CLASS:	REGISTER NO.:	NAME:

SECONDARY FOUR
PRELIMINARY EXAMINATION 2016

CHEMISTRY
Paper 2

5073/2
17th August 2016
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 or graphs.
All final answers for calculations are to be rounded off to **3 significant figures**.
Do not use staples, paper clips, highlighters, and glue or correction fluid.

Section A (50 Marks)
Answer **ALL** questions in the spaces provided.

Section B (30 Marks)
Answer all **THREE** questions from this section. The last question is in the form of EITHER/OR and only ONE of the alternatives should be attempted.
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.

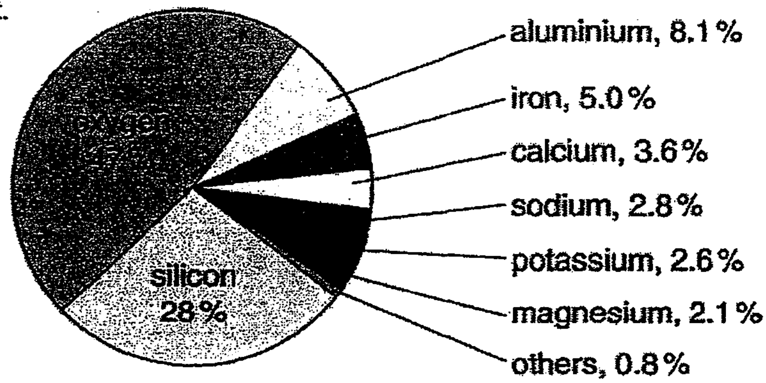
For Examiner's Use	
Section A	
B7	
B8	
B9 EITHER/OR	
Total	80

This paper consists of 20 printed pages, including the cover page.

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 the percentages of common elements found present in Earth's crust.



Use elements from the diagram to answer the following questions.

(a) Which element is extracted by reduction of its oxide with carbon? **[1]**

____

(b) Which metallic element reacts with steam but not with cold water? **[1]**

____

(c) Which <u>two</u> elements form hydroxides that are insoluble in excess aqueous sodium hydroxide? **[2]**

____

(d) Name the<u>two</u>elements that exist in greatest abundance in Earth's crust. **[1]**

____

(e) Using information from the pie-chart, suggest a possible reason why iron and aluminium are used widely as a material to manufacture many products for use in our daily lives. **[1]**

____

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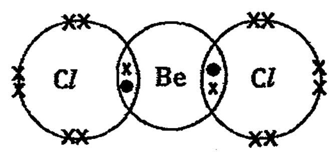
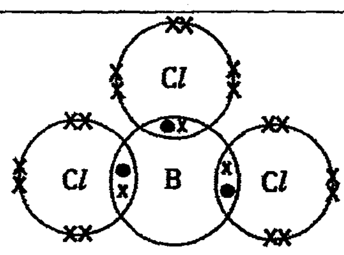
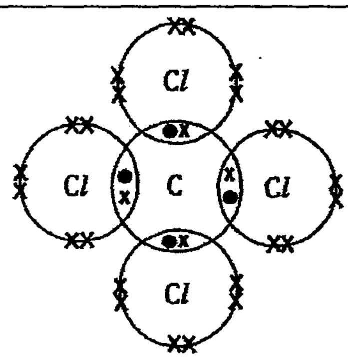
[Total: 6 marks]

A2 The shape of covalent molecules can be predicted using the Valence Shell Electron Pair Repulsion (VSEPR) theory. According to the theory, electron pairs around the central atom will arrange themselves as far as possible in space to minimise mutual repulsion.

The table below shows examples of some compounds with 2 – 4 electron pairs around the central atom and theresulting shape of their moleculesaccording to the VSEPR theory.

Name of Substance	'Dot-and-cross' Diagram	No. of electron pairs around central atom	Shape of molecule
Beryllium chloride, $BeCl_2$		2	Linear
Boron trichloride, BCl_3		3	Trigonal planar
Tetrachloromethane, CCl_4		4	Tetrahedral

(a) Are the bonds formed in beryllium chloride expected? Explain your answer. [2]

___

___

(b) (i) Tetrachloromethane can be prepared by reacting methane with chlorine in the presence of UV light. [2]

State the type of reaction that has occurred and give a balanced chemical equation for the reaction.

___

___

A2 (b) (ii) Draw the 'dot-and-cross' diagram for methane. [2]

(iii) Hence, using the VSEPR theory, deduce the shape of methane molecule. [1]

____

(iv) State and explain, in terms of structure and bonding, the physical state that methane exists in at room temperature and pressure. [3]

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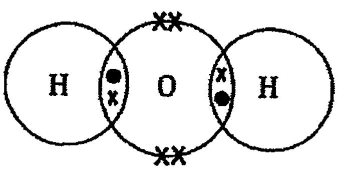
____

(c) The 'dot-and-cross' diagram for water is shown below.



(i) In terms of electron pairs, state one similarity and one difference observed between the bonding in water and in tetrachloromethane. [3]

____

____

____

A2 (c) (ii) Hence, deduce whether water will exist as a linear molecule like beryllium chloride. [1]

____

[Total: 14 marks]

A3 A thin layer of ozone, O_3, is present in the Earth's stratosphere. This layer of ozone in the Earth's stratosphere is essential to human's health. However, at the ground level, ozone is considered as a pollutant.

(a) Explain why the ozone layer in the Earth's stratosphere is essential to human's health. [2]

____

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(b) At the ground level, unburnt hydrocarbons react with nitrogen dioxide to produce ozone to form photochemical smog.

(i) State the source of unburnt hydrocarbons and nitrogen dioxide. [2]

____

____

____

(ii) State one harmful effect of photochemical smog on human health. [1]

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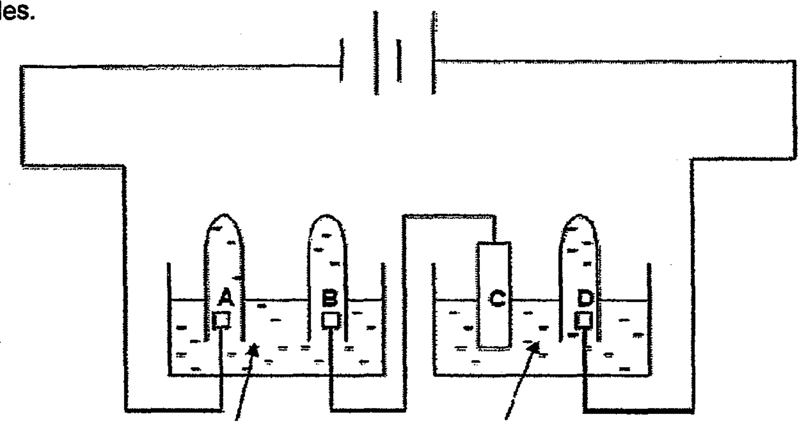
____

[Total: 5 marks]

A4 The following set-up can be used for the electrolysis of electrolyteQ and dilute nitric acid using inert electrodes.



(a) (i) Write the ionic equation, with state symbols, for the reaction at electrodes **A** and **B**. [2]

Electrode A:	
Electrode B:	

(ii) Given that 140 cm^3 of gas was collected in the test-tube at electrode **A** after carrying out the electrolysis for 15 minutes, predict the volume of gas collected at electrode **B**. [1]

____

(iii) Explain your answer in **(a)(ii)**. [2]

____

____

____

____

(b) The products formed at electrodes **C** and **D** are copper and chlorine respectively.

(i) Suggest a suitable identity for electrolyte **Q**. [1]

____

(ii) Write the ionic equation, with state symbols, for the reaction at electrode **C**. [1]

____

[Total: 7 marks]

A5 **(a)** The flow chart below shows a series of reactions carried out to produce vinegar, ethanoic acid.

