Name	Index Number	Class

HUA YI SECONDARY SCHOOL

Preliminary Examination 2022

4E **4E**

CHEMISTRY **6092/2**

Paper 2

23 August 2022

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Name, Index Number and Class on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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

Section B
Answer **all three** questions, the last question is in the form of either/or.
Answer all the questions in the spaces provided on the question paper.

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 24.

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

For Examiner's Use		
Section A		
Section B		
B7		
B8		
B9		
Total		

This document consists of **24** printed pages including the cover page.

[Turn Over]

Setter: Ms Keziah Seow

Section A

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

A1 The symbols of the elements of Period 3 of the Periodic Table are shown.

Na	Mg	A*l*	Si	P	S	C*l*	Ar

Answer the following questions about these elements.

(a) Write the symbol of an element which

(i) forms an amphoteric oxide,

.... [1]

(ii) exists as diatomic molecules,

.... [1]

(iii) shows both metallic and non-metallic character,

.... [1]

(iv) is used to fill light bulbs,

.... [1]

(v) can conduct electricity in solid state and floats on water.

.... [1]

(b) The oxides of sulfur and silicon have very different melting points.

Explain how and why the melting points of sulfur dioxide and silicon dioxide are different.

....

....

....

....

....

.... [3]

[Total: 8]

A2 The first ionisation energy of elements is the energy required for one mole of gaseous atoms to lose one mole of electrons, forming one mole of gaseous ions with a charge of 1+.

The reaction can be described by the equation below, where M represents an atom.

$$M(g) \rightarrow M^{+}(g) + e^{-}$$

Fig. 2.1 shows the first ionisation energy of Group I elements.

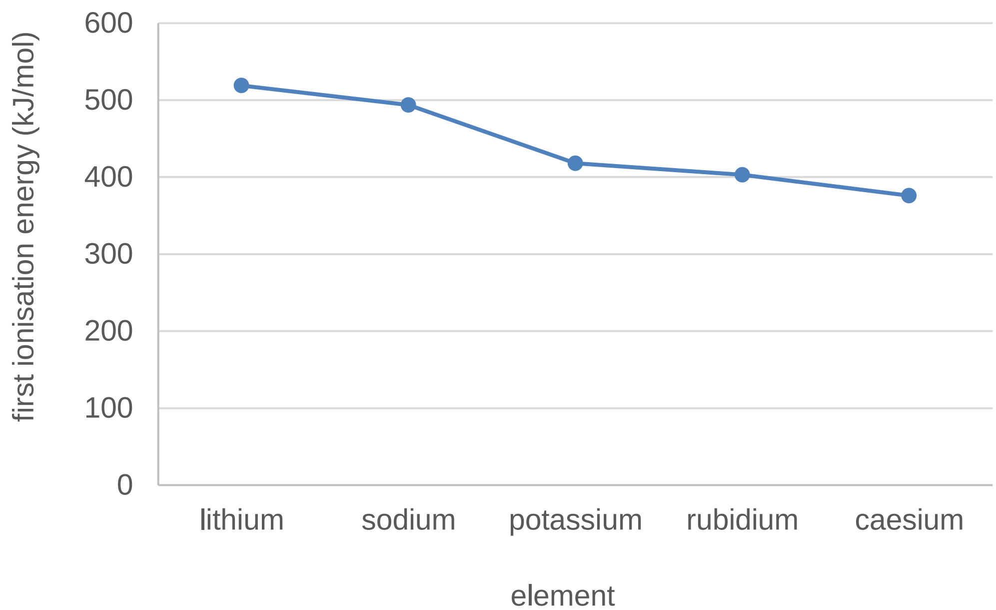

Fig. 2.1

Table 2.2 shows some information about atomic radii of Group I elements.

Table 2.2

element	atomic radius /pm
lithium	152
sodium	186
potassium	231
rubidium	244
caesium	262

(a) Describe the trend in the first ionisation energy down Group I and use Table 2.2 to explain this trend.

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…………………………………………………………………………………………………… [3]

(b) Using Fig. 2.1, compare the reactivities of sodium and potassium. Explain your answer.

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……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(c) Lithium contains two isotopes, lithium-6 and lithium-7.

Do you think that the first ionisation energy of both the isotopes is the same? Explain your answer.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(d) Among the elements in the Periodic Table, neon has one of the highest first ionisation energy of 2080 kJ/mol.

