Name: ……………………………………………….. (   )   Class: Sec 4 SG 1 / 2

Queenstown Secondary School

Preliminary Examination 2024
Secondary Four Express
Chemistry
6092/02

20 August 2024
Tuesday

Time: **1115 – 1300h**
Duration: **1 hour 45 minutes**

Setter:

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

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.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

The number of marks is given in brackets [ ] at the end of each question. A copy of the Periodic Table is printed on page 24.

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

Examiner's Use	
Section A	/70
Section B	/10
B9	
B10	
TOTAL	**/80**

Section A

Answer **all** questions.

A1 Use the list of substances to answer the questions.

calcium hydroxide	**carbon monoxide**	**copper**
hydrogen	**magnesium**	**nitrogen**
nitrogen dioxide	**sulfur dioxide**	**zinc oxide**

Each substance can be used once, more than once or not at all.

Name the substance(s) which

(a) is added to soil to increase the pH,

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

(b) helps prevent iron in underwater pipes from rusting,

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

(c) lead to the formation of acid rain that corrodes limestone buildings,

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

(d) react in a 1:3 ratio in the Haber Process to produce ammonia.

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

[Total: 4]

A2 Esters are commercially used as solvents for cosmetics, perfumes and glue.

(a) Propyl ethanoate has a characteristic odour of pears and is commonly used in fragrances. A bottle of perfume containing propyl ethanoate is left opened in a laboratory and it diffused throughout the laboratory.

(i) Give the names and draw the full structural formulae of the carboxylic acid and the alcohol that react to form propyl ethanoate.

…………………………….. …………………………….. [2]

(ii) The temperature of the laboratory is increased.

Explain, in terms of collisions between reacting particles, what effect would this have on the rate of diffusion of propyl ethanoate.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(b) The table shows some information about different esters.

Table 2

name	formula	relative molecular mass
methyl methanoate	HCO_2CH_3	60
ethyl methanoate	$HCO_2C_2H_5$	74
propyl methanoate	$HCO_2C_3H_7$	88
butyl methanoate	$HCO_2C_4H_9$	102
pentyl methanoate	$HCO_2C_5H_{11}$	116

(i) Use information in the table to give **one** piece of evidence that suggests that the esters belong to the same homologous series.

…………………………………………………………………………………………

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

(ii) Which ester has the greatest rate of diffusion at room temperature and pressure? Explain your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

[Total: 7]

A3 Seawater constitutes a rich source of various commercially important elements.

(a) Magnesium bromide is an important salt found in seawater.

Table 3 shows some information about two isotopes of bromine.

Table 3

symbol	number of protons	number of neutrons	number of electrons
$^{79}_{35}\mathrm{Br}$	35		35
$^{81}_{35}\mathrm{Br}^{-}$		46	

(i) Complete the table. [1]

(ii) Use data from the table to explain the term *isotopes*.

……………………………………………………………………………………..…

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

(iii) Chlorine is treated with a sample of seawater containing magnesium bromide.

Write the ionic equation for the reaction that occurs.

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

(iv) Explain why astatine does not react with aqueous magnesium bromide.

……………………………………………………………………………………...

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

(b) The distinctive smell of the seaside was thought to be due to ozone (O_3).

Ozone reacts with aqueous potassium iodide as shown in the equation below.

$$2I^- (aq) + O_3 (g) + 2H^+ (aq) \rightarrow I_2 (aq) + O_2 (g) + H_2O (l)$$

(i) Describe what is observed when ozone is bubbled into aqueous potassium iodide.

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

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

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

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

(c) It is now known that the smell of the seaside is due to the presence of dimethyl sulfide, $(CH_3)_2S$.

(i) Draw a ‘dot-and-cross’ diagram for dimethyl sulfide, $(CH_3)_2S$.

[2]

(ii) Explain, in terms of bonding and structure, why dimethyl sulfide is a gas at room temperature and pressure.

……………………………………………………………………………………...

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

[Total: 10]

A4 **(a)** Complete the table.

Table 4.1

electrolyte	state	electrode	half-equation at anode	effect on electrolyte
silver nitrate	aqueous			no change
copper(II) chloride		graphite		fully decomposed

[2]

(b) The diagram below shows the electrolysis of concentrated aqueous sodium chloride.