Carbohydrates —(Reaction I: Yeast, 37°C)→ Compound Y —(Reaction II)→ Ethanoic acid, CH_3COOH

(i) State the name of reaction **I**. **[1]**

____

(ii) Give the chemical equation for reaction**I**. **[1]**

____

____

(iii) State the reagents and conditions required to react compound Y to form ethanoic acid. **[1]**

____

(iv) Ethanoic acid reacts with compound Y to form a sweet-smelling compound, compound Z, when heated with concentrated sulfuric acid. **[2]**

State the name of compound Z and draw its full structural formula in the table below.

Name of Compound Z	
Full structural formula	

(b) Ethanoic acid, CH_3COOH, is a weak monobasic acid. It reacts with magnesium, giving a colourless gas and a soluble magnesium salt.

(i) Explain what is meant by the term '*weak monobasic acid*'. **[2]**

____

____

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A5 **(b)** **(ii)** Give a balanced chemical equation for the reaction between ethanoic acid and magnesium. **[1]**

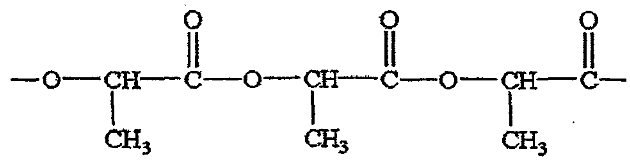
____

(iii) Name the magnesium salt formed. **[1]**

____

[Total: 9 marks]

A6 The diagram below shows the structure of polyactide (PLA), a synthetic polymer that is commonly used as materials for food packaging or disposable utensils.



Structure of polyactide (PLA)

In recent years, polyactide has been widely used as an alternative material for food packaging or disposable utensils in replacement of petroleum-based plastics.

Polyactide is an example of bioplastics, a group of polymers manufactured using raw materials derived from plants. As such, bioplastics are biodegradable when they are disposed. Products made from bioplastics such as polyactide can also be easily converted back to its raw materials that can be used to regenerate new products.

(a) **(i)** State the type of polymerisation undergone to form polyactide. **[1]**

____

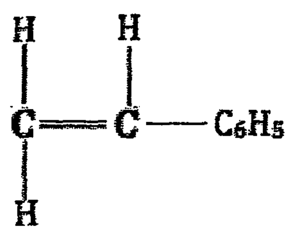
(ii) State the name of the linkage present in polyactide. **[1]**

____

(ii) Deduce and draw the structure of the monomer used to manufacture polyactide. **[1]**

A6 (b) Polystyrene is an example of petroleum-based plastics that has been used traditionally as materials for food packaging or disposable utensils.

The structure of the monomer of polystyrene is shown in the diagram below.



Monomer of polystyrene

(i) State the type of polymerisation reaction undergone to form polystyrene. [1]

____

(ii) Draw the structure of the polystyrene, showing at least 2 repeat units. [1]

(iii) Describe one difference and one similarity between polystyrene and its monomer. [2]

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A6 (c) Other than being biodegradable, suggest two other advantages of using polyactide over polystyrene as materials for food packaging and disposable utensils. [2]

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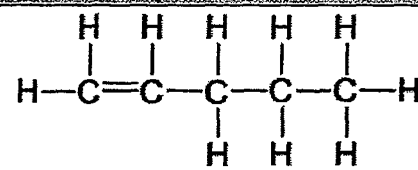
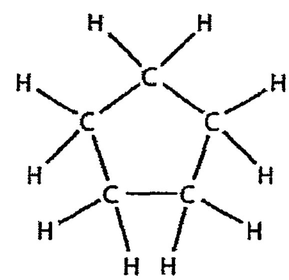
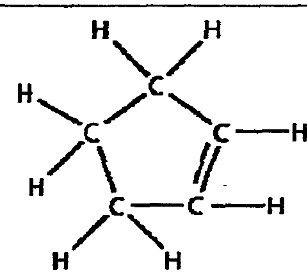
[Total: 9 marks]

Section B (30 Marks)

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.

B7 The table below shows some information about three organic compounds: pentene, cyclopentane and cyclopentene.

Organic Compound	Molecular Formula	Enthalpy change of combustion(kJ/mol)	Structural Formula
pentene	C_5H_{10}	**(c)(ii)**	
cyclopentane	C_5H_{10}	-2430	
cyclopentene	C_5H_8	-2170	

(a) **(i)** Cyclopentane is an isomer of pentene. **[2]**

Using information provided in the table, explain this statement.

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B7 **(a)** **(ii)** Both pentene and cyclopentane give the same products when they undergo complete combustion. **[2]**

Using structural formulae for pentene and cyclopentane, write equations to show the complete combustion of pentene and cyclopentane.

(iii) Using the data on bond energies provided, calculate the enthalpy change of combustion of pentene. **[3]**

Bond	C = C	C – C	C – H	C = O	O – H	O = O
Energy (kJ/mol)	610	350	410	740	460	496

(iv) Suggest a reason to account for the difference in enthalpy change of combustion of pentene and cyclopentane. **[2]**

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B7 **(b)** A student made this statement when asked about the relationship between pentene and cyclopentene:

"Both pentene and cyclopentene belongs to the same ***homologous series*** *as they both contain the carbon-to-carbon double bond functional group."*

(i) Define the term ***'homologous series'***. **[1]**

____

____

____

(ii) Do you agree with the student's statement? **[2]**

Explain your answer, using information from the provided in the table.

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[Total: 12 marks]

B8 **(a)** In an experiment, small amounts of three transition metals, zinc, chromium and copper, were added separately to their metal nitrates solutions.

The results of the reactions with zinc and copper are shown in the table.

	aqueous zinc nitrate	**aqueous nickel(II) nitrate**	**aqueous copper(II) nitrate**
zinc		Green solution turned colourless and grey metal coated with a silvery solid	Blue solution turned colourless and grey metal coated with a reddish-brown solid
copper	no visible reaction	no visible reaction	

(i) Describe the observations expected when nickel is added to aqueous zinc nitrate and aqueous copper(II) nitrate. **[2]**

	aqueous zinc nitrate	**aqueous copper(II) nitrate**
nickel		

(ii) Give the ionic equation, with state symbols, for the reaction between zinc and aqueous copper(II) nitrate. **[1]**

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(iii) In terms of oxidation state, explain why the reaction in **(a)(ii)**is a redox reaction. **[2]**

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B8 **(b)** Hydrated nickel(II) nitrate, $Ni(NO_3)_2.6H_2O$, can be produced by reacting excess nickel(II) carbonate with dilute nitric acid. The resulting mixture is then filtered and heated to saturation. Green nickel(II) nitrate crystals can be obtained by allowing the saturated solution to cool at room temperature.

(i) Explain why it is necessary to add nickel(II) carbonate in excess to dilute nitric acid. **[1]**

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(ii) Explain why nickel(II) nitrate crystals were obtained by allowing the saturated solution to cool at room temperature instead of heating to dryness. **[1]**

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(ii) 25.0 cm^3 of 1.00 mol/dm^3 dilute hydrochloric acid was reacted with excess nickel(II) carbonate in an experiment to produce hydrated nickel(II) nitrate. **[3]**

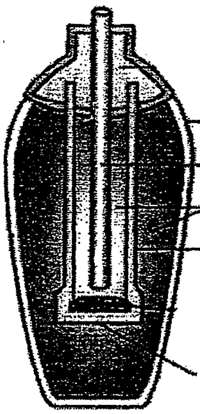
Given that 2 moles of hydrochloric acid is required to react to produce 1 mole of hydrated nickel(II) nitrate, calculate the percentage yield if 2.00 g of hydrated nickel(II) nitrate crystals were obtained at the end of the reaction.

