical formulae are given in the table below.

name of oxyacid	chemical formula	oxidation state of iodine
periodic acid	HIO_4	
iodic acid	HIO_3	
hypoiodous acid	HIO	

(a) Complete the table to show the oxidation states of iodine in the respective oxyacids.

[2]

(b) Suggest the formula of the anion present in periodic acid.

……..[1]

(c) Draw a 'dot-and-cross' diagram to show the bonding in a molecule of hypoiodous acid, HIO. Show outer shell electrons only.

[2]

(d) Iodic acid is produced when iodine is mixed with water and chlorine, as shown in the equation below.

$$I_2 + 6H_2O + 5Cl_2 \rightleftharpoons 2HIO_3 + 10HCl$$

Explain, in terms of oxidation states, why this is a redox reaction.

……

……

……

……...[2]

End of Section A

Section B [30 marks]

Answer **all** questions
Question **B10** is in the form of an either/or and only one of the alternatives should be attempted.
Write the answers on the spaces provided.

B8 Nature of a Chemical Bond

The formulae and the type of bonding of the oxides and chlorides of the elements across Period 3 are shown in Table 10.1 below.

Table 10.1

element	metal/non-metal	formula of main oxide	bonding in oxide	formula in chloride	bonding in chloride
Na	metal	Na_2O	ionic	$NaCl$	ionic
Mg	metal	MgO	ionic	$MgCl_2$	ionic
Al	metal	Al_2O_3	ionic	$AlCl_3$	covalent
Si	non-metal	SiO_2	covalent	$SiCl_4$	covalent
P	non-metal	P_4O_{10}	covalent	PCl_3	covalent
S	non-metal	SO_3	covalent	S_2Cl_2	covalent
Cl	non-metal	Cl_2O_7	covalent	Cl_2	covalent

Electronegativity is a measurement of the tendency of an atom to attract a bonding pair of electrons. A bonding pair of electrons is the pair of electrons shared in a chemical bond. The higher the electronegativity, the greater the tendency of an atom to attract the bonding pairs of electrons towards itself.

The Pauling scale is used to measure the electronegativity of elements. It ranges from 0.7 to 4.0, with a higher value representing greater electronegativity. Table 10.2 shows the electronegativity values of some elements in the Periodic Table.

Table 10.2

proton number	element	electronegativity
8	O	3.4
9	F	4.0
10	Ne	undefined
11	Na	0.9
12	Mg	1.3
13	Al	1.6
14	Si	1.9
15	P	2.2
16	S	2.6
17	Cl	3.2
18	Ar	undefined

The difference in electronegativity between two elements involved in a chemical bond, Σ, can be calculated by the following equation

Σ = larger electronegativity value − smaller electronegativity value

An example is sodium oxide, Na_2O, where

$$\Sigma = 3.4 - 0.9$$
$$= 2.5$$

The strength of a bond can be measured by its bond energy. Bond energy is the amount of energy needed to break a mole of a particular bond. It is a measure of the strength of a chemical bond. Bond lengths are the distances between the centers of bonded atoms.

Table 10.3 shows the bond lengths and bond energies of some bonds.

Table 10.3

bond	bond length (pm)	bond energy (kJ /mol)
C–C	154	348
C=C	134	614
C≡C	120	839
Si–C*l*	202	381
P–C*l*	203	326
S–C*l*	207	253
C*l*–C*l*	199	243

Note: pm = picometers (10^{-12} m)

Source: http://www.science.uwaterloo.ca/~cchieh/cact/c120/bondel.html

(a) **(i)** Describe the trend in the values of the electronegativity for elements across Period 3 in the Periodic Table.

……...

……..[1]

(ii) Suggest a reason why argon and neon have an undefined value of electronegativity.

……...

……..[1]

(b) A student wrote the following conclusion by studying Table 10.1 and 10.2.

> "The bonding in the oxides and chlorides are ionic when the difference in electronegativity, Σ, between two elements is more than 2.0."

Do you agree with this conclusion?

Use the information provided to explain your reasoning.

……..

……..

……..

……..

……..

……..

……..