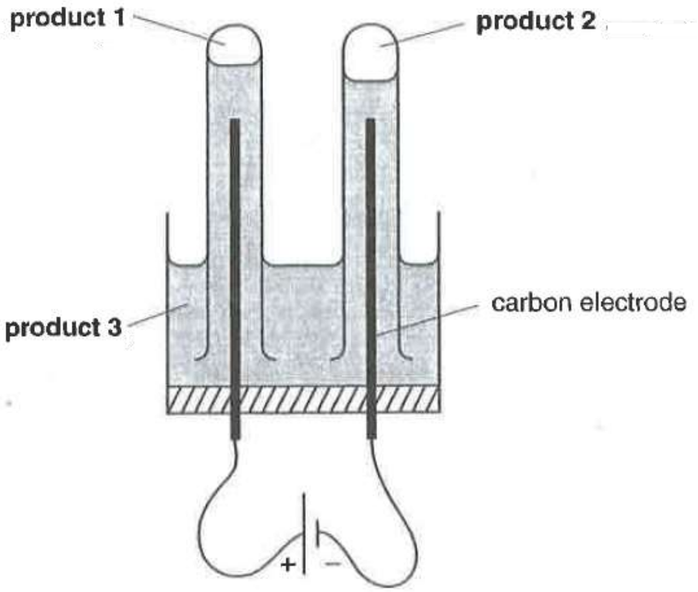


Fig. 4.2

(i) Write the half equation for the reaction that occurs at the negative electrode.

……………………………………………………………………………………… [1]

(ii) The volumes of products 1 and 2 should theoretically be the same.

Explain why the volume of product 1 is lesser.

……………………………………………………………………………………… [1]

(iii) What happens to the resulting solution during the electrolysis?

Explain your reasoning.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [1]

(iv) The same apparatus can be used to electrolyse dilute aqueous sodium chloride. Give **one** similarity and **one** difference between the products of the electrolysis of concentrated and dilute aqueous sodium chloride.

similarity ……………………………………………………………………...

………………………………………………………………………………………

difference …………………………………………………………………….

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

[Total: 7]

A5 Ethanol is the intoxicating ingredient of many alcoholic beverages such as beer.

(a) Ethanol is manufactured by the reaction between ethene and steam.

$$C_2H_4\ (g) + H_2O\ (g) \rightarrow C_2H_5OH\ (l)$$

Table 5

bond	C−C	C=C	C−H	O−H	C−O	C=O	O−O	O=O
bond energy in kJ/mol	346	610	414	463	358	804	144	498

(i) Using the bond energies provided in Table 5.1, calculate the enthalpy change for this reaction.

enthalpy change …………………………… [3]

(ii) The reaction between ethene and steam is exothermic.

Using ideas about bond breaking and bond forming, explain why the reaction is exothermic.

……………………………………………………………………………………..

……………………………………………………………………………………..

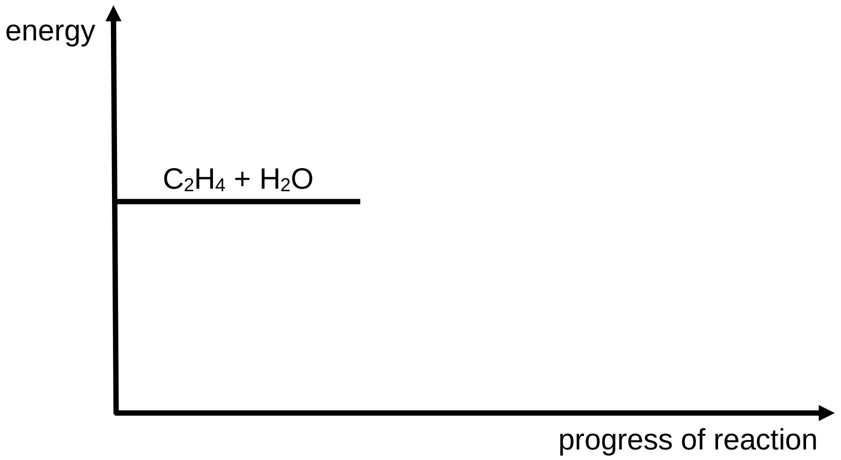
……………………………………………………………………………………..

