Candidate Name: _____ Class | Index No.

FUHUA SECONDARY SCHOOL

Secondary Four Express

Preliminary Examination 2021

4E

CHEMISTRY

6092/01

Paper 1 Multiple Choice

31 August 2021
0800 – 0900
1 hour

Additional Material: Optical Mark Recognition (OMR)

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, index number on the OMR and this question booklet.

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 separate OMR.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on this paper.
A copy of the Periodic Table is printed on page **12**.
The use of an approved scientific calculator is expected, where appropriate.

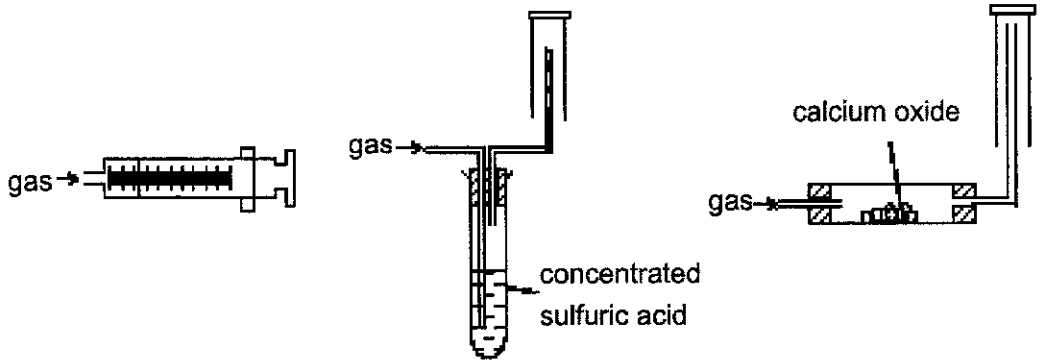
PARENT'S SIGNATURE	FOR EXAMINER'S USE	
		~~40~~ 37

Setter: Mr Elton Tan

Vetters: Mdm Hia Soo Ching, Mr Ng Wei Ping, Mr Travis Neo & Miss Choo Hui En

This question paper consists of 12 printed pages including this page.

1 A gas is produced when aqueous calcium hydroxide and aqueous ammonium chloride are heated. Which of the following methods can be used to collect a dry sample of the gas?



A 1 only **B** 3 only **C** 1 and 3 only **D** 2 and 3 only

2 A student is exploring various ways to monitor the rate of the following reaction by measuring changes in different variables of the reaction.

$$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 3C_2O_4^{2-}(aq) \rightarrow 2Cr^{3+}(aq) + 6CO_2(g) + 7H_2O(l)$$

Which of the following variables can be measured to monitor the rate of reaction?

1 pH of the reaction mixture
2 mass of the reaction mixture
3 amount of precipitate obtained

A 1 only **B** 2 only **C** 1 and 2 only **D** 1, 2 and 3

3 A series of experiments was conducted on an unknown pure substance. Which observation suggests that the pure substance could be an element?

A The pure substance is soluble in water.
B The pure substance has a fixed melting point.
C The pure substance conducts electricity in the solid state.
D The pure substance forms two products when undergoing heating.

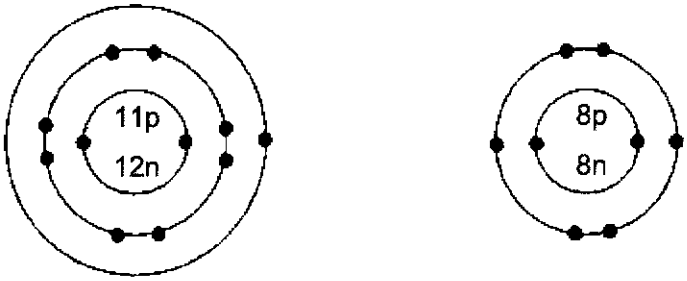
4 The equation shows the reaction of an oxide of metal M in water.

$$M_2O(s) + H_2O(l) \rightarrow 2MOH(aq)$$

What types of bonding are present in M_2O and MOH?

	M_2O	MOH
A	ionic	ionic
B	ionic	ionic and covalent
C	covalent	ionic
D	covalent	covalent

5 The diagrams below show the atoms of two elements, S and T.



S T

What is the relative molecular mass of the compound formed between these two elements?

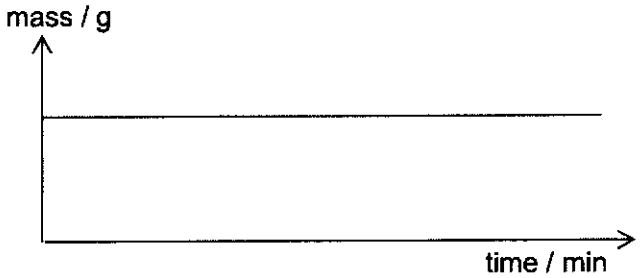
A 30 **B** 39 **C** 55 **D** 62

6 Which methods are suitable to test the strength of acids with the same volume and concentration?

1 titration
2 measuring their electrical conductivity
3 using a pH meter

A 1 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

7 Two solutions were mixed in a beaker. The mass of the beaker and its contents was recorded at regular time intervals. The graph below shows the results.



What could the two solutions be?

A aqueous ammonium nitrate and warm dilute hydrochloric acid
B aqueous ammonium chloride and warm aqueous sodium hydroxide
C aqueous silver carbonate and warm aqueous dilute hydrochloric acid
D magnesium and dilute sulfuric acid

8 When 42.0 g of sodium hydrogen carbonate, $NaHCO_3$, was strongly heated, 4.50 dm^3 of gas was collected at room temperature and pressure.

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

What was the percentage yield of carbon dioxide?

A 29.0% **B** 37.5% **C** 40.9% **D** 75.0%

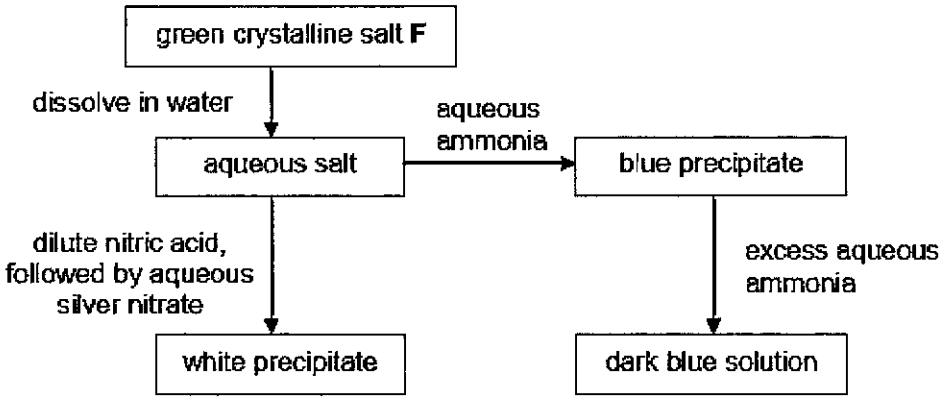
9 A student attempted to prepare some salts by using reagents shown in the table below.

experiment	salt	reagents
1	zinc chloride	mixing aqueous zinc nitrate and hydrochloric acid
2	sodium nitrate	titrating aqueous sodium carbonate with nitric acid
3	calcium sulfate	mixing aqueous calcium nitrate and sulfuric acid

Which of the experiments give a good yield?