[Total: 10 marks]

Either

B9 **(a)** During 500 B.C., a clay jar with an iron rod placed inside a copper cylinder was used to generate electricity. The clay jar was filled with vinegar solution.

The diagram below shows a simplified representation of the clay jar used.



(i) Which metal acts as the negative electrode in this electric cell? **[2]**

Explain your answer.

____

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____

(ii) Bubbles of a colourless and odourless gas are observed at the copper electrode. **[2]**

Suggest the identity of the gas formed and describe a suitable chemical test to confirm its identity.

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Either

B9 **(b)** A methanol fuel cell is a modern version of an electric cell. Electrical energy is produced from a reaction between methanol and oxygen.

The following ionic half-equations show the reaction that takes place at the respective electrodes:

Anode: $CH_3OH\ (aq) + H_2O\ (l) \rightarrow 6H^+\ (aq) + CO_2\ (g) + 6e^-$

Cathode: $O_2\ (g) + 4H^+\ (aq) + 4e^- \rightarrow 2H_2O\ (l)$

(i) Give the overall equation, with state symbols, for the reaction that takes place in the methanol fuel cell. **[1]**

____

(ii) Draw an energy level diagram for the overall reaction that occurred in the methanol fuel cell. **[2]**

(iii) State one possible effect on the environment that may result from the use of the methanol fuel cell. **[1]**

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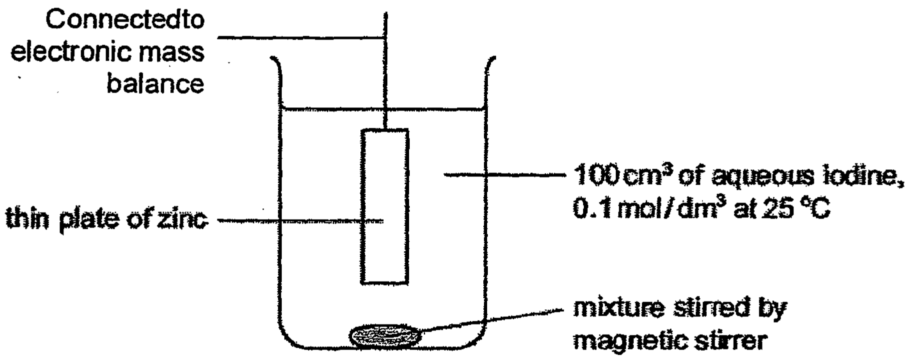
[Total: 8 marks]

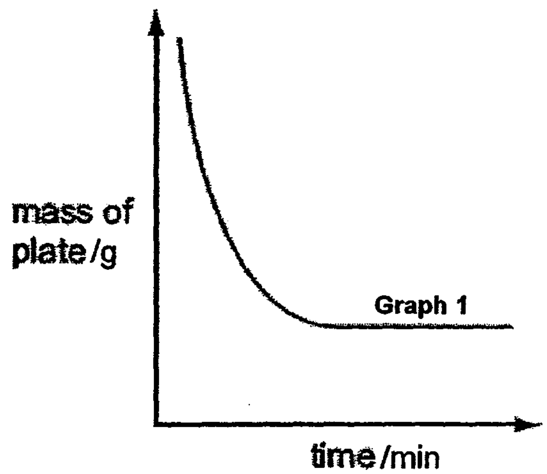
Or

B9 Zinc reacts with aqueous iodine to form zinc iodide. The following apparatus was used to measure the rate of the reaction between zinc and aqueous iodine at 25 °C.



The mass of the zinc plate was measured every minute until the reaction was complete.

From the results obtained, graph 1 (below) was obtained.



(a) With reference to graph 1, deduce the reagent that was used in excess. [1]

(b) (i) The experiment was repeated with 100 cm^3 of 0.05 mol/dm^3 iodine and keeping all other conditions the same. On the same axes as graph 1 above, sketch the curve that would be obtained and label it 'X'. [1]

Or

B9 (b) (ii) Explain the shape of the graph obtained in **(b)(i)**. [2]

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(c) Explain, in terms of collision theory, the effect on the speed of reaction if the experiment was repeated at 15 °C with all other conditions kept constant. [2]

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(d) Describe and explain what would be observed if aqueous chlorine was bubbled into the resulting zinc iodide solution obtained. [2]

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[Total: 8 marks]

☺End of Paper☺

The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										4 He helium 2
7 Li lithium 3	9 Be beryllium 4											11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	64 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	– Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57 *	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	– Po polonium 84	– At astatine 85	– Rn radon 86
– Fr francium 87	– Ra radium 88	– Ac actinium 89 †															

*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	– Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	162 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	– Pa protactinium 91	238 U uranium 92	– Np neptunium 93	– Pu plutonium 94	– Am americium 95	– Cm curium 96	– Bk berkelium 97	– Cf californium 98	– Es einsteinium 99	– Fm fermium 100	– Md mendelevium 101	– No nobelium 102	– Lr lawrencium 103

Key: a over X over b

a = relative atomic mass

X = atomic symbol

b = proton (atomic) number

Secondary Four
Prelim Examination 2016
Chemistry Paper 1 – Worked Solutions

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

1.	Since the gas is denser than air, so 1 (downward delivery / upward displacement of air) can be used. 3 can't be used as the gas is acidic and hence soluble in water. **Answer: A**
2.	The less soluble the substance is in a given solvent, the shorter the distance travelled by the substance. ∴ distance travelled by the less soluble spot = x Distance travelled by solvent = y $R_f = \frac{\text{distance travelled by substance}}{\text{distance travelled by solvent}} = \frac{x}{y}$ **Answer: B**

Secondary Four
Prelim Examination 2016
Chemistry Paper 1 – Worked Solutions

3.	Gas **X** is ammonia gas. The set up given is the positive test for nitrate ions. Ammonia gas is weakly alkaline thus changing universal indicator to blue. Sodium hydroxide is also a strong alkali like potassium hydroxide thus can be used. **Answer: A**
4.	Option A: potassium manganite (VII) will change from purple to colourless as hydrogen peroxide is acting as a reducing agent. Option B: This is an addition reaction of alkene. Bromine water changes from brown to colourless. Option D: This is a displacement reaction. Magnesium displaces iron from iron(II) chloride and the solution changes from green to colourless. **Option C:** Potassium bromide is colourless. Displacement reaction occurred but the brown solution forms as bromine is displaced from potassium bromide. **Answer: C**
5.	Silver nitrate is in excess hence there should be silver and nitrate ions in the filtrate. Insoluble silver chloride formed will remove chloride ions as precipitate. Hence, the filtrate only contains silver, nitrate and sodium ions. **Answer: A**
6.	Assumption to make: water at room temperature around 30 °C. Only pentane will be condensed as the boiling point is higher than the temperature of water. **Answer: B**
7.	At -170 °C, which is lower than the boiling point but higher than the boiling point of methane, it exists in liquid state\. Option A: both liquid and gaseous state Option B: Gaseous state Option C: Solid state **Answer: D**
8.	Option B: different compound of nitrogen Option C: diamond and graphite are **allotrope** of carbon Option D: the two diagrams show the isomer of butane **Answer: A**
9.	The electrostatic force of attraction between Ca^{2+} and O^{2-} is stronger than K^{+} and Br^{-}. Both compound are ionic compound with giant ionic lattice structure. **Answer: C**
10.	No of mol of hydrazine = $\frac{600}{1000} \div 24$ = 0.025 mol. Molar mass of hydrazine = 0.8 ÷ 0.025 = 32 g/mol $(NH_2)_n = 32$ $\therefore n = 2$ Molecular formula of hydrazine = $(NH_2)_2$ = N_2H_4

