NAME: ( )

CLASS:

YISHUN TOWN SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2021

SEC 4 EXPRESS

CHEMISTRY

(6092/2)

DATE : 25 Aug 2021 DAY : Wednesday

DURATION : 1 hr 45 min MARKS : 80 marks

READ THESE INSTRUCTIONS FIRST

Write your name, class and register number in the spaces provided at the top of this page.

Section A

Answer **all** the questions.
Write your answers in the spaces provided.

Section B

Answer **three** questions. Question **B9** and **B10** are compulsory. Choose one question from B11.
Write your answers in the spaces provided.

INFORMATION FOR CANDIDATES
The number of marks is given in brackets [ ] at the end of each question or part question.

You may use an approved calculator.

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

Section A	
Section B	
TOTAL	

SECTION A
Answer all the questions in the spaces provided.

A1 Choose from the following list of ions to answer the questions below. Each substance can be used once, more than once or not at all.

hydroxide	copper (II)	carbonate	iron (II)
nitrate	ammonium	hydrogen	iodide

Choose **one** ion from the list above which [5]

(a) is responsible for the alkaline properties of an alkali. _____

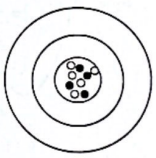
(b) forms a blue precipitate when added to aqueous sodium hydroxide. _____

(c) when added to acid forms a gas. _____

(d) when added to alkali forms a gas. _____

(e) forms a brown solution when added to aqueous chlorine. _____

A2 The diagram below shows the structure of an atom. The electrons are missing.



(a) Complete the table below about the three particles found in this atom. [2]

Particle	Name of particle	Relative mass of the particle	Relative charge on the particle
o		1	
●		1	+1
×	electron		-1

(b) Complete the diagram to show the arrangement of the electrons in the atom. [1]

(c) Write the chemical symbol of this element in the form ${}^{A}_{Z}X$ showing clearly the nucleon number and proton number. [1]

A3 The following information is given for the chlorides of some elements in Period 2. The elements are labelled W, X, Y and Z.

Element	Formula of chloride	Melting point /°C	Boiling point /°C
W	WCl_2	714	1418
X	XCl	790	1407
Y	YCl_2	-80	138
Z	ZCl_4	-70	58

(a) Arrange the elements W, X, Y and Z in order of increasing atomic number. [1]

(b) Describe the movement and arrangement of the particles of YCl_2 at -50 °C. [2]

(c) Explain how and why the melting points of XCl and ZCl_4 are different. [3]

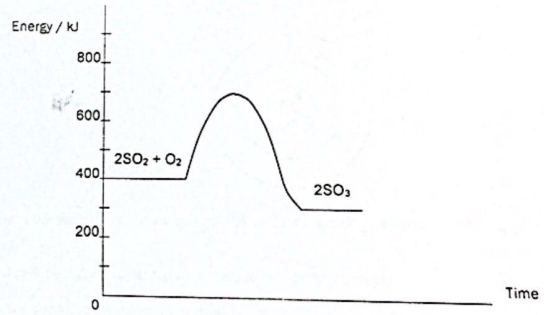
(d) Draw the dot and cross diagram of WCl_2 showing all electrons. [2]

A4 The table gives some data about three fuels that are currently used in the world today.

Fuel	Gas formed on burning		
	Carbon dioxide	Sulfur dioxide	Water vapour
Petrol	√		√
Diesel	√		√
Coal	√	√	√

(a) Explain why coal is said to be a bad fuel compared to petrol and diesel. [2]

(b) The diagram shows the energy profile diagram for the formation of sulfur trioxide from sulfur dioxide and oxygen. This reaction is a reversible reaction. [2]



(i) State the activation energy of the reaction and label Ea on the graph.

(ii) State the enthalpy change of the backward reaction.

(c) Some information on other type of fuels used is shown in the table below.