A 1, 2 and 3 **B** 2 and 3 only **C** 3 only **D** 1 only

10 The scheme below shows some reactions of salt F.



What is the identity of F?

A copper(II) chloride
B copper(II) sulfate
C iron(II) chloride
D Iron(II) sulfate

11 In which equations are each underlined substance acting as a reducing agent?

1 $\underline{ZnO}\,(s) + CO\,(g) \rightarrow Zn\,(s) + CO_2\,(g)$
2 $Cu\,(s) + \underline{N_2O}\,(g) \rightarrow CuO\,(s) + N_2\,(g)$
3 $CuO\,(s) + 2\underline{NH_3}\,(g) \rightarrow 3Cu\,(s) + N_2\,(g) + 3H_2O\,(l)$
4 $\underline{H_2SO_4}\,(aq) + Na_2O\,(s) \rightarrow Na_2SO_4\,(aq) + 2H_2O\,(l)$

A 3 only **B** 1 and 2 only **C** 3 and 4 only **D** 1, 2 and 3 only

12 Six oxides are listed below.

Al_2O_3 CO CuO Na_2O P_4O_6 SO_2

How many of these oxides can react with aqueous sodium hydroxide?

A 2 **B** 3 **C** 4 **D** 5

13 W, X, Y and Z are metals. When the metals were heated with an oxide of another metal, the following results are obtained.

- oxide of Z + W → oxide of W + Z
- oxide of X + W → no reaction
- oxide of Z + Y → oxide of Y + Z
- oxide of W + Y → no reaction

What is the correct arrangement of metals W, X, Y and Z in order of increasing reactivity?

A W, X, Y, Z
B X, W, Y, Z
C Y, Z, W, X
D Z, Y, W, X

14 How will the addition of a catalyst affect the energy of the particles and the activation energy of the reaction?

	energy of particles	activation energy
A	remains the same	remains the same
B	remains the same	decreases
C	increases	remains the same
D	increases	decreases

15 Four students each dissolved an indigestion tablet in 100 cm^3 of water. They titrated 25.0 cm^3 of their solutions with dilute hydrochloric acid using the same indicator. The results are shown in the table.

student	P	Q	R	S
volume of hydrochloric acid / cm^3	19.40	19.50	19.40	21.00

Which statement could explain the anomalous result obtained by student S?

A The burette was rinsed with hydrochloric acid.
B The titration flask was rinsed with hydrochloric acid.
C The pipette was rinsed with solution of indigestion tablet.
D The titration flask was rinsed with solution of indigestion tablet.

16 Three main group elements, X, Y and Z, have consecutive increasing atomic numbers. What are the possible formulae for the ions formed by elements X and Z in their compounds?

A X^- and Z^+
B X^{2-} and Z^+
C X^+ and Z^{2-}
D X^+ and Z^{2+}

17 Q, R, S and T are elements in the Periodic Table. Here are some results obtained from experiments conducted on these substances or their corresponding compounds.

- Q and R are formed as elements at the anode during electrolysis of its aqueous solution.
- S and T are formed as elements at the cathode during electrolysis of its aqueous solution.
- S has a higher melting point than T.
- R gains electrons more readily than Q.

Which of the following statements could be correct?

A Q could be bromine and R could be iodine.
B R could be paler in colour than Q.
C S could exist as diatomic molecules.
D T could be lithium and S could be sodium.

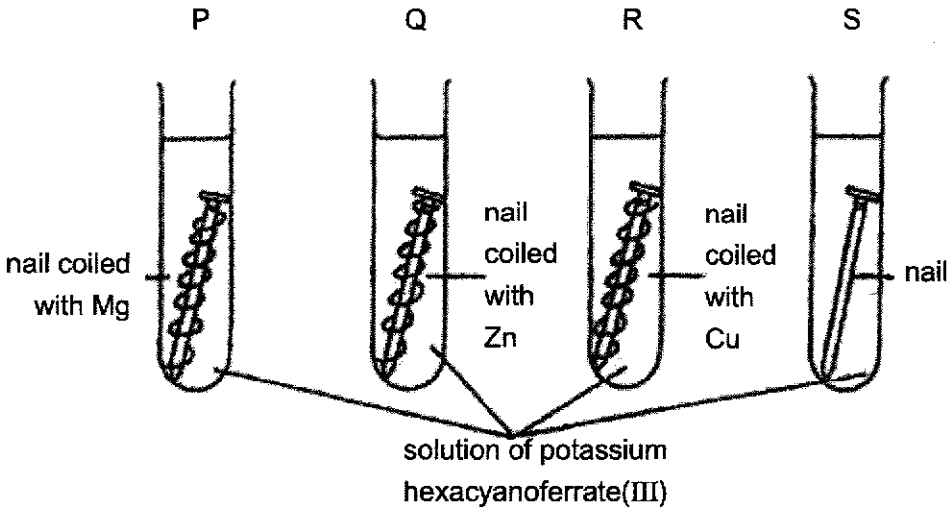
18 Which of the following ions would lose an electron most readily?

A Al^{3+} **B** Fe^{2+} **C** Ag^{+} **D** Na^{+}

19 Four clean iron nails were prepared and three of them were coiled with metals.

The nails were put into four test tubes, P, Q, R and S. Potassium hexacyanoferrate(III) solution was then poured into the test tubes to cover the nails.

Potassium hexacyanoferrate(III) solution forms a dark blue colour with iron ions that are present in the rust. The intensity of blue colour indicates the extent of rusting that has taken place.



Which of the following shows the correct arrangement of the test tubes, in order of increasing intensity of blue?

A P, Q, S, R
B R, S, Q, P
C P, Q, R, S
D S, R, Q, P

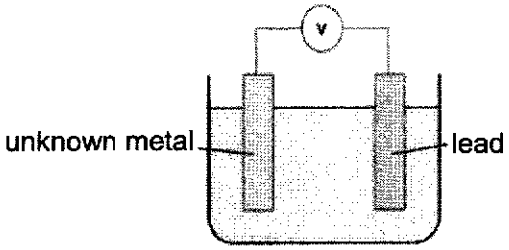
20 An electric current was passed through molten calcium chloride, producing 2.00 g of calcium metal at the cathode. What was the mass of chlorine produced at the anode?

A 1.20 g **B** 1.78 g **C** 3.55 g **D** 7.1 g

21 Which of the following reactions takes place in a hydrogen fuel cell?

A Hydrogen ions are oxidised at the anode.
B Hydrogen ions are reduced at the cathode.
C Oxygen loses electrons to form O^{2-} at the cathode.
D Hydrogen loses electrons to form H^+ ions at the anode.