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

(iii) Complete the energy profile diagram for the reaction between ethene and steam.

Your diagram should show:

- the products of the reaction
- the activation energy for the reaction
- the enthalpy change of reaction, Δ*H*



[3]

(b) Ethanol is also manufactured by the fermentation of glucose.

(i) Write a balanced chemical equation for this fermentation.

……………………………………………………………………………….. [1]

(ii) Briefly describe this process.

Include in your answer the conditions needed for fermentation and how the ethanol is purified.

………………………………………………………………………………..

………………………………………………………………………………..

………………………………………………………………………………..

………………………………………………………………………………..

………………………………………………………………………………..

……………………………………………………………………………….. [3]

(c) Ethanol is oxidised by oxygen in the air to form ethanoic acid.

Ethanol and ethanoic acid can be distinguised by chemical tests.

Describe **two** of these chemical tests and the observations that allow you to make the distinctions.

test 1 ……………………………………………………………………………………

observation ………………………………………………………………………………

…………………………………………………………………………………………..

test 2 ……………………………………………………………………………………

observation ………………………………………………………………………………

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

[Total: 14]

A6 Poly(propene) and nylon are both used to make strong, waterproof ropes.

Poly(propene) is an addition polymer. Nylon is a condensation polymer.

(a) Describe **one** difference between addition polymers and condensation polymers.

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

…………………………………………………………………………………………..

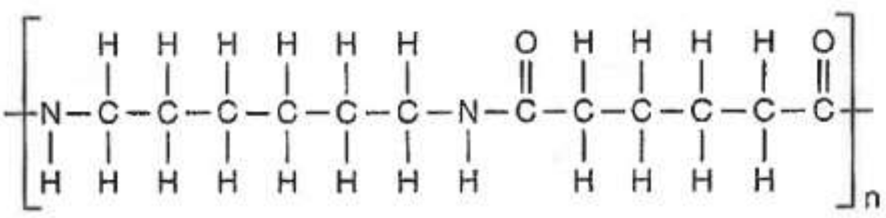
………………………………………………………………………………………….. [1]

(b) Draw the structure of poly(propene), showing two repeat units.

[1]

(c) There are several different types of nylon. One type of nylon is nylon-6,6.

This is the repeating unit of nylon-6,6.



(i) Draw the structures of the two monomers that react to form nylon-6,6.

[2]

(ii) During the manufacturing process, the chain length of the nylon is controlled so that the nylon polymer molecules have an average relative molecular mass in the range 12 000 to 20 000.

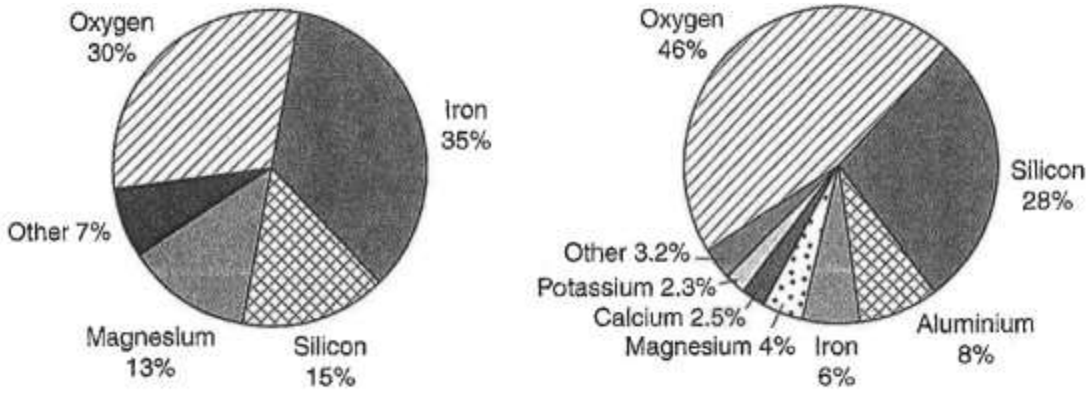
What is the range of the average number of repeating units in the nylon-6,6 molecules? Show your working.

range ……………………………. [2]

[Total: 6]

A7 Read the information about elements and compounds in the Earth.

The Earth's crust is the thin outer layer of the Earth. The pie charts show a comparison of the percentages of elements in the whole Earth and in the Earth's crust.