Name	Formula	Physical state at rtp	Enthalpy change of combustion / kJ per 100 g
Ethanol	C_2H_5OH	Liquid	- 2972
Propane	C_3H_8	Gas	- 5045

(i) Calculate the amount of energy given out when 2.5 mol of ethanol is burnt. [2]

(ii) Describe one advantage of using ethanol as a fuel compared to propane. [1]

A5 The table below shows the percentage of nitrogen and carbon monoxide present in air and in the exhaust fumes of a car without and with a catalytic converter.

	Percentage by volume		
		Exhaust fumes of car	
Gas	Air	Without catalytic converter	With catalytic converter
N_2	78	76	77
CO	0	0.2	0

In the catalytic converter, the following reactions take place.

Reaction 1: $2NO\,(g) \rightarrow N_2\,(g) + O_2\,(g)$
Reaction 2: $2CO\,(g) + O_2\,(g) \rightarrow 2CO_2\,(g)$

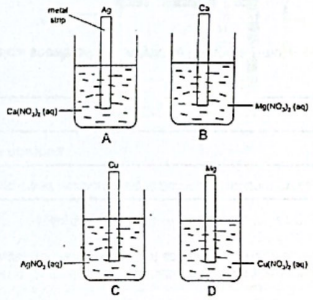
(a) Using the information given, account for the difference between the percentage of nitrogen in air and in the exhaust fumes of a car without a catalytic converter, and the difference between the percentage of nitrogen in the exhaust of a car with and without a catalytic converter. [3]

(b) (i) Write the overall chemical equation for the reaction that takes place in the catalytic converter. [1]

(ii) Explain using oxidation states, why CO is acting as the reducing agent in the overall reaction. [1]

(c) A student suggested removing CO by passing the gas through calcium carbonate. State with a reason whether this suggestion will work. [1]

A6(a) A series of experiments was set up as shown in the diagram below. The metal strips are in excess.



(i) Construct an ionic equation for any one of the beakers that has a reaction. [1]

(ii) Describe two observations made for beaker D. [2]

(iii) In beaker **C**, the copper strip was replaced with aluminium. No reaction was observed. Explain why aluminium does not react. [1]

(b) Brass is an alloy containing a mixture of zinc and copper. With the aid of a diagram, explain why this alloy is strong. [3]

A7 A student carried out a few experiments to investigate the effect of concentration on the reaction between acids and magnesium metal. A 15.0 cm length of magnesium ribbon was added to each of the following flasks. At the end of the experiment, small bits of magnesium ribbon were found to be left in each flask.

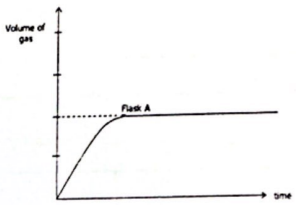
Flask **A**: 100.0 cm^3 of 0.1 mol/dm^3 hydrochloric acid

Flask **B**: 100.0 cm^3 of 0.1 mol/dm^3 sulfuric acid

Flask **C**: 100.0 cm^3 of 0.1 mol/dm^3 ethanoic acid

(a) Comparing flask **A** and **B**, explain which flask contains the lower concentration of hydrogen ions. [3]

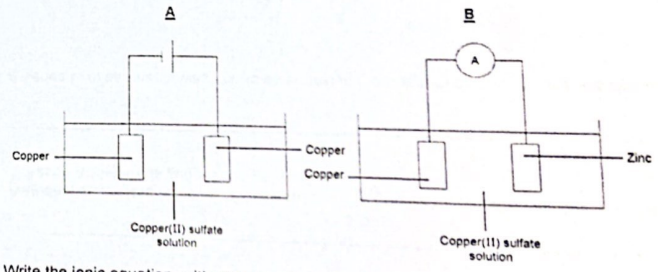
(b) The gas evolved in flask **A** was recorded every 30 seconds and a graph of volume of gas produced against time was plotted as shown below.