22 Four metal strips W, X, Y and Z were tested for their reactivities by using a set-up as shown below. If lead is the positive electrode, it will result in a positive voltmeter reading. Readings from the voltmeter are shown in the table below.



unknown metal	voltmeter reading / V
W	1.10
X	0.00
Y	–0.66
Z	0.58

Which of the following shows the correct arrangement of the four unknown metal strips in order of decreasing reactivity?

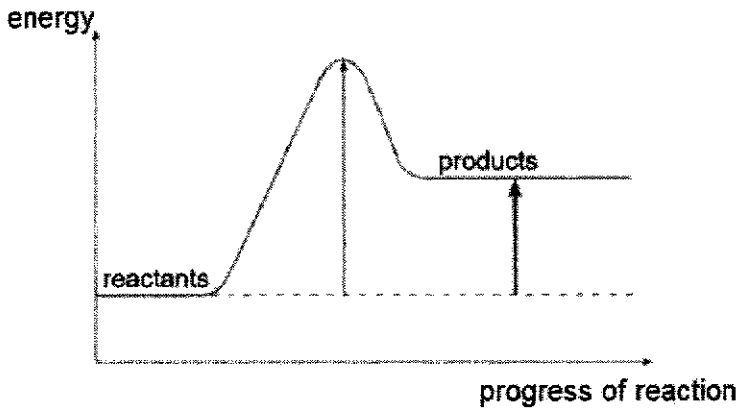
A W, Z, X, Y
B Y, X, Z, W
C W, Y, Z, X
D X. Z, Y, W

23 During the electroplating of a silver spoon using gold,

1 the anode is the silver metal.
2 the spoon is made the cathode.
3 the electrolyte used is aqueous silver nitrate.
4 the concentration of the electrolyte increases during electroplating.

Which of the above statements are correct?

A 2 only **B** 1 and 2 only **C** 1, 2 and 3 only **D** 1, 3 and 4 only

24 

Which of the following reactions could have the energy profile shown above?

A $CuCO_3$ (s) → CuO (s) + CO_2 (g)
B $Cu(s) + 2AgNO_3$ (aq) → $Cu(NO_3)_2$ (aq) + 2Ag (s)
C CH_4 (g) + $2O_2$ (g) → CO_2 (g) + $2H_2O$ (g)
D H_2O (g) → H_2O (*l*)

25 Which of the following statements explains why less energy is released for the incomplete combustion of hydrocarbons?

A Incomplete combustion occurs at a lower temperature than complete combustion.
B The activation energy of incomplete combustion is higher than that of complete combustion.
C The products of incomplete combustion have a higher energy content than that of complete combustion.
D The total number of bonds broken and formed for incomplete combustion is less than that for complete combustion.

26 Solid copper metal, aqueous copper(II) sulfate, solid graphite and molten magnesium chloride will all conduct electricity. Which pair of substances will conduct electricity because of mobile electrons?

A aqueous copper(II) sulfate and molten magnesium chloride
B aqueous copper(II) sulfate and solid copper metal
C molten magnesium chloride and solid graphite
D solid copper metal and solid graphite

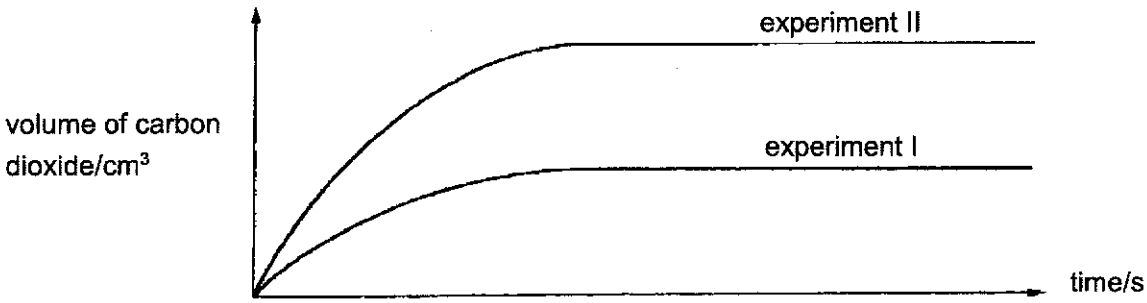
27 Vanadium oxide reacts with dilute sulfuric acid in the reaction shown below.

$$V_2O_5 + H_2SO_4 \rightarrow (VO_2)_2SO_4 + H_2O$$

What type of reaction is this?

A dehydration
B neutralisation
C precipitation
D redox

28 Two experiments were performed at 30°C and the results are shown in the diagram below.



Experiment I was a reaction between excess calcium carbonate and 25 cm^3 of 0.75 mol/dm^3 hydrochloric acid. The volume of carbon dioxide collected in experiment II was twice the volume collected in experiment I.

What change was made to produce the graph of experiment II?

A addition of a catalyst
B changing the volume of hydrochloric acid to 50 cm^3
C changing the temperature of hydrochloric acid to 60°C
D changing the concentration of hydrochloric acid to 1.50 mol/dm^3

29 Ammonia is manufactured by the Haber process according to the equation shown below.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Which statement is correct?

A Hydrogen is reduced by nitrogen.
B Nickel is added as the catalyst in this reaction.
C Increasing temperature will increase the rate of this reaction.
D Hydrogen is obtained from the fractional distillation of liquefied air.

30 Powdered calcium oxide is commonly placed near chimneys in coal-burning power stations to reduce atmospheric pollution by removing the waste gases. Which gas will **not** be removed by powdered calcium oxide?

A carbon dioxide
B sulfur dioxide
C hydrogen chloride
D nitrogen monoxide

31 Ammonia burns in oxygen, forming nitrogen and water. The equation is shown below.

$$4NH_3\,(g) + 3O_2\,(g) \rightarrow 2N_2\,(g) + 6H_2O\,(l)$$

If 40 cm^3 of ammonia is burnt in 60 cm^3 of oxygen, what will be the total volume of gases left after combustion at room temperature and pressure?

A 20 cm^3 **B** 40 cm^3 **C** 50 cm^3 **D** 60 cm^3

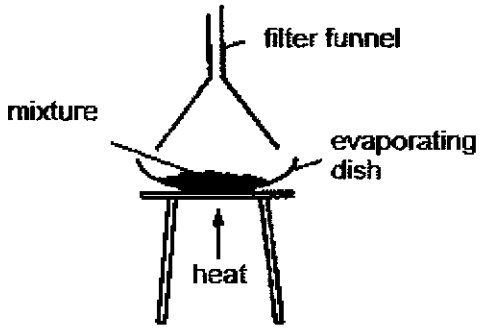
32 Petrol and diesel are two common fuels used by cars and buses respectively. The combustion of these fuels produces air pollutants. The following table shows the mass of pollutants found in the exhaust fumes when 1 kg of each fuel is burnt.

fuel	mass of pollutants/ g			
	carbon monoxide	oxides of nitrogen	sulfur dioxide	unburnt hydrocarbons
petrol	240	20	1	25
diesel	10	60	4	20

Which statement can be inferred from the table?