……..[5]

(c) State the relationship between bond length and bond energy.

……

……[1]

(d) How is the strength of a bond affected by the number of bonds between atoms? Use evidence from the information provided to explain your reasoning.

……..

……..

……..[2]

(e) All single covalent bonds have similar bond strength.

Do you agree with this statement? Justify your answer with evidence from the passage.

……

……[1]

B9 A commercial glow stick usually contains a thin glass capsule of hydrogen peroxide solution in a solution of phenyl oxalate ester. A fluorescent dye is also included, which determines the colour of the glow stick.

When the glass capsule is broken, 1, 2–dioxetanedione (C_2O_4) which causes the glow is formed. Fig. 9.1 shows the structural formula of 1, 2–dioxetanedione (C_2O_4).

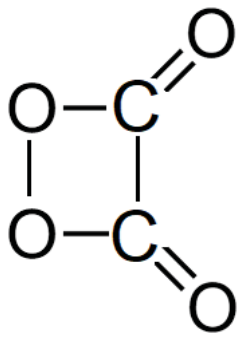


Fig 9.1

C_2O_4 is unstable and spontaneously decomposes to form carbon dioxide gas. The reaction is shown below.

The bond energies between carbon and oxygen are listed in Table 9.1.

Table 9.1

bond	bond energy/ kJ mol^{-1}
C – C	331
C – O	326
C = O	803
O – O	146

(a) A standard glow stick can glow up to 8 hours. When kept in the refrigerator, the working duration of the glow stick can be extended.

Explain this observation in terms of collision of reacting particles.

……

……

……

……[2]

(b) **(i)** Using the bond energies provided in the table, calculate the enthalpy change of the decomposition reaction of 1, 2–dioxetanedione.

[2]

(ii) Based on your answer in part **b(i)**, would you expect the glow stick to become colder or hotter as the reaction proceeds? Explain your reasoning in terms of bond breaking and bond forming.

……

……

……[2]

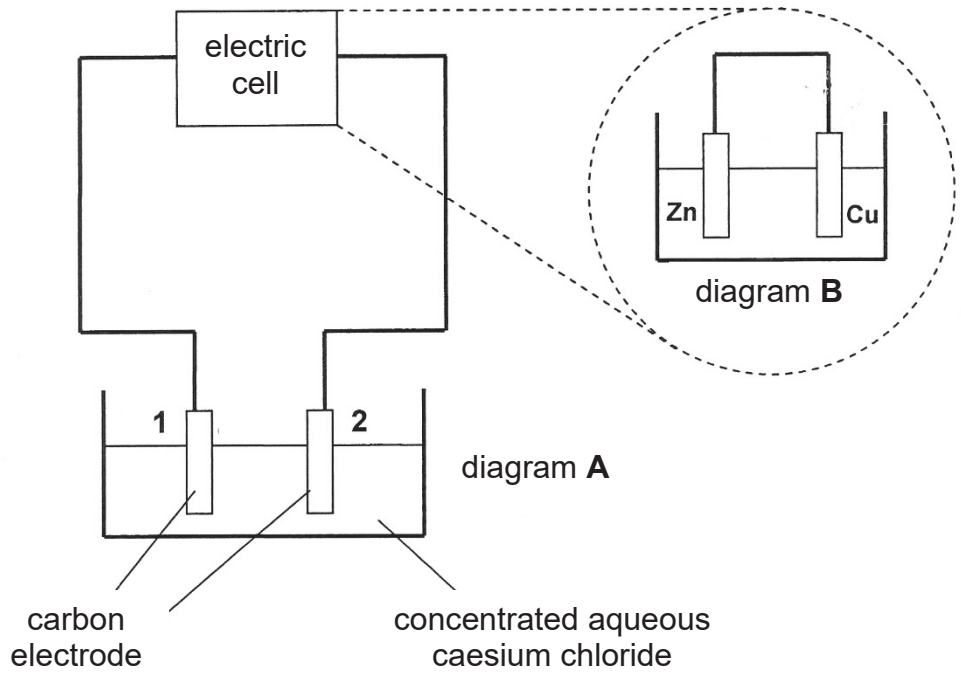
(iii) Draw the energy profile diagram of the reaction.

