Candidate Name:	Class	Index No.

FUHUA SECONDARY SCHOOL

Secondary Four Express

Preliminary Examination 2022

4E

CHEMISTRY 6092/02

Paper 2

23 August 2022
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: Mdm Hia Soo Ching

Vetters: Mr Elton Tan, Ms Veron Lee, Ms Nur Hanis & Ms Choo Hui En

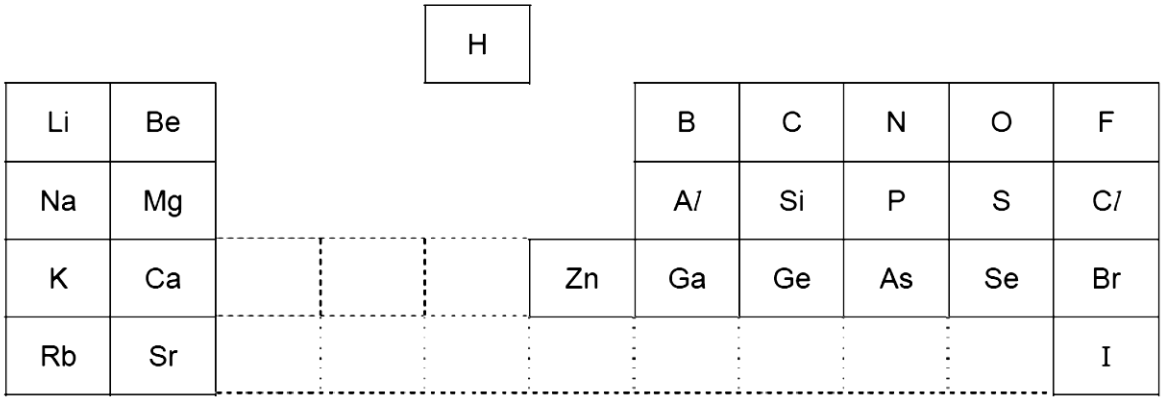
This document consists of **20** printed pages.

Section A

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

The total mark for this section is 50.

A1 The diagram below shows part of the Periodic Table.



Answer the following questions using only the elements shown in the diagram above. Each element can be used once, more than once or not at all.

(a) Which two elements react together to give the most vigorous reaction?

.....

[1]

(b) **(i)** Which two elements in Period 3 form an ionic compound with a formula of the type $\mathbf{Y_2Z}$?

.....

[1]

(ii) Draw a dot and cross diagram to represent the bonding in $\mathbf{Y_2Z}$.
Show only outer electrons.

[2]

(c) Which elements react with oxygen to give an oxide that dissolves in both aqueous sodium hydroxide and dilute hydrochloric acid?

.....

[1]

(d) Describe the trends in melting point and reactivity for Group I and Group VII.

.....

.....

[2]

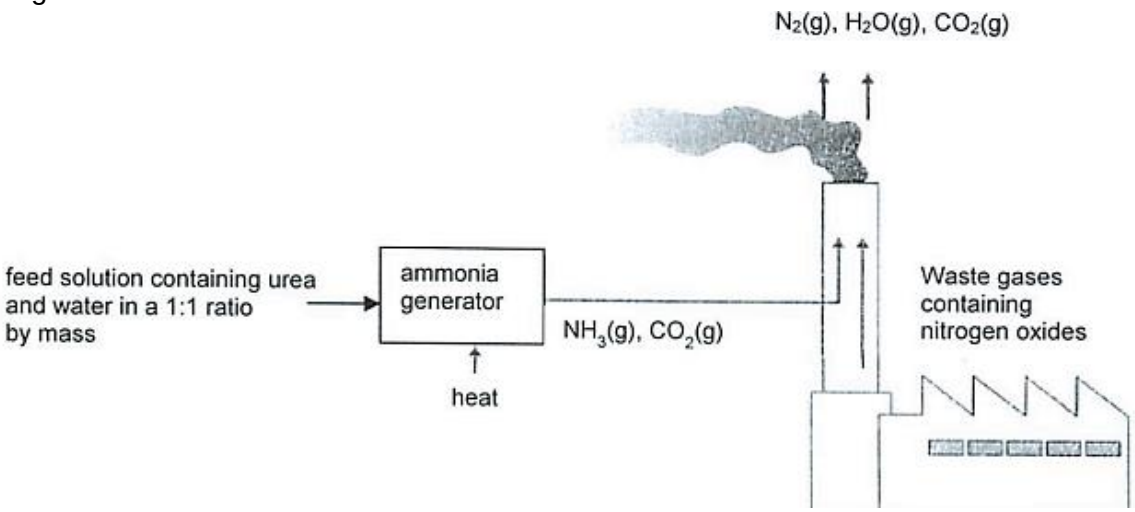
(e) Construct a balanced chemical equation when a piece of calcium is added to water.