A Petrol contributes more towards the formation of acid rain.
B Carbon monoxide is produced by complete combustion of the fuels.
C All the pollutants listed can be removed by installing a catalytic converter.
D The temperature in the petrol engine is lower than that in the diesel engine.

33 A student used the following setup to separate mixtures.



Which of the following mixtures can be separated into its components using this setup?

A copper(II) sulfate and sugar
B copper(II) sulfate and sodium chloride
C sodium chloride and ammonium chloride
D ammonium chloride and iodine

34 When dilute nitric acid and aqueous barium nitrate were added to solution R, a white precipitate was observed. When aqueous sodium hydroxide was added to solution R, a white precipitate which was soluble in excess aqueous sodium hydroxide to form a colourless solution was observed.

What is the identity of solution R?

A aluminium sulfate
B calcium chloride
C lead(II) sulfate
D zinc chloride

35 When concentrated magnesium chloride undergoes electrolysis using platinum electrodes, what are the products collected at the electrodes?

	positive electrode	negative electrode
A	oxygen	hydrogen
B	hydrogen	chlorine
C	magnesium	chlorine
D	chlorine	hydrogen

36 Antimony oxide has a chemical formula of Sb_2O_3 while sodium phosphate has a chemical formula of Na_3PO_4. What is the formula of antimony phosphate?

A $SbPO_4$
B Sb_2PO_4
C Sb_3PO_4
D $Sb_2(PO_4)_3$

37 The complete combustion of 20 cm^3 of a gaseous alkane, Y, requires 70 cm^3 of oxygen. Both volumes were measured at r.t.p. What could the identity of Y be?

A butane
B ethane
C methane
D propane

38 The reaction between a carboxylic acid, C_xH_yCOOH, and an alcohol, $C_nH_{2n+1}OH$ produces an ester. How many carbon and oxygen atoms are there in one molecule of the ester?

	number of carbon atoms	number of oxygen atoms
A	x + n	2
B	x + n	3
C	x + n + 1	2
D	x + n + 1	3

39 In which of the following processes is water **not** part of the reaction?

A manufacture of ethanol from glucose
B manufacture of propanol from propene
C manufacture of margarine from vegetable oils
D manufacture of nylon from dicarboxylic acid and diamine

40 Which pair of gases would change the colour of moist red litmus paper in separate experiments?

A carbon dioxide and sulfur dioxide
B chlorine and ammonia
C chlorine and nitrogen dioxide
D methane and hydrogen chloride

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

Class | Index No.

Candidate Name: _____

FUHUA SECONDARY SCHOOL

Secondary Four Express

Preliminary Examination 2021

4E

CHEMISTRY

6092/02

Paper 2

24 August 2021
1040 – 1225
1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number 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 of either/or.
Answer all questions in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 20.

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

PARENT'S SIGNATURE

FOR EXAMINER'S USE		
Section A	Section B	Total
/50	/30	/80

Setter: Mr Elton Tan

Vetters: Mdm Hia Soo Ching, Mr Ng Wei Ping, Mr Travis Neo & Miss Choo Hui En

This document consists of **19** printed pages and **1** blank page.

Section A

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

A1 The following information is given for the oxides of some elements in Period 3. The elements are labelled **A**, **B**, **C**, **D**, **E** and **F**. The labels are not symbols of any element.

element	formula of oxide	melting point/ °C	boiling point/ °C	behaviour with water
A	A_2O	-120	2	soluble forming a weak acid
B	**B**O	2800	3600	slightly soluble forming an alkali
C	C_2O_3	2054	3000	insoluble
D	DO_2	1650	2230	insoluble
E	EO_2	-72	-10	soluble forming an acid
F	F_2O	1132	1950	soluble forming a strong alkali

(a) Which element is most likely to be in Group I?

.....

[1]

(b) Which oxide can react with both hydrochloric acid and sodium hydroxide solution?

.....

[1]

(c) Which oxide is found as an impurity in haematite?

.....

[1]

(d) No elements from Group 0 appear in the table.
Use information in the table to explain why this statement is true.

.....

.....

.....

[2]

(e) The table shows some differences between the properties of **B**O and EO_2.
Explain why these two substances have different properties.

.....

.....

.....

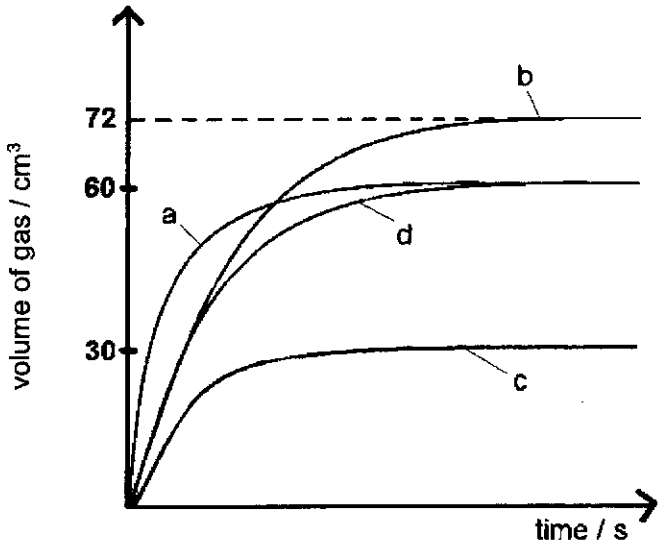
.....

.....

[3]

[Total: 8]

A2 The following graph shows the volume of gas produced with time for some experiments of a metal, **M** with hydrochloric acid.



(a) Complete the table below.

experiment	concentration of acid in mol/dm³	volume of acid / cm³	particle size of metal
	0.125	20	large
	0.200	30	large
	0.250	20	small
d	0.200		

[3]

(b) The mass of **M** used in each experiment is 0.195 g. Only one of the experiments has an exact mole ratio of the reactants (i.e. there is no excess of either reactant), while the rest have an excess of metal **M**. **M** forms an ion with a +2 charge.

By means of calculation using the information provided, identify metal **M**.

identity of metal **M** is _____ [3]

[Total: 6]

A3 Sulfur and its compounds make up almost 3.0% of earth's mass. A student found the following information about sulfur on the internet.

> **Sulfur** is an abundant, multivalent non-metal. Under normal conditions, sulfur atoms form cyclic octatomic molecules with chemical formula S_8.
>
> Symbol: S
> Atomic number: 16
> Melting point: 115.2 °C
> Electrons per shell: 2,8,6
> Discovered: 2000 BC
> Relative Atomic mass: 32.065 (accurate to ± 0.005 unit)

(a) (i) Explain why the relative atomic mass of sulfur is not a whole number.

[1]

(ii) Using information from the table, state which period and group sulfur belongs to. Explain your reasoning.

[2]

(b) At normal room condition, pure sulfur is odourless, but many of its compounds has a pungent smell. Blue cheese gets its distinctive aroma from carbonyl sulfide, OCS, which has a boiling point of −50.2 °C.