Whole Earth **Crust**

Fig. 7.1

In the Earth's crust, silicon and oxygen are the most abundant elements. Rocks such as quartz are made of covalently bonded compounds of silicon and oxygen. Typically, quartz contains 46.7% silicon and 53.3% oxygen by mass.

Some rocks such as feldspars contain ionic silicate compounds. These contain metal ions ionically bonded to silicate ions.

Examples of naturally occurring silicates are shown in the table below.

Table 7.2

name of silicate compound	formula
forsterite	Mg_2SiO_4
phenacite	Be_2SiO_4
anorthite	$CaAl_2Si_2O_8$
microcline	$KAlSi_3O_8$

The formulae of the silicate compounds are not simple. Some silicate compounds contain one type of metal ion, others contain more than one. All silicate ions contain silicon and oxygen, but the numbers of the atoms and the charges on the ions vary. For example,

- **phenacite** (Be_2SiO_4) contains only **Be^{2+}** metal ions and the formula of its silicate ion is **SiO_4^{4-}**,
- **microcline** ($KAlSi_3O_8$) contains **K^+** and **Al^{3+}** metal ions and the formula of its silicate ion is **$Si_3O_8^{4-}$**.

(a) Scientists believe that the centre of the Earth is made from an inner core made mainly of iron.

What evidence from the pie charts supports this idea?

……………………………………………………………………………………….

……………………………………………………………………………………….

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

(b) **(i)** Use the information to work out the empirical formula and hence the name of the main compound in quartz.

empirical formula ……………..

name ………………………………………….. [2]

(ii) There are other compounds of oxygen found in the Earth's crust as well as quartz. One such example is potassium oxide.

The table shows some differences between the properties of potassium oxide and the compound in **(b)(i)**.

Table 7.3

compound	melting point / ^{o}C	electrical conductivity under room conditions
potassium oxide	740	does not conduct
compound in **(b)(i)**	2230	does not conduct

Explain, in terms of bonding and structure, why potassium oxide and the compound in **(b)(i)** have different properties.

……………………………………………………………………………………..

……………………………………………………………………………………..

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……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….. [4]

(c) Give the formulae and charges of the ions present in anorthite.

…………….., …………….. and …………….. [1]

(d) Beryllium and silicon can both be extracted from the mineral phenacite.

Show by calculation that 1 kg of phenacite contains a larger mass of silicon than beryllium but a larger number of moles of beryllium atoms than silicon atoms.

[4]

[Total: 12]

A8 A series of experiments was carried out to investigate the effect of different catalysts on the rate of a reaction.

The table shows the time taken for the reaction to finish when different metal compounds were used as catalysts.

The metal compounds contained Group 1 metals, Group 2 metals or transition metals.

Table 8

experiment	catalyst	temperature at start / ^{o}C	time taken for reaction to finish / s
1	$NaCl$	19	45
2	$FeCl_2$	20	22
3	$CoCl_2$	19	26
4	$MgCl_2$	20	46
5	$NaNO_3$	19	45
6	$Fe(NO_3)_2$	20	22
7	$Fe(NO_3)_3$	19	15
8	$Co(NO_3)_2$	19	26
9	$Mg(NO_3)_2$	19	46

(a) Explain, in terms of collisions and energy, the effect of a catalyst on the rate of a reaction.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(b) Group 1 and Group 2 metal compounds are less effective than transition metal compounds as catalysts.

Explain how the information in the table supports this statement.

………………………………………………………………………………………….

………………………………………………………………………………………….

………………………………………………………………………………………….

………………………………………………………………………………………….

………………………………………………………………………………………….

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

(c) Iron is a transition metal.

Two different iron ions were used in the experiments.

(i) Give the formulae of the two ions. …………….. and …………….. [1]

(ii) Which iron ion appears to be the more effective catalyst?

Explain your reasoning.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

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

(iii) State **one other** property of transition metals.

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

(d) A student wrote this conclusion from the results in the table.

> The type of anion in the catalyst compound does not affect the rate of reaction.

(i) Do you agree with this conclusion?

Use the results to explain your reasoning.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

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

(ii) Predict the time taken for the reaction to finish if iron(III) chloride was used as a catalyst.