.....

[1]

[Total: 8]

A2 In a particular factory, ammonia generated in a small-scale ammonia generator is used to treat waste gases containing nitrogen oxides. This treatment converts nitrogen monoxide to nitrogen and water.



(a) (i) Write an equation to show the reaction between nitrogen monoxide and ammonia.

.....[1]

(ii) Explain, in terms of oxidation state, why the reaction in **(a)(i)** is a redox reaction.

.....

.....

.....[2]

(b) Explain how waste gases released by the factory affects the environment if they are not treated by reacting with ammonia.

.....

.....

.....[2]

(c) Suggest one advantage, other than cost, of producing ammonia on-site by this method rather than having ammonia delivered from a plant at another location.

.....

.....[1]

(d) In terms of colliding particles, explain why increasing the temperature of the ammonia generator is necessary.

.....

.....

.....

.....[2]

(e) Ammonia has a boiling point of -33.3°C. Explain, in terms of structure and bonding, why ammonia has a low boiling point.

.....

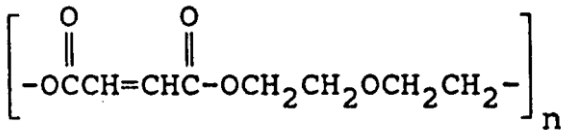
.....

..... [2]

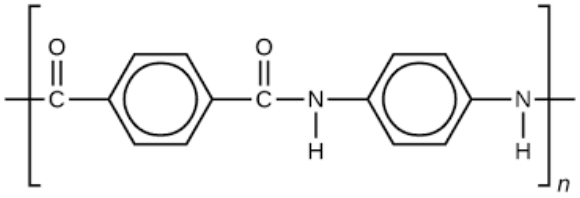
[Total: 10]

A3 The diagram below shows the structure of some polymers **A**, **B**, **C** and **D**.

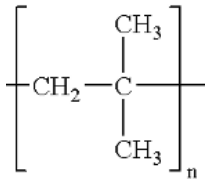
A



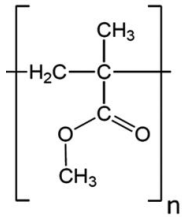
B



C



D



(a) A sample of **C** contains molecules with an average relative molecular mass of 14 000. How many carbon atoms are there in an average molecule of the polymer?

.....

..... [1]

(b) Describe a test to distinguish between polymer **A** and **C**.

.....

.....

..... [2]

(c) Which of these statements would you predict to be true and which to be false?
Put a tick (√) in one box in each row.

	true	false
D is a polyester.		
Water is formed as a by-product when monomers react to form **A** and **B**.		
The empirical formula of **C** is the same as its monomer.		
One of the monomers that react to form **B** must be an alcohol.		

[2]

(d) Draw the displayed formulae of the monomers that react to form **A**.

[2]

(e) **(i)** Draw the structural formula of the monomer that react to form **D**.

[1]

(ii) The monomer in **(e)(i)** can be formed by reacting an acid and an alcohol under suitable conditions. State the name and formula of the alcohol.

.....

[1]

(iii) A student states that the acid in **(e)(ii)** is butanoic acid.
Do you agree with his statement? Explain your reasoning.

.....

.....

[1]

(f) Some polymers are non-biodegradable.
Explain why being non-biodegradable is both an advantage and a disadvantage.

.....

.....

.....

[2]

[Total: 12]

A4 A student carried out a series of experiments according to the following procedure:

- She added excess magnesium powder to 25.0 cm^3 of various aqueous salt solutions with the same concentration.
- She calculated the maximum temperature rise in each experiment.

She tabulated the results obtained in the table below.

experiment	solution	maximum temperature rise / °C
1	copper(II) sulfate	42.0
2	lead(II) nitrate	32.0
3	calcium chloride	0.0
4	sodium nitrate	0.0
5	sulfuric acid	38.0
6	zinc sulfate	14.0

(a) Explain why there is no rise in temperature for experiments 3 and 4.