Suggest a reason why neon has a very high first ionisation energy.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

[Total: 7]

A3 'Lean burn' engines are a type of car engine.

This table shows some information about lean burn engines compared to normal car engines.

type of engine	**amount of air mixed with petrol**	**operating temperature**	**concentration of CO in exhaust gases**	**concentration of NO in exhaust gases**
normal	less air	higher	higher	higher
lean burn	more air	lower	lower	lower

(a) **(i)** How is nitrogen monoxide formed in a car engine?

....

.... [1]

(ii) Suggest why lean burn engines produce smaller amounts of nitrogen monoxide.

....

.... [1]

(b) **(i)** How is carbon monoxide formed in a car engine?

....

.... [1]

(ii) Suggest why lean burn engines produce smaller amounts of carbon monoxide.

....

.... [1]

(c) The catalytic converter removes pollutant gases.

(i) Construct a balanced chemical equation to show how the carbon monoxide and nitrogen monoxide are converted to harmless gases in the catalytic converter.

.... [1]

(ii) When catalytic converters were first available, some advertisements claimed they 'solved all car pollution problems'.
Explain why this is not true.

....

.... [1]

(d) Sulfur dioxide is another common air pollutant.

Sulfur dioxide can be detected by bubbling a sample of polluted air into aqueous acidified potassium manganate(VII).

$$5SO_2(g) + 2MnO_4^-(aq) + 2H_2O(l) \rightarrow 5SO_4^{2-}(aq) + 2Mn^{2+}(aq) + 4H^+(aq)$$

A 5.00 dm^3 sample of polluted air was found to contain 2.5% by volume of sulfur dioxide measured at room temperature and pressure.

A solution of 0.200 mol/dm^3 of manganate(VII) ions was used to test for the presence of sulfur dioxide gas. Calculate the minimum volume of this solution that will be needed to test for sulfur dioxide in 5.00 dm^3 sample of polluted air.

[3]

[Total: 9]

A4 In the presence of a catalyst, chlorine reacts with carbon monoxide to produce phosgene gas, $COCl_2$. This reaction is reversible.

When one mole of chlorine reacts with one mole of carbon monoxide, 230 kJ of energy is released.

$$Cl_2(g) + CO(g) \rightleftharpoons COCl_2(g) \quad \Delta H = -230 \text{ kJ/mol}$$

(a) Use ideas about oxidation states to explain why this is a redox reaction.

....

....

....

.... [2]

(b) Calculate the enthalpy change when 1g of chlorine reacts with excess carbon monoxide.

[1]

(c) Complete the energy profile diagram below. Label clearly the reaction enthalpy change and the activation energy.

[3]

(d) In practice, when carbon monoxide reacts with chlorine, the yield of phosgene gas is never 100%. Explain why.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(e) Draw the dot-and-cross diagram to show the electron arrangement in a molecule of phosgene gas. Show outer electrons only.

[2]

(f) Bromine also reacts with carbon monoxide.

$$Br_2(g) + CO(g) \rightleftharpoons COBr_2(g)$$

When the same number of moles of carbon monoxide is reacted with both bromine and chlorine, the rates for the two reactions are different.

How would you expect the rates to differ? Explain your reasoning.

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…………………………………………………………………………………………………… [1]

[Total: 10]

A5 The reaction between peroxodisulfate(VI) ions, $S_2O_8^{2-}$, and iodide ions, I^-, forms iodine.

A student investigated the time taken for reaction to complete when peroxodisulfate(VI) ions reacts with iodide ions. He used different concentrations of peroxodisulfate(VI) ions.

Table 5.1 shows the results of each experiment.

Table 5.1

experiment	**concentration of $S_2O_8^{2-}$ / mol/dm^3**	**time taken for reaction to complete / s**
1	0.30	8
2	0.15	16
3	0.10	24
4	0.05	48

If a small amount of Fe^{2+} ions is added to the reaction mixture, the rate of reaction will increase. Fe^{2+} will react with the peroxodisulfate(VI) ions, forming Fe^{3+} ions, which will then react with the iodide ions in the following two stages:

stage 1: $2Fe^{2+}(aq) + S_2O_8^{2-}(aq) \rightarrow 2Fe^{3+}(aq) + 2SO_4^{2-}(aq)$

stage 2: $2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$

(a) **(i)** Use the equations to write an overall ionic equation for the reaction.