…………….. [1]

[Total: 10]

Section B

Answer **one** question from this section.

B9 A factory is suspected of releasing non-biodegradable toxic waste such as calcium ions, aluminium ions, zinc ions and nitrate ions into the nearby river.

A scientist tested two samples of the river water by adding excess aqueous sodium hydroxide and aqueous ammonia respectively, followed by warming with aluminium foil. He recorded his observations in Table 9 below.

Table 9

test	on adding a few drops	on adding excess	on warming with aluminium foil
aqueous sodium hydroxide	white precipitate formed	white precipitate, soluble in excess giving a colourless solution	no visible reaction
aqueous ammonia	white precipitate formed	white precipitate, some soluble in excess giving a colourless solution, some remained insoluble in excess	gas evolved turns damp litmus paper blue

Based on this information, the scientist claimed that the factory had indeed been releasing aluminium ions, zinc ions and nitrate ions into the river. However, the factory owner argued that this data showed that the factory was only releasing aluminium ions and zinc ions, but not nitrate ions.

(a) **(i)** Explain how the data shows that calcium ions are absent, but both aluminium ions and zinc ions are present in the river water.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

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

(ii) The scientist claims that nitrate ions are detected in the river water as the test with aqueous ammonia produced ammonia gas.

Do you agree? Explain your answer.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

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

(b) The river water also contained trace amounts of chloride ions.

Describe how you would carry out a test to show the presence of chloride ions in a solution. Include the observations you would expect.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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

(c) The salt zinc chloride found in the river water can be prepared in the laboratory.

Describe how a pure sample of zinc chloride crystals can be prepared from insoluble zinc carbonate.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

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

[Total: 10]

B10 The reactivity series summarises information about the reactions of metals with acids and water, displacement reactions and the extraction of metals from their ores.

(a) A student carried out some experiments to place four metals, **W**, **X**, **Y** and **Z** in order of reactivity. The table shows the results.

Table 10.1

	metal **W**	metal **X**	metal **Y**	metal **Z**
solution of **W** nitrate		×	×	×
solution of **X** nitrate	✓		✓	✓
solution of **Y** nitrate	✓	×		✓
solution of **Z** nitrate	✓	×	×	

[key: ✓ = shows a reaction happened; × = shows no reaction happened]

(i) Place the metals in order of reactivity, starting with the most reactive.

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

(ii) Metal **Z** reacts with hydrochloric acid.

What would you see when metal **Z** reacts with hydrochloric acid?

Explain your reasoning.

………………………………………………………………………………………..

………………………………………………………………………………………..

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

(iii) The student carried out further experiments to place metal **M** in the list.

She used dilute hydrochloric acid and samples of the metals.

She found out that metal **M** is the fourth most reactive metal.

Describe the experiments that the student carried out.

Your answer should include

- the experiments that she carried out using dilute hydrochloric acid and samples of the metals,
- the measurements that she made,
- how the results showed that metal **M** is the fourth most reactive metal.

……………………………………………………………………………………..

……………………………………………………………………………………..

…………………………………………………………………………………….

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……………………………………………………………………………………..

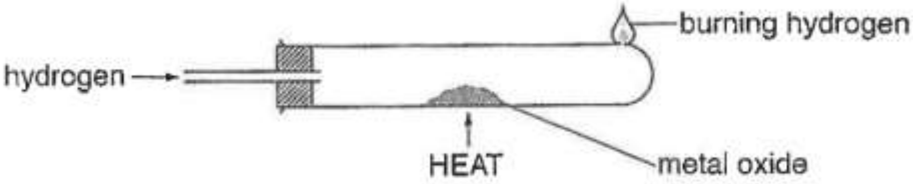
……………………………………………………………………………………..

……………………………………………………………………………………...

……………………………………………………………………………………...

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

(b) The student also carried out some experiments to investigate the reduction of three metal oxides by hydrogen.



The table shows the appearance of each metal oxide when cold.

Table 10.2

experiment	metal oxide	colour when cold
1	calcium oxide	white
2	copper oxide	red
3	lead oxide	yellow

(i) What would you expect to see happen in each experiment?

Explain your answer.

………………………………………………………………………………………..

………………………………………………………………………………………..

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

(ii) In which tube would you expect to see the fastest reaction?

Explain your answer.