.....

..... [1]

(b) **(i)** Predict the temperature rise when she added excess magnesium powder to 25.0 cm^3 of iron(II) sulfate of the same concentration.

..... [1]

(ii) Write an ionic equation for the reaction in **(b)(i).**

..... [1]

(iii) Suggest the temperature rise when she added excess magnesium powder to 25.0 cm^3 of ethanoic acid of the same concentration.
Explain your answer.

.....

.....

.....

.....

.....

..... [3]

(c) Complete the energy profile diagram for experiment 1.

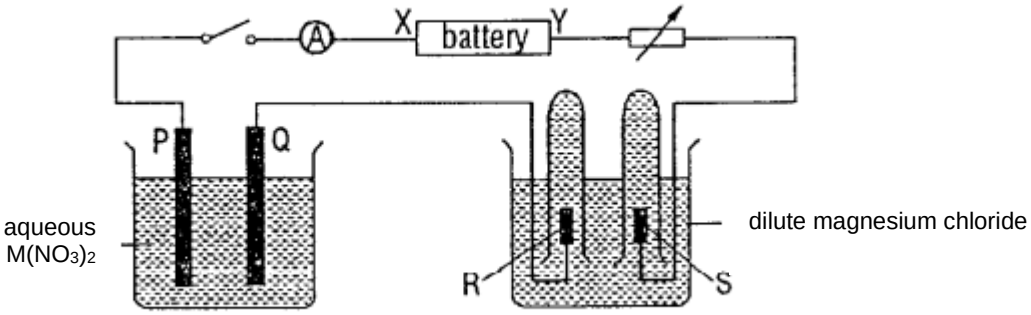
Your diagram should include

- formulae of reactants and products
- enthalpy change of reaction
- activation energy

[2]

[Total: 8]

A5 The following figure shows an electrolytic setup.
Electrodes **P** and **Q** are made of metal **M**.
Electrodes **R** and **S** are made of graphite.
X and **Y** are terminals of a battery.



When the switch is closed and electrolysis is allowed to run for some time, the ratio of the volume of gases produced at **R** and **S** is 2:1 respectively.

(a) (i) Deduce the polarity of terminals **X** and **Y** of the battery.

.....

[1]

(ii) Write an overall equation for the reaction occurring in cell 2.

.....

[1]

(iii) In cell 2, concentrated aqueous magnesium chloride is used instead of dilute magnesium chloride. Give one similarity and one difference between the products of the electrolysis of dilute and concentrated aqueous magnesium chloride.

.....

.....

.....

[2]

(b) (i) Construct the ionic equations, including state symbols for the reactions occurring at electrode **P** and **Q** respectively.

electrode **P**: .....

electrode **Q**: .....

[2]

(ii) If the relative atomic mass of **M** is 64, describe the observation at electrode **P**.

.....

.....

[1]

(iii) If 150 cm^3 of gas is produced at **S**, calculate the change in mass of electrode **Q**.

[2]

(c) Describe and explain the results you would expect when the pH of the electrolyte in cell 1 and cell 2 is tested separately.

[3]

[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 Bronsted-Lowry Theory

The definition of acids and bases you have learnt so far is the Arrhenius theory and is limited to acid and base reactions occurring in aqueous solutions. However, acid and base reactions can occur in the absence of aqueous solutions. Hence, other theories like Bronsted-Lowry and Lewis theories extend to these reactions.

The Bronsted-Lowry theory defines acid as a substance which donates a H^+ ion or a proton and forms its conjugate base while the base is a substance which accepts a H^+ ion or a proton and forms its conjugate acid.

For example, consider a reaction in which ammonia (base) is dissolved in water (acid). Ammonia accepts a proton from water and the reaction is as follows,

$$\underset{\text{acid}}{H_2O(l)} + \underset{\text{base}}{NH_3\,(aq)} \rightleftharpoons \underset{\text{conjugate base}}{OH^-\,(aq)} + \underset{\text{conjugate acid}}{NH_4^+\,(aq)}$$

In this example, H_2O is the acid that donates a proton and it forms the conjugate base OH^-. On the other hand, NH_3 is the base that accepts a proton and it forms the conjugate acid NH_4^+. In the reverse reaction, $NH_4^+(aq)$ is the acid and OH^- is the base.

Strength of acids

The strength of an acid is indicated by the dissociation constant, K_a.