.... [1]

(ii) Explain how the equations in stage 1 and 2 show that Fe^{2+} ions act as a catalyst for the reaction.

....

.... [1]

(b) Using Table 5.1, explain, in terms of collisions between reacting particles, how the concentration of peroxodisulfate ions affect the rate of reaction.

....

....

....

....

.... [2]

(c) Suggest a way to remove Fe^{2+} ions, as a precipitate, from aqueous iodine after stage 2.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(d) The experiment was repeated with another concentration of peroxodisulfate(VI) ions. The time taken for the reaction to complete is 32 s. Estimate the concentration used.

…………………………………………………………………………………………………… [1]

[Total: 7]

A6 Two metal electrodes and an electrolyte can be used to produce electrical energy.
Fig. 6.1 shows a set up with copper and zinc electrodes in dilute copper(II) sulfate as the electrolyte.

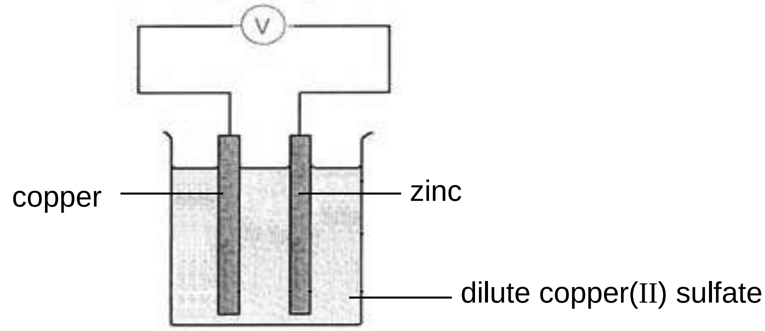


Fig. 6.1

(a) **(i)** Write equations, with state symbols, to show the reactions that happen at the copper electrode and zinc electrode.

copper electrode: ………………………………………………………………………………

zinc electrode: ……………………………………………………………………………….. [2]

(ii) How would you expect the voltage to change if the zinc electrode is changed to a magnesium electrode?

Explain your answer.

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

……………………………………………………………………………………………………. [2]

(b) Fig. 6.2 shows the beaker when the wire is removed.

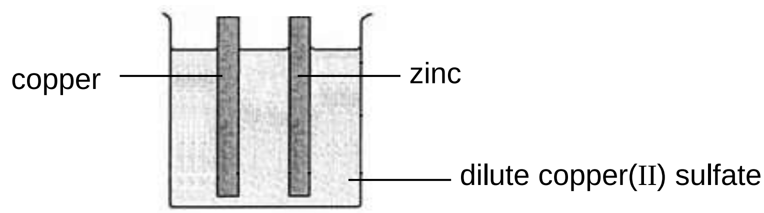


Fig. 6.2

(i) Describe the difference in observation at the zinc electrode in Fig. 6.1 and Fig. 6.2.

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(ii) Describe and explain the colour change of the solution in Fig. 6.2.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(c) The zinc electrode is changed to a copper electrode and a battery is added to the set-up as shown in Fig. 6.3.

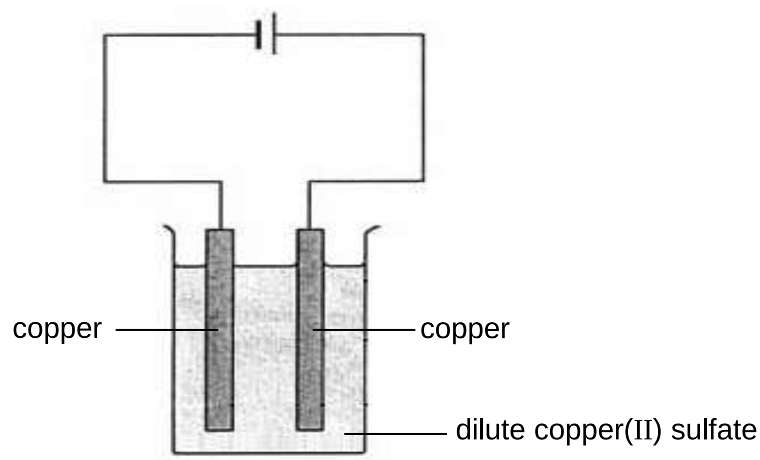


Fig. 6.3

What are the products formed at each electrode?

negative electrode: ……..…………………………………………………………………………

positive electrode: ……..……………………..……………………………………………….. [2]

[Total: 9]

Section B

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

B7 Instrumental techniques in analysis

Many chemicals are indistinguishable by their appearance. Though some chemicals have different colours, odours, or textures compared with others, this is seldom sufficient to identify the structure of those compounds. Spectroscopy is used as a tool for studying the structures of atoms and molecules.