Secondary Four
Prelim Examination 2016
Chemistry Paper 1 – Worked Solutions

	Answer: C
11.	$2C_5H_{12} \rightarrow 5C_2H_4 + 2H_2$ $2C_5H_{12} \equiv 5C_2H_4$ No of mol of C_5H_{12} = $7200 \times 1 \times 10^3 \div 72$ = 100,000 No of mole of C_2H_4 = $100{,}000 \times 5 \div 2$ = 250,000 Mass of C_2H_4 = 250,000 x 28 = 7,000,000 g = 7×10^3 kg **Answer: A**
12.	No of mol of barium hydroxide = 1.71 / 171 = 0.01 mol Concentration of barium hydroxide solution = 0.01 / 0.25 = 0.04 mol/dm^3 The concentration of hydroxide ions in the solution = 2 x 0.04 = 0.08 mol/dm^3 **Answer: D**
13.	Mass of iron in one molecule of haemoglobin = 0.33 / 100 x 68,000 = 224.4 No of iron atoms in one molecule of haemoglobin = 224.4 / 56 = 4 **Answer: B**
14.	Statement 1: for both electrode Q and S, the following reaction occur: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ Given that the same amount of charge passing through the same circuit, the mass of copper deposited in Q and S should be the same. Statement 2: Only electrode P decreases in mass as it is a reactive electrode. Hence, electrode P dissolves in the solution to form copper(II) ions. Electrode R is an inert electrode. Statement 3: only the solution in Cell 2 fades in colour. Electrode P in cell 1 dissolves into the solution forming copper(II) ions replenishing the copper(II) ions that are discharged in electrode Q. Hence, there is no change in the concentration of copper(II) ions in the solution in Cell 1. Thus, there is no change in the colour of the solution. **Answer: D**
15.	The more reactive metal has a higher tendency to lose electrons and hence a stronger reducing power. Metal Y is placed at the anode (-) of the simple cell 1 and the reading is +1.60 V. Hence, it can be concluded that Y is more reactive than Z. Metal Z is placed at the negative terminal of simple cell 2 and the reading is -1.06 V. It indicates that X is more reactive than Z but Z was placed at the (+) terminal. The difference in reactivity between Z and X is smaller than Z and Y which can be concluded from

	the smaller voltage generate for Cell 2. The order in increasing reactive is Z<X<Y and so does the reducing power. **Answer: D**
16.	Oxygen is introduced into the positive terminal which is the cathode of the fuel cell. Reduction occurs at cathode. **Answer: A**
17.	Neutralisation is an exothermic reaction. Temperature of the surroudninng increases during an exothermic reaction. Higher temperature increase for Experiment II as there is a higher number of mole of limiting reactants used. **Answer: C**
18	Freezing involves reestablishing the forces of attractions between the particles in liquids thus energy is given out to the surroudings. **Answer: D**
19.	Combustion is an example of exthermic reaction. Option A: The products should have lower energy than the reactants. Option B: The total energy absorbed and released in breaking and forming the bonds determine if a reaction is exothermic or endothermic. **Answer: D**
20.	When fluorine is added to iron(II) chloride, halogen displacement occurs as fluorine is more reactive than chlorine. Displacement is an example of redox. Fluorine reduces chlorine in iron(II) chloride as the oxidation state of chlorine increases from -1 in iron(II) chloride to 0 in chlorine. $F_2 + FeCl_2 \rightarrow FeF_2 + Cl_2$ **Answer: B**
21.	The oxidation state of oxgyen in H_2O_2 increases from -1 in H_2O_2 to 0 in O_2. Hence, it is oxidised. The oxidation state of oxgyen in H_2O_2 decreases from -1 in H_2O_2 to -2 in H_2O. Hence, it is reduced. ∴ H_2O_2 is oxidised and reduced at the same time. **Answer: C**
22.	Ethanoic acid is a weak acid that dissociate partially in water to form lower concentration of H^+ ions. Hence, the speed of reaction of Experiment II is higher than Experiment I and the gradient of the graph for Experiment II is steeper. The volume of the gas produced at the end of the reaction are the same for both Experiment I and II as the same number of mole of acids (limiting reactant) are used. **Answer: D**
23.	Activation energy can only be reduced with the use of catalyst. **Answer: A**

Secondary Four
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24.	Sulfuric acid is used in the manufacturing of fertilisers. **Answer: B**
25.	Silver is not reactive enough to react with acid. **Answer: C**
26	Option A: Nitrogen is obtained from the fractional distillation of liquid air not crude oil. Option B: Hydrogen is obtained from cracking or electrolysis of water. Option D: Bond breaking is an endothermic process not exothermic. **Answer: C**
27.	The ionic radius of W and X is smaller than their atomic radius showing that W and X forms cations by losing electrons. Y forms anion by gaining electrons as its' ionic radius is bigger than the atomic radius. Option C: X forms cations while Y forms anions. The two elements should form an ionic compound and not covalent compound. Option A: X has a smaller atomic radius than W. Hence, It would be easier for W to lose its valence electrons and thus being more reactive. Option B: W forms cations while Y forms anions. The two elements form an ionic compound. **Answer: C**
28.	The electronic configuration of X, Y and Z are as follow: X 2.8.1 Y 2.8.8.1 Z 2.8.7 From the electronic configuration of the elements, we can conclude that X and Y are from Group I while Z from Group VII. Y is more reactive than X as Y has a greater atomic radius. Hence Y has a higher tendency to lose electrons to form ions. Y is a metal and hence it should form basic oxide. **Answer: C**
29.	The table shows that element P has variable oxidation states. Furthermore, oxides of P are solid at room temperature shows that oxides of P should be an ionic compound. Transition metals have variable oxidation states and form coloured compound. **Answer: A**
30.	Metal oxide forms basic oxide or amphoteric oxide. Option A: **non-metal** forms **acidic oxide** Option C: ionic compound can conduct electricity in molten state as well Option D: not conclusive as some metals don't react with water. **Answer: B**
31.	Rusting of iron involves iron losing electrons and be oxidised. With the constant flow of electrons into iron in steel, it prevents iron from being oxidised.

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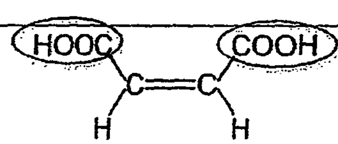
	Answer: D
32.	Zinc, Aluminium and lead form amphoteric oxides. However, only ore of aluminium requires electrolysis of molten aluminium compound for extraction. Ore of zinc and lead can be extracted using coke. **Answer: A**
33.	CFC causes the depletion of ozone layer which increases the occurrence of skin cancer in human being. Green-house gases (carbon dioxide and methane) cause global warming. **Answer: D**
34.	During the fractional distillation of petroleum, a mixture of compounds are collected at each level of the column. **Answer: A**
35.	Isomers have the same molecular but different structural formula. **Answer: B**
36.	Only alkene undergoes hydrogenation to form alkane. Both alkane and alkene can't react with magnesium. **Answer: C**
37.	Pure ethanol can't be prepared through fermentation as yeast denatures and reaction stops when the concentration of ethanol reaches 12 – 15% by volume. **Answer: D**
38.	 Both carboxylic acid group circled in the diagram above undergo esterification with the addition of ethanol under suitable conditions. **Answer: D**
39.	Empirical formula remain as CH_2 during addition polymerisation of alkene. **Answer: B**
40.	The molecule given undergo both addition and condensation polymerisation. **Answer: D**

CLASS:	REGISTER NO.:	NAME:

SECONDARY FOUR
PRELIMINARY EXAMINATION 2016

CHEMISTRY
Paper 2

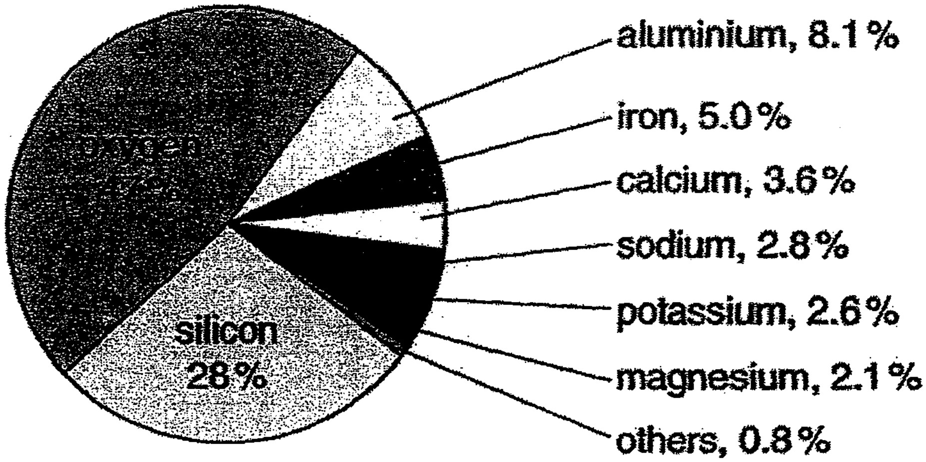
MARKING SCHEME + MARKERS' REPORT

5073/2
17th August 2016
1 hour 45 minutes

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 the percentages of common elements found present in Earth's crust.



Use elements from the diagram to answer the following questions.

(a) Which element is extracted by reduction of its oxide with carbon? **[1]**
Iron

(b) Which metallic element reacts with steam but not with cold water? **[1]**
Aluminium/ iron

(c) Which **two** elements forms hydroxides that are insoluble in excess aqueous sodium hydroxide? **[2]**
Iron/ calcium/ magnesium

(d) Name the **two** elements that exist in greatest abundance in Earth's crust. **[1]**
Silicon and **oxygen**

(e) Using information from the pie-chart, suggest a possible reason why iron and aluminium are used widely for as a material to manufacture many products for use in our daily lives. **[1]**

They exists in **higher abundance** on earth's crust and thus cost **relatively cheaper** to obtain.

General comments:

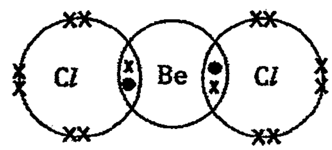
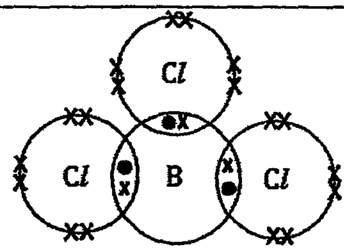
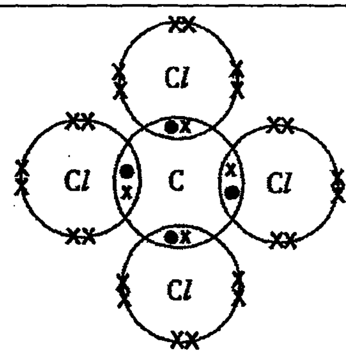
1. Most students scored at least 5 out of 6 for this question.
2. Students need to read the question carefully and quote the information given in their answer.
   For eg: students should quote the higher abundance from the pie chart given instead of explaining that the metals are cheaper as they are not given the cost price.

Common mistakes:

1. Part (c), about 30% of the cohort gave aluminium
2. Part (d), a small number of students didn't ready the question properly and gave iron and aluminium as answer

A2 The shape of covalent molecules can be predicted using the Valence Shell Electron Pair Repulsion (VSEPR) theory. According to the theory, electron pairs around the central atom will arrange themselves as far as possible in space to minimise mutual repulsion.

The table below shows examples of some compounds with 2 – 4 electron pairs around the central atom and the resulting shape of their molecules according to the VSEPR theory.

Name of Substance	'Dot-and-cross' Diagram	No. of electron pairs around central atom	Shape of molecule
Beryllium chloride, $BeCl_2$		2	Linear
Boron trichloride, BCl_3		3	Trigonal planar
Tetrachloromethane, CCl_4		4	Tetrahedral

(a) Are the bonds formed in beryllium chloride expected? Explain your answer. **[2]**
No. Since **beryllium is a metal** and **chlorine is a non-metal** **[1]**, they **usually form ionic bonds** **[1]** instead of covalent bonds as seen in beryllium chloride.

[Max 1 for students explaining that beryllium didn't achieve octet configuration]

General comments:

1. Most students are able to score full credit for this part.
2. A small number were given max. 1 as they explain that beryllium didn't achieve octet configuration. Max. 1 is given as the explanation is not complete. Students will also learn in higher level that there are exceptions to octet rule.

(b) (i) Tetrachloromethane can be prepared by reacting methane with chlorine in the presence of UV light. [2]

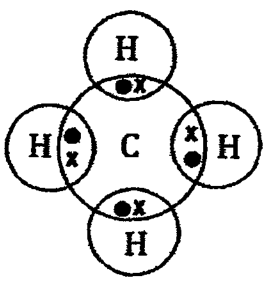
State the type of reaction occurred and give a balanced chemical equation for the reaction.

Substitution reaction [1]
$CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl$ [1]

General comments:
1. Most students only score half the credit.
2. About 70% of the cohort stated substitution but gave the addition reaction equation (H_2 as by product).
3. A small number of students didn't read the question and gave CH_3Cl as the product.

Common mistakes:
1. Students were confused between addition and substitution reaction. Methane (alkanes) can only undergo substitution with HCl as by-product

A2 (b) (ii) Draw the 'dot-and-cross' diagram for methane. [2]



General comments:
1. Most of the students scored full credit for this part.
2. Students show good understanding of deriving chemical formula of alkane from chemical name and drawing of dot-and-cross diagram.

(iii) Hence, using the VSEPR theory, deduce the shape of methane molecule. [1]
Tetrahedral

General comments:
1. Almost all students manage to derive the shape of methane molecule based on the dot-and-cross diagram.

(iv) State and explain, in terms of structure and bonding, the physical state that methane exists in at room temperature and pressure. [3]

Methane exists as a **gas** (✓) at room temperature and pressure.

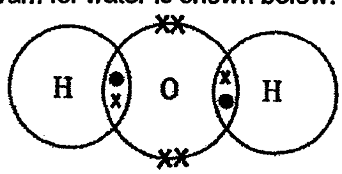
Methane exists as a **simple molecular structure** (✓). **Small amount of energy** (✓) is required to break the **weak intermolecular forces of attraction** (✓) between the molecules. Hence, it has a **low melting point** (✓).

5(✓): 3m; 3 – 4(✓): 2m; 1 - 2(✓): 1m

General comments:
1. Generally well done.
2. Some students didn't mention low boiling point thus missing out 1 of the important marking point.

Common mistakes:
1. A small number of students show serious misconception in bonding and structure:
   a. Weak covalent bond
   b. Methane has giant covalent structure (probably confused and associate organic compound with polymer)

(c) The 'dot-and-cross' diagram for water is shown below.



(i) In terms of electron pairs, state one similarity and one difference observed between the bonding in water and in tetrachloromethane. **[3]**

Similarity:
Both water and tetrachloromethane consists of **4 electron pairs around its central atom** [1]

Difference:
In tetrachloromethane, **all 4 electron pairs are formed due to sharing with another atom (Cl atom)** [1].

In water, **only 2 out of the 4 electron pairs are formed due to sharing with another atom (H atom)** [1]. The other 2 electron pairs are due to oxygen's remaining valence electrons.