For any acid, HA, we can write the dissociation process as

$$HA(aq) \rightleftharpoons H^+(aq) + A^-(aq)$$

If the value of K_a is large, this means the acid is mostly dissociated, hence the acid is strong. If K_a is small, little dissociation has occurred, hence the acid is weak.

Table B6.1 gives the K_a of some common acids.

Table B6.1

acid	K_a / molL^{-1}
HI	3.2×10^{9}
HBr	1.0×10^{9}
HC*l*	1.3×10^{6}
HF	6.4×10^{-4}
H_2CO_3	4.5×10^{-7}
HNO_3	2.8×10^{1}
HNO_2	4.5×10^{-4}
H_3PO_4	7.1×10^{-3}
H_2SO_4	1.0×10^{3}
H_2SO_3	1.4×10^{-2}
HC*l*O$_4$	1.0×10^{10}

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 pair 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 B6.2 shows the electronegativity values of some elements in the Periodic Table.

Table B6.2

element	electronegativity
N	3.0
H	2.2
F	4.0
C*l*	3.2
Br	3.0
I	2.7
Ar	undefined

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

$$\Sigma = \text{larger electronegativity value} - \text{smaller electronegativity value}$$

An example is the H-F bond, where

$$\Sigma = 4.0 - 2.2 = 1.8$$

Σ gives an indication of the polarity of a covalent bond formed between two non-metallic elements. It is said that if Σ is greater, then the covalent bond is more polar.

Bond Energy

The strength of a bond can be measured by its bond energy. Bond energy is the amount of energy taken in to break one mole of a particular bond. It is a measure of the strength of a chemical bond.

Table B6.3 shows the bond energies of some bonds.

Table B6.3

bond	bond energy in kJ/mol
H–F	566
H–C*l*	431
H–Br	366
H–I	298

(a) **(i)** Explain why H^+ ion is known as a proton.

[1]

(ii) Two reactions are shown below. For each reaction, based on the Bronsted-Lowry theory, state in the boxes provided, whether the substance is acting as a

acid **base** **conjugate base** **conjugate acid**

you may use each word once, more than once or not at all.

HNO_3 + H_2SO_4 ⇌ $H_2NO_3^+$ + HSO_4^-

CH_3NH_2 + H_2O ⇌ $CH_3NH_3^+$ + OH^-

[2]

(b) For the halogen halide acids, HX (X is the halide), two students made the following comments.

Student 1: The more polar the H-X bond, the more easily the acid will ionise in aqueous solution and hence the stronger the acid.

Student 2: The less energy taken in to break the H-X bond, the stronger the acid.

Do you agree with the students?
Use evidence from the information to explain your reasoning.

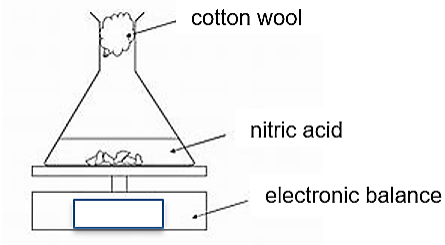
[4]

(c) For the oxoacids H_nYO_m, m is the number of oxygen atoms and n is the number of hydrogen atoms in the acids. Y is a non-metallic element.
Identify two factors that affect the strength of the oxoacids.
Using the information provided, explain your reasoning.

[4]

[Total: 11]

B7 A student conducted an experiment using 2.00 g of impure lead(II) carbonate and excess nitric acid of concentration 0.150 mol/dm^3 in a conical flask.



She measured the mass of the setup at fixed time intervals and obtained the following graph, experiment I, as shown in Figure B7.1.