(i) Using the information given, suggest why pure sulfur is odourless but carbonyl sulfide gives off a distinctive aroma at room temperature.

[1]

(ii) Draw a 'dot-and-cross' diagram to show the bonding in carbonyl sulfide. Show outer electrons only.

[2]

(c) When sulfur is burnt in air, sulfur dioxide is produced.

(i) Identify two sources of sulfur dioxide.

.....

..... [1]

(ii) Sulfur dioxide is one of the main gases that cause acid rain.
With the aid of chemical equation(s), describe the formation of acid rain.

.....

.....

.....

..... [2]

(iii) Other than the effect stated in part **(ii)**, state one harmful effect of sulfur dioxide.

.....

..... [1]

(d) Sulfuric acid is a common reagent used to prepare salts. The table shows the names of salts that are prepared using sulfuric acid and another compound.

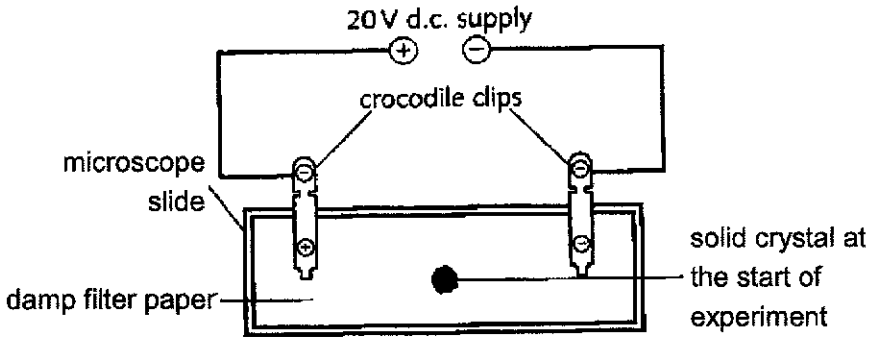
Complete the table by filling in the missing information.

name of salt	**formula of salt**	**name of other compound used to make salt**
calcium sulfate		
potassium sulfate		

[2]

[Total: 12]

A4 **(a)** An experiment was conducted to find out the effect of electricity on the following ionic compounds: potassium chromate(VI), potassium sulfate and copper(II) sulfate. The results are shown in the table below.



compound	colour of crystals	changes seen on the filter paper
potassium chromate(VI)	yellow	yellow colour moves towards the positive electrode
potassium sulfate	white	no observable change
copper(II) sulfate	blue	blue colour moves towards the negative electrode

(i) Why must water be added to the filter paper before the start of each experiment?

[1]

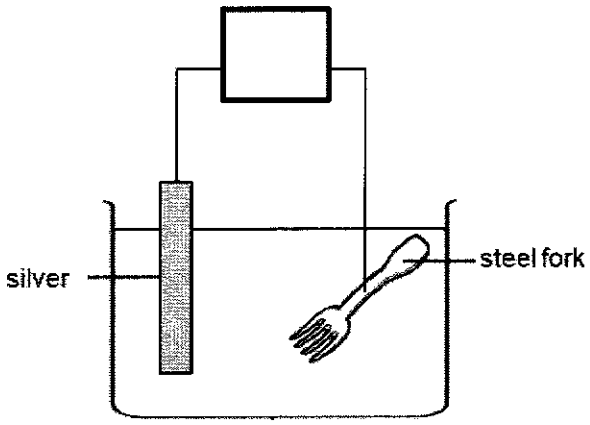
(ii) Use information from the table to deduce the colour of the chromate(VI) ion. Explain your reasoning.

[2]

(iii) Predict and explain the changes seen on the filter paper if another compound, copper(II) chromate(VI), is used in a new experiment.

[2]

(b) The diagram below shows a setup for electroplating a steel fork with silver.



(i) There is an electrical component that is missing in the above setup. Draw the component in the box provided. [1]

(ii) Suggest a suitable electrolyte for the reaction to take place.

[1]

(iii) Write the ionic equation for the reaction that happens at the negative electrode.

[1]

(iv) What effect would you expect the above electroplating process to have on the concentration of metal cations in the electrolyte? Explain your answer.

[2]

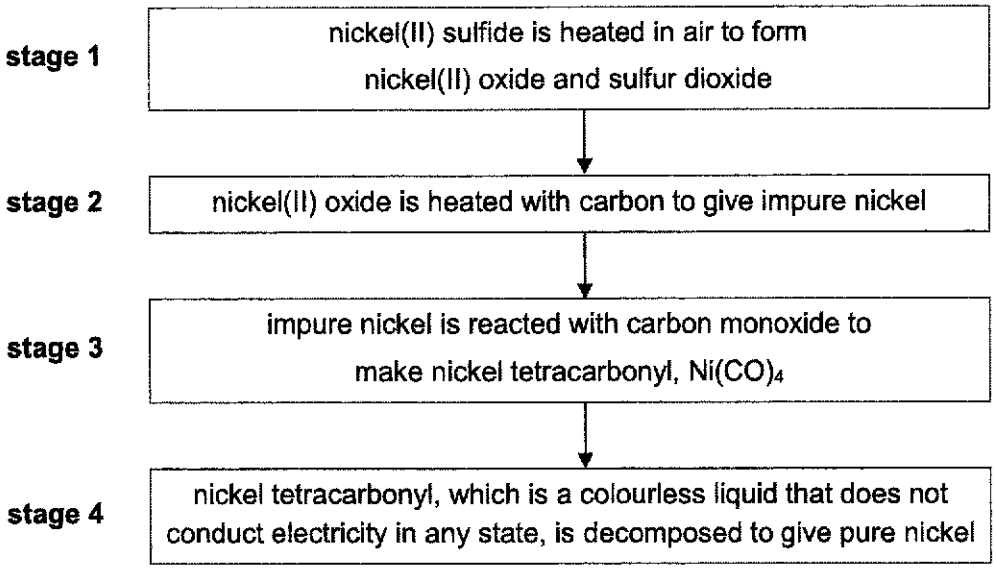
(v) A student wants to speed up the electroplating process by increasing the initial concentration of the electrolyte in the solution.

Explain whether the student's method will work.

[2]

[Total: 12]

A5 Nickel is a transition element.
It is manufactured in a four-stage process from nickel(II) sulfide, NiS.



(a) Write a balanced equation, with state symbols, for the reaction in stage 1.

[2]

(b) Using information above, suggest the structure of nickel tetracarbonyl.
Explain your reasoning.

[2]

(c) Nickel is commonly used as a catalyst as it speeds up the rate of the reaction.

Explain, in terms of collisions and energy, why using nickel increases the rate of this reaction.