Infrared spectroscopy

The most common identification method chemists use to determine functional groups in organic compounds is infrared spectroscopy. Infrared spectroscopy (IR spectroscopy) in the simplest terms involves analysing how a molecule interacts with infrared light. Different organic functional groups absorb different amounts of infrared light and produce different patterns. Identification of a particular functional group is made by matching it to its absorption range in the infrared spectrum.

Table 7.1 shows the approximate absorption range (in wavenumbers) of some functional groups.

Table 7.1

bond	absorption range (in wavenumbers) / cm^{-1}	more information about the appearance of peak
C=O (carboxylic acids)	1680 – 1730	-
C=O (ester)	1710 - 1750	sharp
C-H (alkanes)	2850 – 2960	-
O-H (alcohols)	3600 – 3800	sharp
O-H (acids)	2500 – 3300	very broad

A scientist would like to investigate the identity of substances **A** and **B** with the molecular formula $C_3H_6O_2$. They are suspected to either be propanoic acid or methyl ethanoate.
Fig 7.2 shows the structure of both molecules.

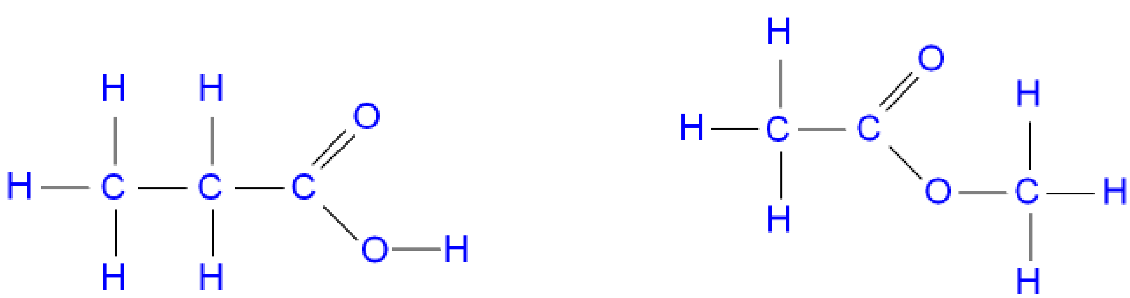
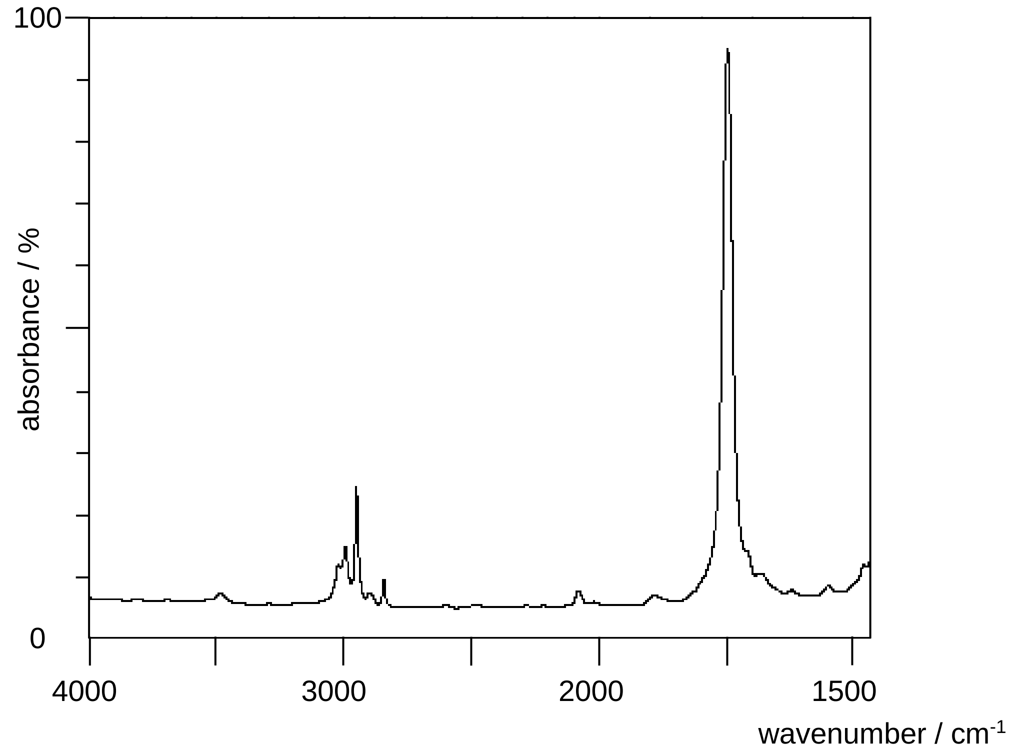