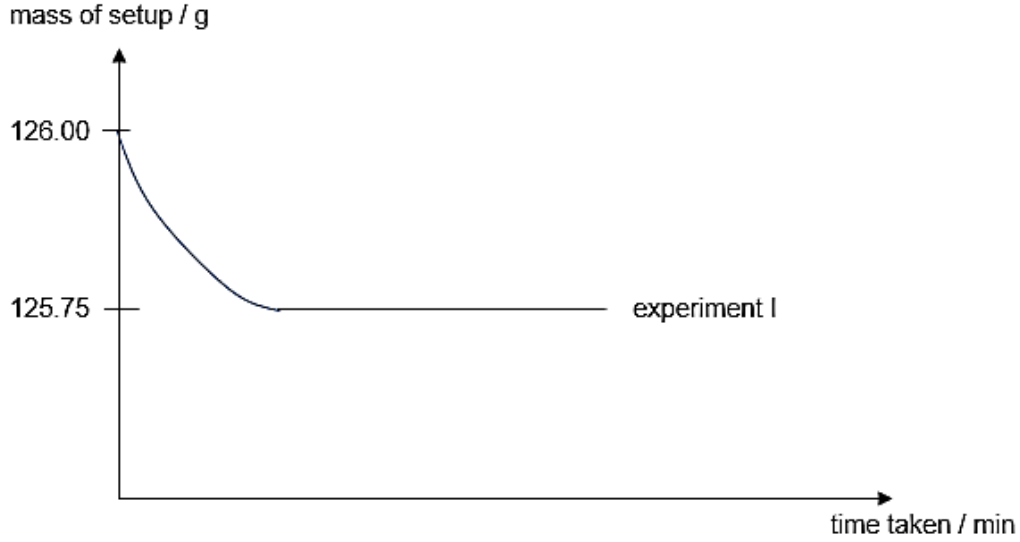


Figure B7.1

(a) Calculate the percentage purity of the lead (II) carbonate sample.

[2]

(b) The student conducted a second experiment using sulfuric acid of the same concentration and volume. All other variables are kept constant.

(i) On the same axes in Figure B7.1, draw the graph that he would obtain for the experiment using sulfuric acid. Label it as experiment II. [1]

(ii) Explain the difference between the graphs drawn for experiment I and II.

.....

.....

..... [1]

(c) The student conducted a third experiment using ethanoic acid of the same concentration and volume. All other variables are kept constant. Lead(II) ethanoate is soluble in water.

(i) On the same axes in Figure B7.1, draw the graph that he would obtain for the experiment using ethanoic acid. Label it as experiment III.

[1]

(ii) Explain your reasoning for the graph obtained for **(c)(i)**.

.....

.....

.....

..... [2]

(d) Describe how you would prepare lead(II) carbonate in the laboratory.

.....

.....

.....

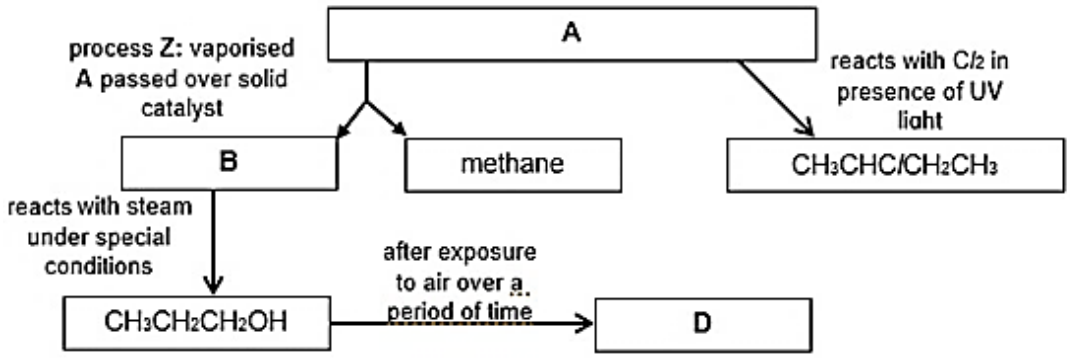
..... [2]

[Total: 9]

Either

B8

(a) The diagram below gives the reaction scheme of organic compound **A**.



.

(i) Name the process **Z** and state the solid catalyst used.

.....

[1]

(ii) Construct a balanced chemical equation for process **Z**.

.....

[1]

(iii) Describe a test to confirm that $CH_3CH_2CH_2OH$ has been completely converted to **D**.

.....

.....

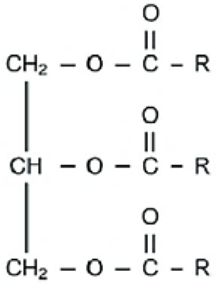
.....

[2]

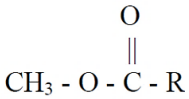
(b) Used cooking oil being processed to produce biodiesel has gained a significant amount of consideration within the world of fuel production.

During the conversion process, fatty acid triglycerides in vegetable oil react with methanol, in presence of an alkali catalyst, to produce biodiesel. Biodiesels are fatty acid methyl esters (FAME), which has similar properties to petrol diesel. The by-product of this reaction is glycerol, a tri-ol, which is extracted and used for other products including soaps and cosmetics.