Sketch on the same graph above, the rate curve obtained for flask **B** and flask **C** each. Label your graphs clearly. [2]

(c) In another similar experiment, the magnesium ribbons were replaced with the same mass of magnesium powder. Explain, in terms of collisions between particles how this affects the rate of reaction. [2]

A8 The diagram below shows an electrolytic cell **A** and a simple cell **B**.



(a) Write the ionic equation, with state symbols, for the reactions that take place at [2]

(i) the anode in cell **A** :

(ii) the positive electrode in cell **B**:

(b) Describe one common observation that would be seen in both cells. [1]

(c) Describe one observation that would only be seen in the electrolyte of cell B but not in cell A. Explain your answer. [3]

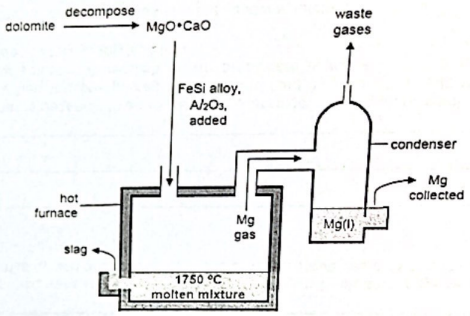
SECTION B

Answer all three questions in the spaces provided.

B9 Extraction of magnesium

Magnesium is found in nature as the ore, dolomite, $MgCO_3 \cdot CaCO_3$. Dolomite contains 75% magnesium carbonate.

To extract magnesium from its ore, the following steps in an industrial extraction process are employed, as shown in the diagram below.



Step 1: Decomposition

The dolomite ore is first decomposed to produce a mixture of magnesium and calcium oxides:

$$MgCO_3 \cdot CaCO_3\,(s) \rightarrow MgO \cdot CaO\,(s) + 2CO_2\,(g)$$

Step 2: Reduction

The oxides prepared in **Step 1** are then mixed with an alloy of iron and silicon, ferrosilicon (FeSi), and loaded into the furnace. In this furnace, reduction of the magnesium oxide takes place but not calcium oxide.

$$2MgO\,(s) + Si\,(s) \rightleftharpoons SiO_2\,(s) + 2Mg\,(g)$$

Small amounts of aluminium oxide may also be added to decrease the melting point of the slag. The reaction is carried out at 1750 °C and under very low pressure. Under these conditions, the magnesium is produced as a gas, which is then condensed in a cooling chamber, and collected as metal blocks. The magnesium obtained has a 95% purity.

Step 3: Removal of impurities

The molten slag formed is calcium silicate and is removed from the molten magnesium.

(a) Calculate the **maximum** mass of magnesium that can be produced from 112 tonnes of dolomite. [1 tonne = 1000 000g]
[4]

(b) What can you infer about the relative reactivities of magnesium, calcium and silicon from the extraction process? Explain your answer. [3]

(c) Suggest how the aluminium oxide added helps to lower the melting point of the slag. [1]

(d) Explain with reason one advantage of using a FeSi alloy with a higher proportion of Si. [2]

(e) Other than calcium oxide, silicon dioxide and calcium silicate, suggest another impurity that could be present in the molten magnesium. [1]

(f) Explain how slag (calcium silicate) is formed during the extraction process. [1]

B10 Some information about Group I and Group VII elements are given in the table below. Electronegativity is a measure of the ability of an atom to attract an electron. The greater the electronegativity value of an atom, the greater is its ability to attract electrons.

	Element	Atomic Radius / pm	Electronegativity
Group I	Lithium	152	
	Sodium	185	
	Potassium	227	
Group VII	Chlorine	99	3.16
	Bromine	115	2.96
	Iodine	156	2.66

(a) Predict the trend in the electronegativity of the Group I elements down the group. [1]

(b) "Group VII elements become poorer oxidizing agents down the group."