[2]

(d) In a laboratory experiment, zinc was added to solutions of zinc nitrate, nickel(II) nitrate and copper(II) nitrate respectively. This experiment is an exothermic reaction. The experiment was repeated with two other metals, nickel and copper. The results are shown below.

		metal nitrate		
		zinc nitrate solution	nickel(II) nitrate solution	copper(II) nitrate solution
metal	zinc	no observed change	green solution turned colourless and zinc coated with a silver solid	blue solution turned colourless and zinc coated with a pink solid
	nickel		no observed change	
	copper	no observed change	no observed change	no observed change

(i) Complete the table to predict what results he should expect when nickel is added to the three salt solutions and explain how you arrived at your answers.

[4]

(ii) List the four metals (zinc, nickel, copper and magnesium) in increasing order of reactivity.

[1]

(iii) State what will happen to the temperature of the nickel(II) nitrate solution when zinc metal is added to it. Explain your reasoning.

[1]

[Total: 12]

Section B

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

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

B6 Bonding and Electronegativity

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 6.1 shows the electronegativity values of some elements in the Periodic Table.

Table 6.1

element	electronegativity
Li	1.0
Be	1.6
B	2.0
C	2.6
N	3.0
O	3.4
F	4.0
Ne	undefined
Na	0.9
Mg	1.3
Al	1.6
Si	1.9
P	2.2
S	2.7
Cl	3.2
Ar	undefined
. . . Se	. . . 2.6

The difference in electronegativity between two elements involved in a chemical bond, Σ, gives an indication of whether a chemical bond formed between two elements is ionic or covalent. Σ can be calculated by the following equation:

Σ = larger electronegativity value − smaller electronegativity value

An example is sodium fluoride, NaF, Σ= 4.0 – 0.9

= 3.1

Table 6.2 shows the formulae and the type of bonding of oxides and chlorides of the elements across Period 3.

Table 6.2

element	metal / non-metal	formula of oxide	bonding in oxide	formula of 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

Table 6.3 shows the bond lengths and bond energies of some bonds.

Table 6.3

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

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

The strength of a bond can be measured by its bond energy. Bond length is the distance between the centres of two bonded atoms.

(a) Describe the trend in the values of the electronegativity for elements down Group VI of the Periodic Table.

[1]

(b) Predict the electronegativity of bromine. Give reasons for your answer.

[3]

(c) Find the difference in electronegativity of the elements in magnesium fluoride.

[1]

(d) **(i)** A student wrote the following conclusion after studying Table 6.1 and 6.2.

"The bonding in the oxides and chlorides are ionic when Σ is more than 1.5."

Do you agree with this conclusion? Explain your reasoning.

[3]

(ii) Suggest a more suitable range of Σ value which will indicate that the bonding in the oxides and chlorides are ionic.

[1]

(e) What is the trend shown by the data in Table 6.3?

[1]

(f) A student makes this conclusion after studying Table 6.3:

"The strength of bond is directly proportional to the number of bonds between carbon atoms"

Does the data in the table support this conclusion? Explain your reasoning.

[2]

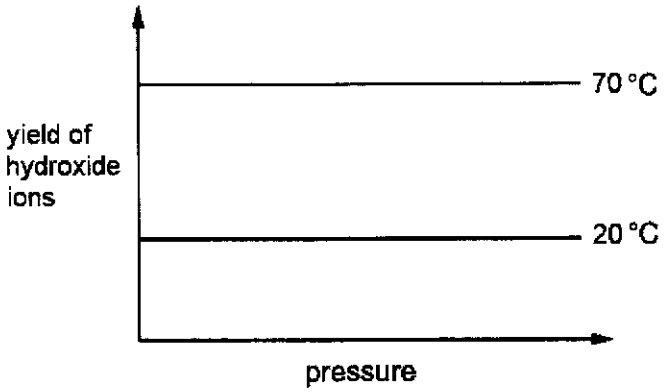
[Total: 12]

Blank Page

B7 Sodium carbonate ionises in water with the following equation.

$$Na_2CO_3(s) + H_2O(l) \rightleftharpoons 2Na^+(aq) + HCO_3^-(aq) + OH^-(aq)$$

The graphs show how pressure affects the yield of hydroxide ions at two different temperatures.



(a) Explain why the yield of this reaction is not 100%.

.....

..... [1]

(b) Describe how the temperature and pressure affect the yield of this experiment.

.....

..... [1]

(c) Explain the effect of pressure on the yield as stated in part **(b)**.

.....

..... [1]

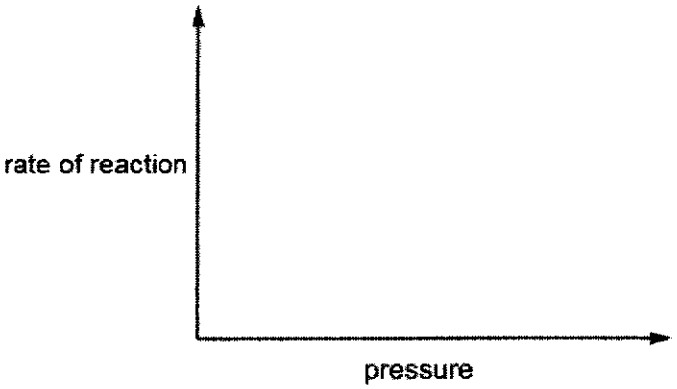
(d) State the colour of the Universal Indicator when added to a solution of sodium carbonate. Explain your answer.

.....

.....

..... [2]

(e) On the axes below, draw two lines to show how pressure affects the rate of this reaction at two different temperatures (20 °C and 70 °C).



[2]

(f) A student hypothesises that he can obtain carbon dioxide gas by heating sodium carbonate solid strongly. State whether he will succeed and explain why.

.....

.....

[1]

[Total: 8]

Either

B8 Fluorine, chlorine, bromine and iodine are collectively known as the halogens. The name 'halogen' means 'salt-producing', as halogens react with metals to produce a wide range of salts. Oxidising power of a halogen is measured as its ability to act as an oxidising agent. Stronger oxidising agent can oxidise other substances to a higher oxidation state.

When halogen vapours are passed over iron wool, the iron wool burns to form salts, called iron halides. The formulae of iron halides are shown in the table.

halogen	halides formed	formula
fluorine	iron(III) fluoride	FeF_3
chlorine	iron(III) chloride	$FeCl_3$
bromine	mixture of iron(II) bromide and iron(III) bromide	$FeBr_2$ $FeBr_3$
iodine	iron(II) iodide	FeI_2

(a) Do the formula of the halides given in the table show clearly that all of the elements belong in the same Group? Explain your reasoning.

[1]

(b) Describe the trend in oxidising power of halogens down the Group.
Explain your answer based on the information given in the table.

[2]

(c) An attempt to prepare iron(III) chloride by adding dilute hydrochloric acid to iron metal failed. Suggest a reason why.

[1]

(d) A jet of chlorine gas is passed over a solution of iron(III) bromide. Describe the observation of this reaction.

[1]

(e) Iron(III) chloride is a starting material for the industrial production of sodium ferrate, Na_2FeO_4. Sodium ferrate is used as a non-toxic wastewater treatment chemical as iron compounds are generally non-toxic. The steps for its production are shown below.