The structure of triglycerides and FAME are



fatty acid triglycerides
where R is a hydrocarbon chain



FAME

(i) One mole of fatty acid triglyceride reacts with 3 moles of methanol to produce FAME and glycerol.

Construct a chemical equation for this reaction. Show the structural formulae of the organic molecules.

[2]

(ii) Suggest why glycerol is known as a tri-ol.

.....

[1]

(iii) Most often methanol is used due to its accessibility and low cost. However, other alcohols such as ethanol and propanol can also be used in the conversion process.

Draw the structure of FAME if propanol is used in place of methanol.

[1]

(iv) Flashpoint is the lowest temperature at which a fuel vaporises and causes ignition. Fuels with lower flashpoints burn more easily at lower temperatures and usually burn more smoothly in the car engine.

The average flashpoint of biodiesel fuel is 150°C while petrol diesel ranges from 55 to 66°C.

State one advantage and disadvantage that biodiesel have over petrol diesel.

.....

.....

.....

[2]

[Total: 10]

OR

B8 (a) In the stratosphere, chlorofluorocarbons (CFCs) can cause the destruction of the ozone layer. $CFCl_3$ is an example of chlorofluorocarbons (CFCs). The series of reactions below show how the ozone layer is being destroyed by $CFCl_3$.

Step 1 (slow): $CFCl_3 \rightarrow CFCl_2 + Cl$
Step 2 (fast): $Cl + O_3 \rightarrow ClO + O_2$
Step 3 (fast): $ClO + O_3 \rightarrow Cl + 2O_2$

The table shows the bond energies for some of the bonds in CFCs.

bond	bond energy in kJ/mol
C–F	485
C–Cl	327

(i) A website states that '*a single CFC molecule can destroy up to 100 000 ozone molecules*'.
Using the above equations, comment on whether this statement is true.

.....

.....

..... [2]

(ii) The first step happens when energy from sunlight breaks a bond in a CFC to produce a chlorine atom. Use the data in the table to explain why the ozone layer contains many more chlorine atoms than fluorine atoms.

.....

.....

..... [2]

(b) Zinc blende is an ore containing compounds of zinc. One of the compounds in the ore is zinc sulfide, ZnS.

The first step in the extraction of zinc is roasting. Zinc sulfide is heated in air, producing zinc oxide and sulfur dioxide.

The second step is heating zinc oxide in a smelting furnace with coke and limestone at 1400°C. Coke burns in oxygen to form carbon monoxide, which reduces zinc oxide to zinc as shown:

$$ZnO + CO \rightarrow Zn + CO_2$$

Since the boiling point of zinc is 907°C, the zinc is produced in the gaseous state. Zinc vapour passes out of the furnace and is cooled and condensed in a tray placed at the top of the furnace. The slag and other impurities such as lead and cadmium form two layers which can be tapped off at the base of the furnace.

(i) Describe one similarity and one difference between the extraction of zinc and iron.

.....

.....

.....

..... [2]

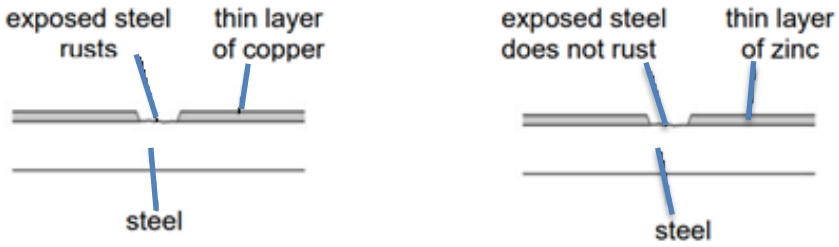
(ii) Explain, with the help of equations, why calcium carbonate is essential in the process of extracting zinc from zinc blende.

.....

.....

..... [2]

(iii) One important application of zinc is galvanising. In an experiment to investigate the rate of rusting of steel, two pieces of steel were used. One piece of steel was completely coated with copper, another piece completely coated with zinc. The coatings on both pieces were scratched, exposing the steel.



The piece of steel coated with zinc did not rust but the copper-coated piece of steel rusted very rapidly.

Explain these observations in terms of the transfer of electrons.

.....

.....

..... [2]

[Total: 10]

– End of Paper –

The Periodic Table of Elements

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

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

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