Suggest how the trend in the atomic radius of the Group VII elements supports this statement. [2]

(c) Although Group I and transition elements are metals, they have different physical properties. Describe one similarity and one difference in the physical properties of Group I and transition metals. [2]

(d) When chlorine gas is passed into aqueous iron (II) bromide, the colour of the solution changes to orange-red. When the orange red solution is heated, it gives off a reddish-brown gas, leaving a yellow solution. A reddish brown precipitate is formed when aqueous sodium hydroxide is added to this yellow solution.

(i) Identify the reddish brown gas and the yellow solution. [1]

Reddish brown gas: _____

Yellow solution : _____

... conductors of electricity as they both exist. [1]

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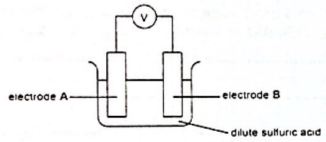
(ii) Explain how the orange red solution and the yellow solution is formed. [2]

EITHER

B11 The diagram shows a simple electrochemical cell.



The voltages produced by different combinations of metal electrodes are shown in the table below.

Experiment	Electrode A	Electrode B	Voltage / V
1	copper	zinc	1.10
2	copper	tin	0.48
3	copper	magnesium	2.70
4	copper	iron	0.78
5	copper	metal P	-0.46

(a) For experiments 1-4, which electrode, **A** or **B**, is the negative electrode? Explain your answer. [2]

(b) Use the information in the table to deduce the order of reactivity of the metals copper, iron, magnesium, tin and zinc. Explain your answer. [2]

(c) (i) What can you infer about the reactivity of metal **P** compared to copper? Explain your answer. [1]

(ii) Hence, suggest a possible identity of metal **P**. [1]

(d) When a student used calcium as electrode **B**, after some time, he noticed white precipitate forming in the electrolyte. Explain the observation. [2]

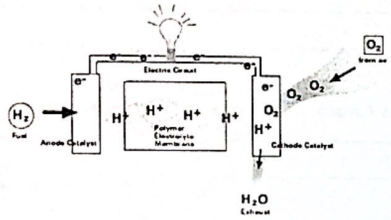
(e) With reference to the particles present in each structure, describe how the metal electrodes and dilute sulfuric acid are able to conduct electricity. [2]

OR

B11 Growing demand for alternative forms of energy that are clean and efficient has led to the rising popularity of commercial fuel cell vehicles powered by hydrogen.

A typical fuel cell found in hydrogen powered cars is shown below. The overall chemical equation for the reaction in the fuel cell is given below:

$$2H_2 + O_2 \rightarrow 2H_2O$$



(a) Using only information from the diagram, deduce the ionic half equations that occur at each electrode. State symbols are not required. [2]

Cathode: _____

Anode : _____

(b) A student claimed that "Hydrogen is only as clean as the fuel source used to produce it." Explain what the student meant. [2]

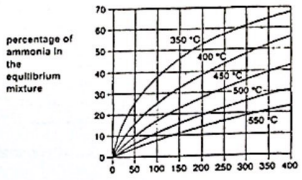
_____

_____

_____

(c) A hydrogen fuel cell car can travel 199 km per kg of hydrogen. If the volume of hydrogen available in the gas tank is 60000 dm^3, what distance can the car travel? [2]

(d) Hydrogen is also used as a raw material in the Haber process. In the Haber process, ammonia gas is produced. The following graph shows the amount of ammonia present in the equilibrium mixture under different conditions of temperature and pressure.



(i) State the source of hydrogen and nitrogen used in the Haber process. [1]

Hydrogen: _____

Nitrogen : _____

(ii) What is the effect of increasing the pressure on the percentage of ammonia in the equilibrium mixture? [1]

_____

_____

(iii) Suggest one advantage and one disadvantage of using 450°C rather than 350°C as the working temperature for the manufacture of ammonia. [2]

_____

_____

_____

_____

_____

The Periodic Table of Elements

Group																	
	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.).