………………………………………………………………………………………..

………………………………………………………………………………………..

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

[Total: 10]

[insert Periodic Table]

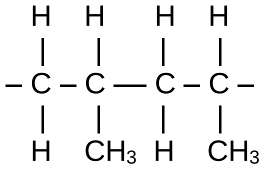
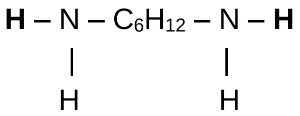
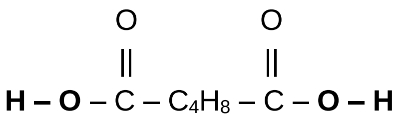
MARK SCHEME

Section A [70 m]

A1	**(a)**		calcium hydroxide **(c)** sulfur dioxide and nitrogen dioxide	[2]
	(b)		magnesium **(d)** nitrogen and hydrogen	[2]
A2	**(a)**	**(i)**	ethanoic acid, CH_3COOH; propanol, C_3H_7OH	[2]
		(ii)	At higher temperatures, the reacting particles move faster leading to	[1]
			a higher frequency of effective collisions between the particles,	[1]
			resulting in a higher rate of diffusion.	
	(b)	**(i)**	The esters have the same general formula, $HCO_2C_nH_{2n+1}$. /	[1]
			The esters have the same functional group, HCO_2.	
		(ii)	Methyl methanoate	[1]
			It has the lowest relative molecular mass of 60.	[1]
A3	**(a)**	**(i)**		

symbol	number of protons	number of neutrons	number of electrons	
$^{79}_{35}\mathrm{Br}$	35	44	35	[1]
$^{81}_{35}\mathrm{Br}^-$	35	46	36	

		(ii)	*Isotopes* have the same number of protons (i.e. 35 protons) but	[1]
			different number of neutrons (i.e. 44 and 146 neutrons).	
		(iii)	$Cl_2\ (g) + 2Br^-\ (aq) \rightarrow 2Cl^-\ (aq) + Br_2\ (l)$	[1]
		(iv)	Astatine, being less reactive than bromine, is unable to displace	[1]
			bromine from its salt.	
	(b)	**(i)**	The colourless solution turns dark-brown.	[1]
		(ii)	The iodine in potassium iodide undergoes oxidation, as the	[1]
			oxidation state of iodine increases from -1 in I^- to 0 in I_2.	
			The oxygen in ozone undergoes reduction, as the oxidation state of	[1]
			oxygen decreases from 0 in O_3 to -2 in H_2O.	
	(c)	**(i)**	'Dot-and-cross' diagram [covalent; $H_3C - S - CH_3$]	[2]
		(ii)	Dimethyl sulfuide is a simple covalent molecule.	[1]
			A small amount of heat energy is required to overcome the weak intermolecular forces of attraction between **molecules**.	
A4	**(a)**		silver; $Ag\ (s) \rightarrow Ag^+\ (aq) + e^-$	[1]
			molten; $2Cl^-\ (l) \rightarrow Cl_2\ (g) + 2e^-$	[1]
	(b)	**(i)**	$2H^+\ (aq) + 2e^- \rightarrow H_2\ (g)$	[1]
		(ii)	As chlorine is slightly soluble in water, the volume collected is lesser.	[1]
		(iii)	The resulting solution becomes increasingly alkaline.	[1]
			With the removal of H^+ and Cl^- ions, the remaining Na^+ and OH^- combine to form the strong alkali, NaOH.	
		(iv)	similarity	
			At the cathode, H^+ ions are discharged to form hydrogen gas.	[1]
			difference	
			At the anode, OH^- ions are discharged to form oxygen gas for dilute aqueous sodium chloride, while Cl^- ions are discharged to form chlorine gas for concentrated aqueous sodium chloride.	[1]