Step 1: $FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaCl$

Step 2: $2Fe(OH)_3 + 3NaClO + 4NaOH \rightarrow 2Na_2FeO_4 + 5H_2O + 3NaCl$

(i) Deduce the formula of the ferrate ion.

[1]

(ii) Is $Fe(OH)_3$ acting as an oxidising or a reducing agent?
Explain your answers in terms of oxidation states.

[2]

(iii) Based on the information above, suggest reasons why the industrial production of sodium ferrate is described to be an environmentally friendly process.

[2]

[Total: 10]

OR

B8 Nitrogen gas exists in a large proportion in the air around us. Chemists have discovered a novel way of 'fixing' atmospheric nitrogen (converting nitrogen gas into its compounds). Moist nitrogen is passed over a TiO_2 plate which has been coated with other chemicals. The nitrogen is thought to react with moisture in the air at room temperature and pressure to form ammonia. A possible equation for the reaction is given below.

$$5N_2(g) + 6H_2O(g) \rightleftharpoons 4NH_3(g) + 6NO(g) \quad \Delta H = +1808 \text{ kJ/mol}$$

(a) Suggest why there are only a few reactions that 'fix' nitrogen.

[2]

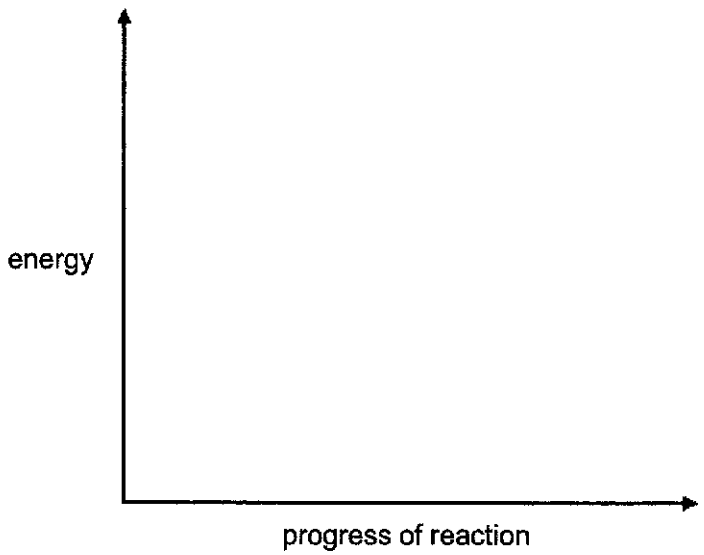
(b) Describe the advantage and disadvantage of the reaction between nitrogen and water as a method of making ammonia compared with the Haber process.

[2]

(c) Draw an energy profile diagram for the reaction between nitrogen and water.

Your diagram should include

- the formulae of the products and reactants
- a label for the enthalpy change of reaction
- a label for the activation energy



[2]

(d) Use ideas about breaking and forming bonds to explain the enthalpy change for the reaction between nitrogen and water.

[2]

(e) In the reaction between nitrogen and hydrogen, various metals added can have different activation energy recorded. Experiments were conducted and the following results were obtained.

metal added	**activation energy in kJ/mol**
no metal added	+335
tungsten	+92
osmium	+197

Describe the effect of each metal added on the rate of reaction.

[2]

[Total: 10]

– End of Paper –

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

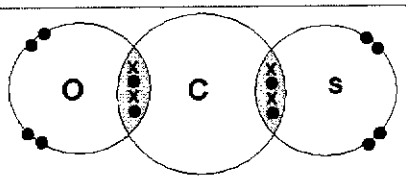
FUHUA SECONDARY SCHOOL
Sec 4E Chemistry 6092
Preliminary Examinations 2021 – Mark Scheme

PAPER 1

1	2	3	4	5	6	7	8	9	10
B	C	C	B	D	C	A	D	B	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	B	D	B	D	A	B	B	A	C
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
D	A	A	A	C	D	B	D	C	D
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
C	D	C	A	D	A	B	C	C	B

FUHUA SECONDARY SCHOOL
Sec 4E Chemistry 6092
Preliminary Examinations 2021 – Mark Scheme

PAPER 2
Section A [50 marks]

Q	Answer	Ma	Remarks
1a	F	1	
b	C_2O_3	1	
c	DO_2	1	
d	Group 0 elements are inert as they have a stable electronic configuration. Therefore, they will not lose, gain or share electrons with oxygen. Since there are no compounds of oxygen for group 0 elements, they will not appear in the table.	1 1	
e	BO has a giant ionic lattice structure while EO_2 has a simple covalent structure. The oppositely charged ions in BO held by strong electrostatic forces of attraction requires more energy to overcome than the weak intermolecular forces of attraction between the EO_2 molecules. EO_2 is an acidic oxide which dissolves in water to form an acidic solution while BO is a basic oxide which dissolves in water to form an alkali solution.	3	1-2 points 1m 3-4 points 2m 5 points 3m
	Total	8 marks	
2a	(table below)	3	1-2 points 1m 3-4 points 2m 5 points 3m
2b	No. of moles of hydrogen gas = $\frac{72}{1000} \div 24 = 0.003$ [1] No. of moles of H_2:M = 1:1 No. of moles of M = 0.003 Molar mass of M = 0.195 / 0.003 = 65 g/mol [1] M is zinc. [1]	3	Every step 1m
	Total	6 marks	
3ai	Sulfur consists of **isotopes** that have **different atomic mass**. Hence, when taking the **average** atomic mass of these isotopes, the relative atomic mass is not a whole number. OR It represents the average atomic mass of the isotopes of S based on their relative abundance.	1	
ii	Group VI as seen from the 6 valence electrons. Period 3 as seen from 3 occupied electron shells.	1 1	
bi	Sulfur is a solid at room temperature while carbonyl sulfide is a gas.	1	
ii		2	1 bonded 1 unbonded
ci	Volcanic eruptions and burning of fossil fuels at power station.	1	
ii	Sulfur dioxide dissolves in water to form acid rain. $H_2O + SO_2 \rightarrow H_2SO_3$ $2H_2SO_3 + O_2 \rightarrow 2H_2SO_4$	1 1	

experiment	concentration of acid in mol/dm^3	volume of acid / cm^3	particle size of metal
c	0.125	20	large
b	0.20	30	large
a	0.25	20	small
d	0.20	**25**	**large**