General comments:
1. A poorly attempted question. Only a small group of students manage to score full credit.
2. Most students didn't answer to the questions. Students answered in terms of electrons (valence electrons) rather than electron pairs.

Common mistakes:
1. Students didn't realize that electron pairs refer to both bonded and unbonded electron pairs.
2. Many mentioned in their answer that H_2O only has 2 electron pairs.

(c) (ii) Hence, deduce whether water will exist as a linear molecule like beryllium chloride. [1]

Water **will not exist as a linear molecule** [1] since it consists of 4 electron pairs instead of 2 electron pairs like beryllium chloride.

General comments:

1. Poorly attempted question. Students don't seems to understand the electron pair concepts well through the context given.

Common mistakes:

1. Most students think that it is a linear molecule.

[Total: 14 marks]

A3 A thin layer of ozone, O_3, is present in the Earth's stratosphere. This layer of ozone in the Earth's stratosphere is essential to human's health. However, at the ground level, ozone is considered as a pollutant.

(a) Explain why the ozone layer in the Earth's stratosphere is essential to human's health. **[2]**

Ozone absorbs **harmful UV layers and prevent them from entering** [1] the atmosphere, **preventing skin cancer** [1].

General comments:

1. Only about half the cohort scored full credit for this part.
2. Students should learn that ozone **absorbs UV rays** and should stop using other terms like reflects, traps, etc.
3. Students have to be more specific in their answer that ozone layer reduce the occurrence of **skin** cancer and not just cancer.

Common mistakes:

1. Students are have mixed up global warming with ozone layer - Ozone traps heat and thus warming up the earth to ensure that human being do not freeze to death and crops can grow
2. Ozone layer absorb UV rays and prevent global warming on earth.

(b) At the ground level, unburnt hydrocarbons react with nitrogen dioxide to produce ozone to form photochemical smog.

(i) State the source of unburnt hydrocarbons and nitrogen dioxide. **[2]**

Unburnt hydrocarbons – **incomplete combustion of** (carbon-containing) **fuels** in car engines [1].

Nitrogen dioxide – **combustion of nitrogen** in car engines [1]

General comments:

1. Students need to learn to present their answer completely. Many gave ambiguous answer for eg
   a. They are produced through incomplete combustion and lightning during thunderstorm.
   b. For students with ambiguous answer as above, BOD were given only if sequence of the answer is according to the question.
2. Alternative answer accepted: nitrogen dioxide is produced during lightning activities during thunderstorm as question didn't ask for human activity only.

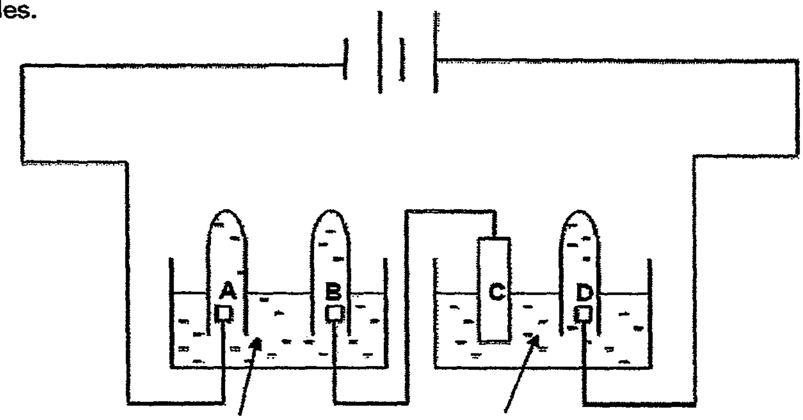
Common mistakes:

1. Both unburnt hydrocarbon and nitrogen dioxide are produced through incomplete combustion or simply combustion of fuel.
2. Nitrogen dioxide is produced in combustion of fuel in chemical plants.
3. Unburnt hydrocarbon is produced from cracking
4. Incomplete answer for eg:
   a. Unburnt hydrocarbon is produced in car exhaust
   b. Unburnt hydrocarbon is produced in car

(ii) State the harmful effects of photochemical smog on human health **[1]**
It causes eye irritation/ breathing difficulties **[1]**.

[Total: 5 marks]

A5 The following set-up can be used for the electrolysis of solution **Q** and dilute nitric acid using inert electrodes.



(a) **(i)** Write the ionic equation, with state symbols, for the reaction at electrode **B**. **[2]**
Electrode A: <u>$2H^+ (aq) + 2e \rightarrow H_2 (g)$</u> [1]

Electrode B: <u>$4OH^- (aq) \rightarrow 2H_2O (l) + O_2 (g) + 4e$</u> [1]

General Comments:

1. Generally well done.

Common mistakes:

1. However, there are students who identified oxidation taking place in Electrode A and reduction occurs in Electrode B. There are also students whose equations consists of no gas evolved at the electrodes.
2. Some students still fail to provide complete state symbols.

(ii) Given that 140 cm^3 of gas was collected in the test-tube at electrode **A** after carrying out the electrolysis for 15 minutes, predict the volume of gas collected at electrode **B**. **[1]**
<u>70 cm^3</u> [1]

(iii) Overall ratio of **<u>$1O_2$: 4e : $2H_2$</u>** [1]. Hence, **<u>volume of H_2 gas formed at electrode A will be twice that of O_2 gas</u>** [1] formed at electrode B.

<u>General Comments:</u>

1. Generally, students are able to explain the volume of gas predicted by making reference to the ratio of hydrogen and oxygen gas and explain in terms of electrons gained and loss.

(b) The products formed at electrodes **C** and **D** are copper and chlorine respectively.

(i) Suggest a suitable identify for electrolyte **Q**. **[1]**
<u>Concentrated copper(II) chloride</u> [1]

(ii) Write the ionic equation, with state symbols, for the reaction at electrode **C**. **[1]**
<u>Cu^{2+} (aq) + 2e → Cu(s)</u> [1]

<u>General Comments:</u>

1. Details to answers are required for b(i). Since chlorine gas is evolved, the electrolyte used can either be a concentrated or molten chloride solution.
2. The oxidation state of copper must also be clearly stated.
3. If student proposed that the electrolyte used is molten copper(II) chloride, the state symbol of Cu^{2+} is (*l*), instead of (aq).

A6 **(a)** The flow chart below shows a series of reactions carried out to produce vinegar, ethanoic acid.

(i) State the name of the reaction that occurred in **I**. **[1]**
Fermentation

(ii) Give the chemical equation for the reaction. **[1]**
$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$

(iii) State the reagents and conditions required to react compound **Y** to form ethanoic acid. **[1]**
Acidified potassium manganate(VII); heat

(iv) Ethanoic acid reacts with compound **Y** to form a sweet-smelling compound, compound Z, when heated with concentrated sulfuric acid. **[2]**

State the name of compound **Z** and draw its full structural formula in the table below.

Name of Compound Z	Ethyl Ethanoate

A6 **(b)** Ethanoic acid, CH_3COOH, is a weak monobasic acid. It reacts with magnesium, giving a colourless gas and a soluble magnesium salt.

(i) Explain what is meant by the term '*weak monobasic acid*'. **[2]**

1 mol of weak monobasic acid **dissociates partially in water** [1] to give **1 mol of H^+ ion** [1].

General Comments:

1. Most students managed to answer partly correct.
2. Students who fail to state that the acid dissolves in water/ aqueous solution to form hydrogen ions will not be credited.
3. Reject: Weak acid dissolves in water to form one hydrogen ion/one mole of hydrogen ions. Students must be able to state that one molecule of acid can dissociate to produce one hydrogen ion or one mole of acid dissociates to produce one mole of hydrogen ions.
4. Accept: 1 mole of acid dissolves in water to form less than 1 mole of hydrogen ions.