A5	**(a)**	**(i)**	energy absorbed for bond-breaking = 610 + 4(414) + 2(463) = 3192 kJ/mol	[1]
			energy released for bond-forming = 346 + 5(414) + 358 + 463 = 3237 kJ/mol	[1]
			enthalpy change of reaction = 3192 + (-3237) = -45 kJ/mol	[1]
		(ii)	More energy is released in bond forming (i.e. C-C, C-H, C-O and O-H) than absorbed in bond breaking (i.e. C=C, C-H and O-H).	[2]
		(iii)	on diagram:	
			• the products of the reaction	[1]
			• the activation energy for the reaction	[1]
			• the enthalpy change of reaction, Δ*H*	[1]
	(b)	**(i)**	$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$	[1]
		(ii)	The fermentation of glucose can be carried out using yeast as catalyst. The mixture is kept at a temperature of about 37°C, producing a dilute solution of ethanol, with concentration 12-14%. The process is carried out under anaerobic conditions.	[2]
			Ethanol is purified using fractional distillation.	[1]
	(c)		test 1 : To 5 cm^3 of sample, add 1 g of solid sodium carbonate. observation : With ethanol, there is no visible reaction. With ethanoic acid, effervescence is observed.	[1]
			test 2 : To 5 cm^3 of sample, add an equal volume of acidified potasisum manganate(VII). observation : With ethanol, the purple solution turns colourless. With ethanoic acid, no visible reaction.	[1]
A6	**(a)**		Choose any one: • The addition polymer contains the C-C chain, while the condensation polymer contains the amide or ester linkages. • The formation of addition polymers does not involve any loss of small molecules (i.e. 1 product formed). While the formation of condensation polymers involves the loss of small molecules like water (i.e. 2 products formed). • The formation of addition polymers involves the C=C functional group, while the formation of condensation polymers involves monomers with functional groups like $-NH_2$, –COOH and –OH.	[1]
	(b)		 $-\underset{H}{\overset{H}{C}}-\underset{CH_3}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{CH_3}{\overset{H}{C}}-$	[1]
	(c)	**(i)**	 $\mathbf{H}-\underset{H}{N}-C_6H_{12}-\underset{H}{N}-\mathbf{H}$  $\mathbf{H-O}-\overset{O}{\overset{\Vert}{C}}-C_4H_8-\overset{O}{\overset{\Vert}{C}}-\mathbf{O-H}$	[2]
		(ii)	M_r of $C_{12}H_{22}N_2O_2$ = 226	[1]
			range = 54 to 88	[1]

A7 **(a)** The pie charts show that there is 35% of iron in the whole Earth, while there is only 6% in the Earth's crust. This implies that 29% of the iron is in the inner core of the Earth. [1]

(b) **(i)**

	Si	O
percentage	46.7	53.3
A_r	28	16
no. of moles	1.6679	3.3333
÷ 1.6679	1	2

empirical formula = SiO_2; name = silicon dioxide [2]

(ii) Potassium oxide is an ionic compound. [1]
A large amount of heat energy is required to overcome the strong electrostatic forces of attraction between oppositely-charged ions.
Silicon dioxide is a giant covalent molecule. [1]
An even larger amount of heat energy is required to overcome the stronger covalent bonds between atoms.

For potassium oxide, the ions are held rigidly in fixed positions in the solid state. The absence of mobile charged ions prevents the electric current from being carried. [1]
For silicon dioxide, all valence electrons are used for bonding. The absence of mobile charged electrons prevents the electric current from being carried. [1]

(c) Ca^{2+}, Al^{3+} and $Si_2O_8^{8-}$ [1]

(d) M_r of phenacite = 110

mass of silicon in phenacite = $\frac{28}{110}$ x 1000 g = 255 g (to 3 s.f.) [1]

mass of beryllium in phenacite = $\frac{2(9)}{110}$ x 1000 g = 164 g (to 3 s.f.) [1]

From the above calculations, 1 kg of phenacite contains a larger mass of silicon than beryllium.

no. of mol. of silicon = $\frac{254.545\text{g}}{28}$ = 9.09 mol (to 3 s.f.) [1]

no. of mol. of beryllium = $\frac{163.636\text{g}}{9}$ = 18.2 mol (to 3 s.f.) [1]

From the above calculations, 1 kg of phenacite contains a larger number of moles of beryllium atoms than silicon atoms.