Fig. 7.2

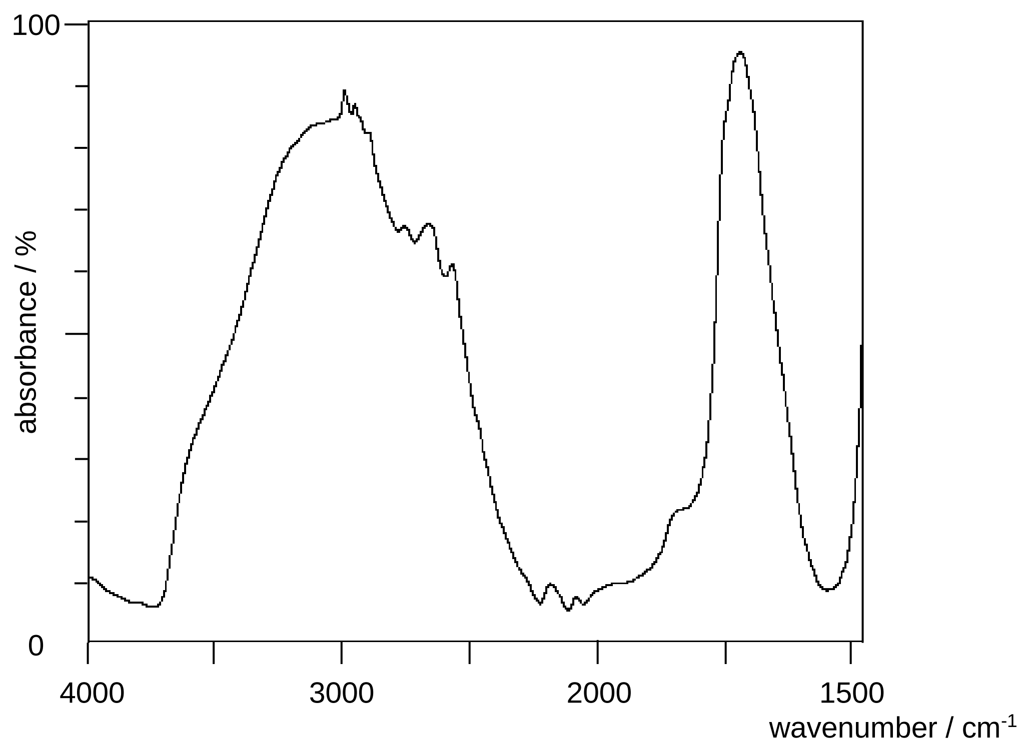
He carries out the IR spectroscopy for both substances.

His results are shown below:

infrared spectrum for substance A



infrared spectrum for substance B



(a) Draw the full structural formulae of the starting materials that react to form methyl ethanoate.

[2]

(b) Explain why substance **A** and substance **B** are isomers of each other.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(c) From the spectrums, determine what substance **A** and substance **B** is. Give two evidences from each spectrum to explain your reasoning.

substance **A**: ………………………………………………………………………………

substance **B**: ………………………………………………………………………………

explanation: …………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

(d) Explain why IR cannot be used to differentiate organic compounds of the same homologous series.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(e) Describe a simple test that can be used to differentiate between substance **A** and substance **B**. Explain your answer.

....

....

....

.... [2]

(f) A polymer, substance **C**, was analysed and found to have an average relative molecular mass of 30 058.