(ii) Give a balanced chemical equation for the reaction between ethanoic acid and magnesium. **[1]**

$CH_3COOH + Mg \rightarrow Mg(CH_3COO)_2 + H_2$

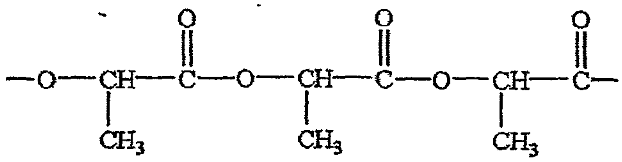
(iii) Name the magnesium salt formed. **[1]**

Magnesium ethanoate.

General Comments:

1. Quite a number of students is unable to write a formula for magnesium ethanoate.

The diagram below shows the structure of polyactide (PLA), a synthetic polymer that are commonly used as materials for food packaging or disposable utensils.



Structure of polyactide (PLA)

In recent years, polyactide has been widely used as an alternative material for food packaging or disposable utensils in replacement of petroleum-based plastics.

Polyactide is an example of bioplastics, a group of polymers manufactured using raw materials derived from plants. As such, bioplastics are biodegradable when they are disposed. Products made from bioplastics such as polyactide can also be easily converted back to its raw materials to be used to regenerate new products.

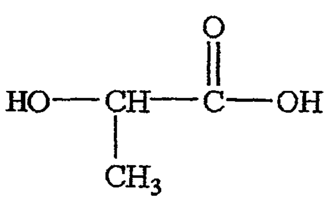
(a) **(i)** State the type of polymerisation undergone to form polyactide. **[1]**

<u>Condensation polymerisation</u>

(ii) State the name of the linkage present in polyactide and the type of **[1]**

Ester linkage [1]

(ii) Deduce and draw the structure of the monomer used to manufacture polyactide. **[1]**



[1]

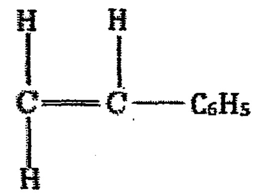
[Total: 9 marks]

General Comments:

1. Generally well done.
2. Some students have problem in identifying the structure of monomer; functional groups in the monomer are not shown.
3. Students need to show in the structuer that the C-C bonds are aligned.

(b) Polystyrene is an example of petroleum-based plastics that has been used traditionally as materials for food packaging or disposable utensils.

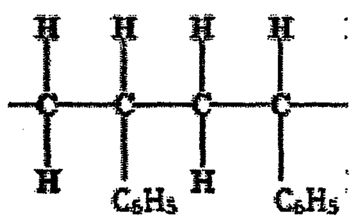
The structure of the monomer of polystyrene is shown in the diagram below.



Monomer of polystyrene

(i) State the type of polymerisation reaction undergone to form polystyrene. **[1]**
Addition polymerisation.

(ii) Draw the structure of the polystyrene, showing at least 2 repeat units **[1]**



(ii) Describe one difference and one similarity between polystyrene and its monomer. **[2]**
Difference **[1m for any one]**:
- polystyrene is a saturated hydrocarbon while its monomer is an unsaturated hydrocarbon
- the monomer contains carbon to carbon double bond (C=C) while polystyrene only have carbon to carbon single bond (C-C)

Similarity **[1]**: both polystyrene and its monomer have the same empirical formula

General Comments:
1. Students' answers are either incomplete or lack clarity.
2. Students who mentioned that monomer has C=C bonds but not polystyrene will not be credited. Students must name the type of bonds present in the polystyrene as well.
3. Reject: polystyrene and its monomer has same mass. It should be ' the mass of polystyrene equals to the total mass of the monomers used as there is no loss of atoms or molecules during addition polymerisation'.
4. Reject: polystyrene and its monomer have the same molecular formula/general formula.
5. Students are expected to be able to distinguish the terms; molecular formula, general formula, empirical formula and structural formula.

(d) Other than being biodegradable, suggest two other advantages of using polyactide over polystyrene as materials for food packaging and disposable utensils. **[2]**

Allows the conservation of finite resource of petroleum as polyactide uses plant-based raw materials which are renewable.

Less energy is required to produce the raw materials required to produce new products since the raw materials can be easily regenerated/ recycled.

General Comments:

1. Students need to provide complete and clear answers to question related to environment.
2. Vague answers such as 'harmful gases emitted', 'causes land pollution' and 'more environmentally friendly' will not be accepted.

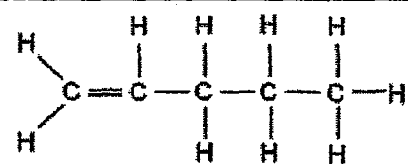
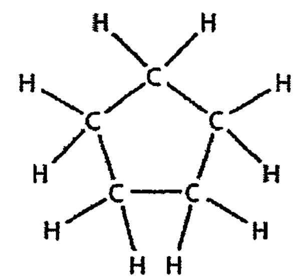
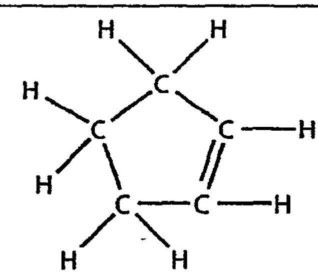
[Total: 9 marks]

Section B (30 Marks)

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.

The table below shows some information about three organic compounds: pentene, cyclopentane and cyclopentene.

Organic Compound	Molecular Formula	Enthalpy change of combustion (kJ/mol)	Structural Formula
pentene	C_5H_{10}	**(c)(ii)**	
cyclopentane	C_5H_{10}	- 2430	
cyclopentene	C_5H_8	- 2170	

(a) **(i)** Cyclopentane is an isomer of pentene. **[2]**

Using information provided in the table, explain this statement.

Both pentene and cyclopentane have the **<u>same molecular formula</u>** (✓) **<u>of C_5H_{10}</u>** (✓), but have **<u>different structural arrangement</u>** (✓).

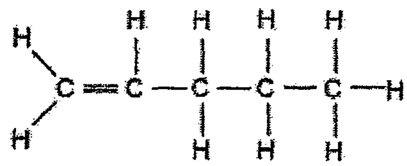
3(✓): 2m ; 1 – 2(✓): 1m; 0 (✓): 0m

<u>General Comments:</u>

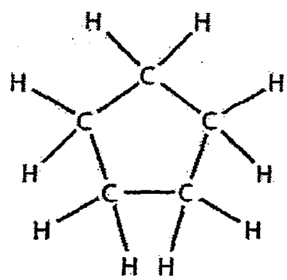
1) Students did not answer to the intent of the question, many students just gave the 'standard' definition of isomers, without reference to the evidence/ information from the table i.e. molecular formula of C_5H_{10}.

(ii) Both pentene and cyclopentane give the same products when they undergo complete combustion. **[2]**

Using full structural formulae for pentene and cyclopentane, write equations to show the complete combustion of pentene and cyclopentane,



$+\frac{15}{2}O_2 \rightarrow 5CO_2 + 5H_2O$



$+\frac{15}{2}O_2 \rightarrow 5CO_2 + 5H_2O$

General Comments:

1) Despite question stating that **full structural formulae** is required, many students only answered using molecular formula of C_5H_{10}. Only partial mark is awarded.

Common mistakes:

1. A large majority of students are unable to provide the correct equation for combustion. Students' answers showed that they do not know the correct products for combustion of hydrocarbons.
   a. Many mixed up combustion with cracking, giving a hydrocarbon with shorter carbon chain as one of the products.
   b. Many also mixed up combustion with oxidation of alcohols, using [O] to represent oxygen.
2. Some students were also unable to correctly balance the equation.