A8 **(a)** A catalyst provides an alternative pathway with a lower activation energy for the reaction to proceed, leading to a higher frequency of effective collisions between the particles, resulting in a higher rate of reaction. [1] [1]

(b) Comparing experiments 5, 7, 8 and 9, with the same starting temperature of 19°C, Group 1 and 2 metal compounds are less effective as the time taken for reaction to finish is longer (i.e. $NaNO_3$ takes 45s, while $Mg(NO_3)_2$ takes 46 s), as compared to the transition metal compounds which take a shorter time (i.e. $Fe(NO_3)_3$ takes 15s, and $Co(NO_3)_2$ takes 26s. [1] [1]

(c) **(i)** Fe^{2+} and Fe^{3+} [1]

	(ii) Iron(III) ion is the more effective catalyst. Comparing experiments 6 and 7, iron(III) ion took a shorter time (i.e. 15s in experiment 7) to complete the reaction, as compared to that of iron(II) ion (i.e. 22s in experiment 6), despite the slight change in temperature.	[1]
	(iii) Transition metals form coloured compounds when hydrated.	[1]
	(d) (i) Yes. Comparing experiments 1 and 5, both $NaCl$ and $NaNO_3$ took 45s to complete the reaction, regardless of the anion. Also, comparing experiments 2 and 6, both $FeCl_2$ and $Fe(NO_3)_2$ took 22s to complete the reaction, regardless of the anion.	[2]
	(ii) 15s	[1]

Section B [10 m]

B9	**(a) (i)** From the test with aqueous NaOH, the white precipitate formed is soluble in excess, implying that both Al^{3+} ions and Zn^{2+} ions are present. If Ca^{2+} ion is present, then some white precipitate formed is insoluble in excess. From the test with aqueous NH_4OH, some white precipitate formed is soluble in excess, confirming that Zn^{2+} ions are present, while some white precipitate formed is insoluble in excess, confirming that Al^{3+} ions are present.	[1] [1] [1]
	(ii) No, the ammonia gas produced could be due to the presence of aqueous ammonia. To test for nitrate ions, the scientist should use warm aqueous sodium hydroxide and aluminium foil.	[1] [1]
	(b) test : To a 2 cm^3 sample of river water, add an equal volume of dilute acid, followed by aqueous silver nitrate. result : white precipitate formed	[1] [1]
	(c) 1. Add excess zinc carbonate [base] powder to warm dilute hydrochloric acid [acid]. 2. Filter the mixture to remove the excess zinc chloride. 3. Heat the filtrate till it is saturated. 4. Allow the solution to cool and crystals of zinc chloride will form. Filter off the crystals. 5. Wash the crystals with distilled water. Dry the pieces of crystals between two pieces of filter paper.	[1] [1] [1]
B10	**(a) (i)** **W > Z > Y > X**	[1]
	(ii) Effervescence is observed. Metal **Z**, being a reactive metal (i.e. above H in the reactivity series), reacts with acid to displace hydrogen gas.	[1] [1]
	(iii) Approach: The student measured and compared the volume of hydrogen gas collected for a metal of fixed mass (i.e. 0.5 g each of metals **W**, **X**, **Y**, **Z** and **M**) to react completely with dilute hydrochloric acid of a fixed concentration (i.e. 1 mol/dm^3) and volume (30 cm^3) over a 2-minute duration.	[1]

			Procedure: 1. Using a 50 cm^3 measuring cylinder, measure 30 cm^3 of HC*l* and place it in a 250 cm^3 conical flask. 2. Transfer the dilute hydrochloric acid into the conical flask, connect a gas syringe 3. Using an electronic mass balance, measure 0.5 g of metal **W** and add it to the conical flask. Stopper the conical flask and connect a gas syringe to the conical flask using a delivery tube. **Start the stopwatch immediately.** 4. Stop the stopwatch when it reaches 2 minutes. Record the volume of gas produced in a table of suitable format.	[1]
			Conclusion: Metal **W** will have the highest volume of hydrogen gas collected, followed by metals **Z**, **Y**, **M** (i.e. 4th most reactive) and **X**.	[1]
	(b)	**(i)**	There is no visible reaction for experiments 1 and 3. Calcium and lead, being more reactive than hydrogen, cannot be displaced from their oxide by hydrogen.	[1]
			In experiment 2, the red copper oxide turns red-brown. Copper, being less reactive than hydrogen, can be displaced from its oxide by hydrogen.	[1]
		(ii)	The tube containing copper oxide. Copper, being the least reactive metal, forms the least stable metal oxide, hence the oxide is more readily reduced by hydrogen.	[1]