$HOOC(CH_2)_4COOH$ and $H_2N(CH_2)_6NH_2$ are used to make substance **C**.

(i) Draw the repeating unit for substance **C**.

[1]

(ii) What is the number of repeating units in substance **C**? Show your working.

[2]

[Total: 12]

B8 Galvanisation is the process of coating the entire surface of a piece of iron with zinc to prevent it from rusting. The information below shows two common ways of galvanising iron – hot-dip galvanisation and electro-galvanisation (electroplating an object with zinc).

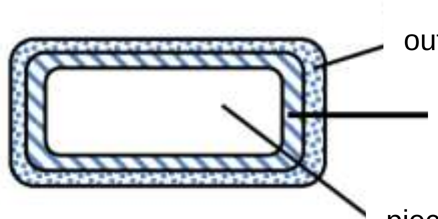
Hot-dip galvanisation

The piece of iron is dipped into a molten bath of zinc at a temperature of around 460 °C. The piece of iron is then cooled and exposed to the air. The outermost layer of zinc then reacts with oxygen and carbon dioxide in air as follows:

reaction 1: Zinc reacts with oxygen to form zinc oxide.

reaction 2: Zinc oxide reacts with carbon dioxide to form zinc carbonate.

The resulting iron piece looks like this:



Electro-galvanisation (electroplating an object with zinc)

The piece of iron to be galvanised and a piece of zinc are used as electrodes and dipped into an electrolyte containing a mixture of aqueous zinc cyanide, $Zn(CN)_2$ and aqueous sodium hydroxide at room temperature and pressure. An external electrical power supply is used. Zinc ions are discharged to form zinc atoms, which are coated onto the piece of iron.

<u>other facts about both types of galvanisation</u>

hot-dip galvanised iron	electro-galvanised iron
layer of zinc is coarse and thick	layer of zinc is smooth and thin
used to make alloy sheets for roofs	used to make bolts and nuts
done at high temperatures of 460 °C	done at room temperature

(a) A student says, "galvanising a piece of iron is more effective in preventing it from rusting than painting or greasing it."

Explain why this comment is true.

………………………………………………………………………………………………………...

………………………………………………………………………………………………………...

………………………………………………………………………………………………………...

………………………………………………………………………………………………………... [2]

(b) **(i)** Write the balanced equation for reaction 1 and reaction 2 in hot-dip galvanisation.

reaction 1: …………..……………..……………………………………………………..

reaction 2: …………………………....…………………………………………………….. [2]

(ii) If 12.5 g of zinc carbonate were found on a piece of galvanised iron, calculate the mass of zinc required to form this mass of zinc carbonate. Use the two equations you have written in part **b(i)** in your calculations.

[2]

(c) Some older processes of electro-galvanisation employ the use of dilute acids in the electrolyte instead of aqueous sodium hydroxide. Suggest what problem this could pose.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………... [1]

(d) From the information given, state an advantage that electro-galvanisation has over hot-dip galvanisation.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………... [1]

[Total: 8]

EITHER

B9 **(a)** K_a is a numerical measure of the strength of an acid. In general, strong acids have K_a values larger than 1, and weak acids have K_a values smaller than 1.

Table 9.1 shows the K_a of some acids.

Table 9.1

name of acid	K_a value	strength
hydrochloric acid	1.3×10^{6}	strong
methanoic acid	1.8×10^{-4}	weak
nitric acid	2.4×10^{1}	
nitrous acid	7.2×10^{-4}	

(i) Complete the table by filling in the strength (strong or weak) for each of the acids. [1]

(ii) The rate of reaction of hydrochloric acid with metal oxides is faster than that of methanoic acid with metal oxides.

Explain your answer.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [2]

(b) Oxalic acid is a weak, dibasic acid. Its formula can be represented by H_2X. In a school laboratory, a student titrated 25.0 cm^3 of oxalic acid against 1.6 mol/dm^3 of aqueous sodium hydroxide. The equation for the reaction is shown below.

$$H_2X(aq) + 2NaOH(aq) \rightarrow Na_2X(aq) + 2H_2O(l)$$

He used a pH meter and a data logger to monitor the pH change.

Fig. 9.2 shows his results.