	Sulfurous acid is oxidised in the air to form sulfuric acid. OR $2H_2O + 2SO_2 + O_2 \rightarrow 2H_2SO_4$		
iii	Sulfur dioxide irritates eyes and causes breathing difficulties.	1	
d	**name of salt** / **formula of salt** / **name of other compound** calcium sulfate / $CaSO_4$ / calcium nitrate/ calcium chloride potassium sulfate / K_2SO_4 / potassium hydroxide/ potassium carbonate	2	2-3 1 mark
	Total	12 marks	
4ai	water helps to ionize the compounds so that the oppositely charged ions can conduct electricity.	1	
ii	Chromate(VI) ion is yellow. Chromate(VI) ion is negatively charged. It is attracted to the anode which is the positive electrode. Since yellow colour moves towards positive electrode, the colour must be caused by the chromate(VI) ions.	1 1	
iii	Copper(II) chromate(VI) compound ionizes to form Copper(II) and chromate(VI) ions. Copper(II) ions which is **positively charged** will be blue, and chromate(VI) ions which is **negatively charged** will be yellow. Thus, blue colour moves towards negative electrode which is the cathode and yellow colour moves towards positive electrode which is the anode.	1 1	
bi	Positive terminal of the battery connected to the silver electrode.	1	
ii	aqueous silver nitrate	1	
iii	$Ag^+ (aq) + e^- \rightarrow Ag (s)$	1	
iv	concentration of silver ions remains constant. As 1 mole of silver ions gets reduced at the cathode, 1 mole of silver ions are replenished at the anode as the electrode ionises into solution.	1 1	
v	This will not speed up the electroplating process. Electroplating depends on the number of electrons being supplied to the cathode per unit time. Since the power source has not changed, with increased Ag^+ ions, the discharge of the Ag^+ ions per unit time remained the same.	1 1	
	Total	12 marks	
5a	$2NiS(s) + 3O_2(g) \rightarrow 2NiO(s) + 2SO_2(g)$	2	
b	Simple covalent structure. It has low melting point as it is a colourless liquid and it does not conduct electricity in any state.	1 1	
c	Catalysts increase the speed of reaction by providing an alternative pathway of lower activation energy for the reaction to proceed. More particles (alkene and hydrogen gas) possess energy equal to or greater than the activation energy. Frequency of effective collision increases, resulting in higher rate of formation of alkane.	2	1 point 1m 3 points 2m
di	zinc nitrate solution: no observed change copper(II) nitrate solution: blue solution turned green and nickel coated with a pink solid nickel is less reactive than zinc, hence no reaction take place between nickel and zinc nitrate solution. Nickel is more reactive than copper, hence nickel displaces copper from copper(II) nitrate solution.	1 1 1 1	

ii	Copper, nickel, zinc and magnesium.	1	e.c.f allowed
iii	It will increase. Displacement of metal is an exothermic reaction, hence energy is given out to the surroundings.	1	
	Total	12 marks	

Section B [30 marks]

Q	Answer	Ma	Remarks
6a	The electronegativity of the elements decreases down the group (from 3.4 in O to 2.6 in Se).	1	
b	2.6< any value<3.2. Electronegativity decreases down the group. Since bromine is below chlorine, electronegativity of bromine should be lower than 3.2. Electronegativity increases across the period. Since bromine is after selenium, electronegativity of bromine should be higher than 2.6.	1 1 1	
c	2.7	1	
di	This statement is true for oxides. Na_2O, MgO and Al_2O_3 have Σ value (2.5, 2.1 and 1.8 respectively) more than 1.5 and they are ionic compounds. The rest of the oxides have Σ value less than 1.5 and they are covalent compounds. This state is false for chlorides. NaCl, MgCl2 have Σ value (2.3 and 1.9 respectively) more than 1.5 and they are ionic compounds. However, AlCl3 has a Σ value of 1.6, which is more than 1.5, and yet it is a covalent compound. Note: Mere stating of Σ value will not be awarded full credit. Comparison must be made to the standard value proposed by student.	1 1 1	ecf for calculation from part c
ii	More than 1.7	1	
e	As the bond length increases, the bond energy of the decreases.	1	
f	No. Looking at C-C, C=C and C≡C. If the statement is true, bond energy of C=C should be twice of C-C, which is calculated to be 696kJ/mol and C≡C should have 3 times the bond energy of C-C, which is calculated to be 1044kJ/mol. However, C=C is only 614 kJ/mol and C≡C is only 839 kJ/mol, lower than the calculated value if strength of bond is directly proportional to the number of bonds between carbon atoms.	2	1m for no with reason. 1m for 696 and 1044
	Total	12 marks	
7a	This is a reversible reaction. Some of the ions form back sodium carbonate and water (until an equilibrium is reached)	1	
b	Changing pressure has no effect on the yield of the reaction. Increasing temperature decreases the yield of the reaction.	1	
c	There are no gases in the reactants and products. Pressure only affects rate of reaction involving gases.	1	
d	Blue. Sodium carbonate is a weak alkali as it dissociates partially (as seen from the reversible reaction arrow) to form a low concentration of OH^-.		
e	Constant rate with increasing pressure. Higher rate with higher temperature.	1 1	
f	No. Sodium carbonate is thermally stable and will not decompose upon heating.		
	Total	8 marks	

E 8a	Yes. From the formula, all the halogens form 1- ion. OR No. Elements from the same Group should form compounds with the same chemical formula with the same element. Fluorine and chlorine forms FeX_3 while bromine and iodine forms FeX_2.	1	
b	Oxidising power decreases down the group. Fluorine and chlorine are stronger oxidising agents as they are able to oxidise iron from 0 to +3 oxidation state (by removing its electrons), while bromine and iodine are only able to oxidise iron from 0 to +2 oxidation state.	1 1	
c	Iron(II) chloride is formed instead. / Hydrochloric acid has a lower oxidising power than chlorine. / Hydrogen ions has a lower oxidising power than chlorine	1	
d	Solution changes from yellow to reddish-brown / brown.	1	
ei	FeO_4^{2-}	1	
ii	$Fe(OH)_3$ is acting as reducing agent. Oxidation state of iron in Iron(III) ions (or iron(III) hydroxide) <u>increases</u> from +3 in Fe^{3+} / $Fe(OH)_3$ to +6 in Na_2FeO_4. Iron is oxidised. OR NaClO is reduced by $Fe(OH)_3$ as the oxidation of chlorine decreases from +1 in NaClO to -1 in NaCl.	 1 1	
iii	Non-toxic products such as sodium chloride and water are formed. They formed a neutral solution.	1 1	
	Total	10 marks	

OR 8a	N≡N triple bond results in nitrogen being unreactive. A lot of energy has to be taken in to break the strong covalent bond.	1 1	
b	Advantage: lower temperature / lower pressure so save energy, less fossil fuel, cost less OR **<u>water, instead of hydrogen</u>**, water is used, cost less Disadvantage: **nitrogen oxide** produced compared to **no side products** formed for Haber process., reacts with oxygen to form nitrogen dioxide which contribute to **<u>acid rain</u>** / an air pollutant,	1 1	
c	1m for correct shape 1m for arrows, activation energy and enthalpy change	2	
d	Energy **taken in** to break the bonds in **nitrogen and water** is **more** than energy **given out** to the surroundings when forming the bonds in **ammonia and nitrogen monoxide**. 1 point, 1 mark. 3 points 2 mark.	2	1) Taken in / given out 2) more 3) substances
e	Both tungsten and osmium increase the rate of reaction between nitrogen and hydrogen. Tungsten increases the rate of reaction more than osmium.	1 1	
	Total	10 marks	