[3]

Either

B10 Diagram **A** below shows the electrolysis of concentrated aqueous caesium chloride while Diagram **B** shows the actual electric cell used in the electrolysis. A few drops of Universal Indicator is added to the caesium chloride solution in **A** before the start of the experiment.

As the experiment proceeds, a coloured gas was observed at electrode 2.



(a) Determine whether electrode **2** is the anode or cathode and write the half-equation for the reaction that occurs at this electrode.

……

……[2]

(b) Describe and explain the observations at electrode **1**.

……

……[2]

(c) State and explain the observations made on the electrolyte in diagram **A** as the experiment proceeds.

……

……

……

……[2]

(d) **(i)** The electrolyte used in diagram **B** is aqueous copper(II) sulfate.
Write the half-equation for the reaction at the copper metal.

……

……[1]

(ii) State the substance that is reduced during the experiment. Explain your reasoning using transfer of electrons.

……

……

……

……[2]

(e) If the position of the zinc and copper electrodes in diagram **B** were switched with each other, suggest what would be observed instead in the setup of diagram **A**.

……

……[1]

Or

B10 Read the information below about fuel cells.

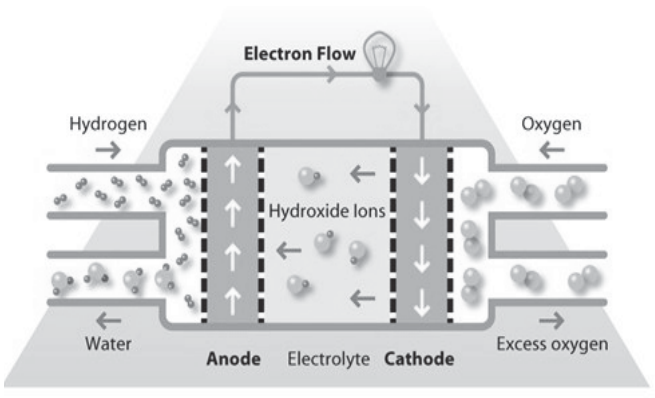
A fuel cell is a chemical cell in which reactants are continuously supplied to produce electricity.

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 70ºC. 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.

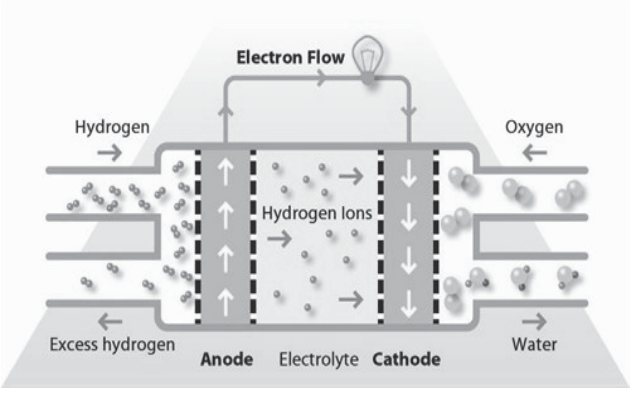
AFCs are easily poisoned by carbon dioxide (CO_2). In fact, even a small amount of CO_2 in the air can affect this cell's operation, making it necessary to purify both the hydrogen and oxygen used in the cell. This purification process is costly.



Proton Exchange Membrane Fuel Cell (PEMFC)

The ***PEMFC*** uses a water-based, acidic polymer membrane as its electrolyte, with platinum-based electrodes. ***PEMFC*** operate at relatively low temperatures (below 100°C). 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) Suggest why do ***AFCs*** work well on a spacecraft.

……..

……..

…… [2]

(b) State one reason why the operation of ***AFC*** is more economical than that of ***PEMFC***.

…… [1]

(c) For the ***PEMFC***, the half equation at the anode is:

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

Write the half equation for the reaction occurring at the cathode.

…… [1]

(d) 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]

(e) 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. This is an endothermic process.

(i) Write the balanced chemical equation for the steam-reforming process.

……..[2]

(iii) 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]

End of Section B