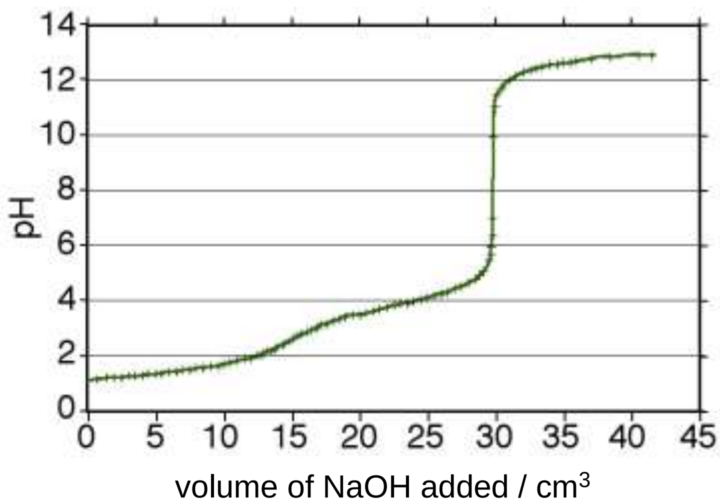


Fig. 9.2

(i) Describe the change in pH when the volume of NaOH increases.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

(ii) Calculate the concentration of oxalic acid.

[2]

(c) Oxalic acid contains 2.20% of hydrogen and 26.7% of carbon by mass. The rest is oxygen.

(i) Determine the empirical formula of oxalic acid.

[2]

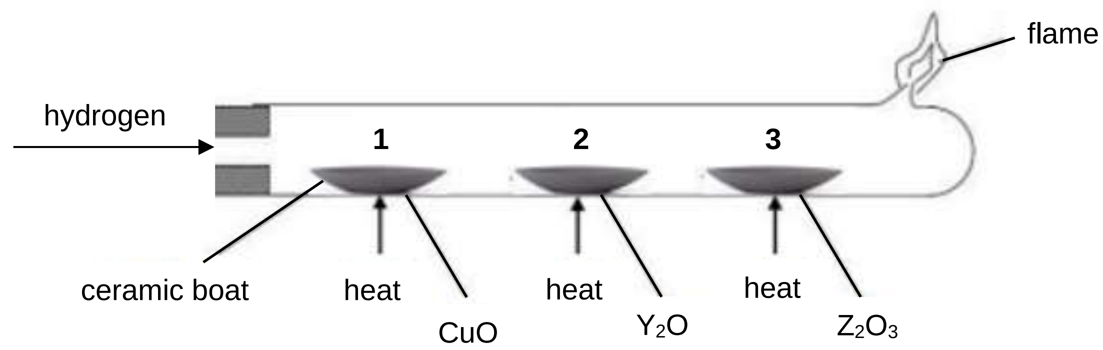
(ii) Given that the relative molecular mass is 90, determine the molecular formula of oxalic acid.

[1]

[Total: 10]

OR

B9 In an experiment, hydrogen gas was passed over equal masses of three heated metal oxides (CuO, Y_2O and Z_2O_3) in identical ceramic boats.



The ceramic boats were weighed 8 minutes into the experiment and at the end of the experiment. At the end of the experiment, the heat was removed. However, the hydrogen kept flowing until the tube is cooled. Table 9.3 shows the data collected from this experiment.

Table 9.3

	start of experiment	**8 minutes into experiment**	**end of the experiment**
mass of empty ceramic boat /g	16.35	-	16.35
mass of ceramic boat 1 /g	22.35	21.15	21.15
mass of ceramic boat 2 /g	22.35	22.35	22.35
mass of ceramic boat 3 /g	22.35	21.20	20.55

(a) What is the main reason why the hydrogen is kept flowing?

……………………………………………………………………………………………………...

……………………………………………………………………………………………………... [1]

(b) Describe the observation seen in ceramic boat 1.

……………………………………………………………………………………………………...

……………………………………………………………………………………………………... [1]

(c) **(i)** Put the three metals, Cu, Y and Z, in order of increasing reactivity.

……………………………………………………………………………………………. [1]

(ii) Explain your reasoning.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

……………………………………………………………………………………………. [3]

(d) Suggest a possible identity of metal Y.

……………………………………………………………………………………………….... [1]

(e) **(i)** Calculate the mass of oxygen in Z_2O_3 in boat 3.

[1]

(ii) Calculate the relative atomic mass of metal Z.

[2]

[Total:10]

End of Paper

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
				Key			1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9			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 –