(a) (iii) Using the data on bond energies provided, calculate the enthalpy change of combustion of pentene. **[3]**

Bond	C = C	C – C	C – H	C = O	O – H	O = O
Energy (kJ/mol)	610	350	410	740	460	496

Total energy required during bond breaking
= 1(610) + 3(350) + 10(410) + 15/2(496) = 9480 kJ **[1]**

Total energy released during bond formation
= 10(740) + 10(460) = 12000 kJ **[1]**

ΔH = 9480 – 12000 = **- 2520 kJ/mol** **[1]**

General Comments:

1) ECF allowed based on students' answers in (a)(ii).
2) Alternative answer if students calculated based on combustion of 2 mols of pentane was accepted.
3) However, most students were only able to obtain partial marks.

Common mistakes:

1. Students were unable to recall the correct formula and used total energy

released for bond formation – total energy required for bond breaking instead

2. For formation of H_2O and CO_2, some students did not recognise that there are 2 O-H or 2 C=O bonds to be broken in each molecule respectively.
3. Students did not calculate according to ratio of reactants and products based on balanced chemical equation

(iii) Suggest a reason to account for the difference in enthalpy change of combustion of pentene and cyclopentane. **[2]**

During combustion of pentene, **1 carbon-to-carbon double bond (-C=C-) and 3 carbon-to-carbon single bonds (-C-C-)** were broken while during combustion of cyclopentane, **5 carbon-to-carbon single bonds (-C-C-)** were broken. This would result in **different amount of energy required** to **break the bonds** in both pentene and cyclopentane.

[1] – identifying that the 2 processes requires the breaking of different type of bonds i.e. carbon-to-carbon double bond (-C=C-) in pentane while cyclopentane requires the breaking of carbon-to-carbon single bonds (-C-C-)

[1] – different amount of energy required for breaking of bonds ***{reject: larger amount of energy required to break bonds in pentene when enthalpy change of combustion of pentene is more negative than that of cyclopentane}***

Explanations:

$\Delta H_{combustion}$ of pentene

$$= \{1\ (C{=}C) + 3\ (C{-}C) + 10\ (C{-}H) + \frac{15}{2}(O{=}O)\} - \{5[2\ (O{-}H)] + 5[2\ (C{=}O)]\}$$

$\Delta H_{combustion}$ of cyclopentane

$$= \{5\ (C{-}C) + 10\ (C{-}H) + \frac{15}{2}(O{=}O)\} - \{5[2\ (O{-}H)] + 5[2\ (C{=}O)]\}$$

General Comments:

1) Question was not well-attempted.

Common mistakes:

1. Students generally assumed that having to break –C=C– bond will require more energy to break. However, students failed to recognise that they should be looking at **OVERALL** energy required to break the bonds. Hence, they need to consider the energy required to break **ALL** the bonds instead of just looking at individual bonds to be broken.
2) Students did not study the two enthalpy change values closely to help craft their answers i.e. enthalpy change of combustion pentene is more negative than that of cyclopentane, which means that more energy is released for the combustion of pentene. Hence, it is wrong for students to say that combustion of pentene requires more energy to break the bonds than the combustion of cyclopentane.

(b) A student made this statement when asked about the relationship between pentene and cyclopentene:

"Both pentene and cyclopentene belongs to the same ***homologous series*** *as they both contain the carbon-to-carbon double bond functional group."*

(i) Define the term '***homologous series***'. **[1]**

Homologous series refers to a group of compounds that **shares the same general formula**, contains the **same functional group** [1], exhibits similar chemical properties and shows a gradual change in physical properties.

(ii) Do you agree with the student's statement? Explain your answer, using information from the provided in the table. **[2]**

No. Although both pentene and cyclopentene have the same functional group, they **do not have the same general formula** [1]. Pentene have a **general formula of C_nH_{2n}** [1] while **(cyclopentene have a general formula of C_nH_{2n-2}).**

3(✓): 2m ; 1 – 2(✓): 1m; 0 (✓): 0m

Common mistakes:

1) Some students had the misconception that having the same functional group will mean that the compounds are in the same homologous series. These students do not have a complete understanding of the definition of ***"homologous series".***
2) Students also had the misconception that being in the same homologous series will mean that the compounds will have the same empirical formula. Students need to note that this is only true for alkenes and hence not universally applied to all homologous series.
3) Students also need to note that the general formula of organic compounds in a homologous series need to follow the format of "C_nH_{2n}...", derived with reference to alkanes. Hence, it is wrong to conclude that the general formula of cyclopentene is C_nH_{n+3}.

[Total: 12 marks]

(a) In an experiment, small amounts of three transition metals, zinc, chromium and copper, were added to separately to their metal nitrates solutions.

The results of the reactions with zinc and copper are shown in the table.

	Aqueous zinc nitrate	**Aqueous nickel(II) nitrate**	**Aqueous copper(II) nitrate**
Zinc		Green solution turned colourless and grey metal coated with a silvery solid	Blue solution turned colourless and grey metal coated with a grey solid
Copper	No visible reaction	No visible reaction	

(i) Describe the observations expected when nickel is added to aqueous zinc nitrate and aqueous copper(II) nitrate. **[2]**

	Aqueous zinc nitrate	**Aqueous copper(II) nitrate**
Nickel	**No visible reaction (✓)**	**Blue solution turned green (✓)** Grey metal coated with **pink/ reddish-brown solid (✓)**

3 (✓): 2m; 1 – 2 (✓): 1m

General Comments:
1) Question was not well-attempted.

Common mistakes:
1. Although most students were able to conclude that a reaction will occur between nickel and copper(II) nitrate, many were unable to infer the colour of resulting nickel(II) nitrate solution from the information provided.
2. Students also were unable to state the colour of copper solid correctly

(ii) Give the ionic equation, with state symbols, for the reaction between zinc and aqueous copper(II) nitrate. **[1]**

$Zn\ (s) + Cu^{2+}\ (aq) \rightarrow Zn^{2+}\ (aq) + Cu\ (s)$

General Comments:
1) Generally quite well-attempted.
2) A small group of students mistook oxidation state of Zn as +1

(iii) In terms of oxidation state, explain why the reaction is a redox reaction. **[2]**

Zn has been oxidised as its oxidation state has increased from 0 (in Zn) to +2 (in Zn^{2+}).

Cu has been reduced as its oxidation state has decreased from +2 (in Cu^{2+}) tp 0 (in Cu).

General Comments:
There are still students who are writing oxidation states as "2+" instead of "+2".

(b) Hydrated nickel(II) nitrate, $Ni(NO_3)_2.6H_2O$, can be produced by reacting excess nickel(II) carbonate with dilute nitric acid. The resulting mixture is then filtered and heated to saturation. Green nickel(II) nitrate crystals can be obtained by allowing the saturated solution to cool at room temperature.

(i) Explain why it is necessary to add nickel(II) carbonate in excess to dilute nitric acid. **[1]**

Excess nickel(II) carbonate is added to ensure that the **dilute nitric acid reacts completely** [1] and pure nickel(II) nitrate is obtained as filtrate.

General comments:
Half the cohort answered this correctly.

Common mistakes:

1. Excess $NiCO_3$ to ensure **all** $NiCO_3$ reacts with nitric acid.
2. Ensure complete reaction (Is there incomplete reaction if $NiCO_3$ not added in excess?)
3. Ensure that a saturated solution is obtained.

(ii) Explain why the nickel(II) nitrate crystals were obtained by allowing the saturated solution to cool at room temperature instead of heating to dryness. **[1]**

If the solution is heated to dryness, **anhydrous nickel(II) nitrate will be obtained** instead.

General comment:
Many students gave their answer as heating to dryness may lead to decomposition of $Ni(NO_3)_2$. However, the question has mentioned that the crystal to be obtained is hydrated $Ni(NO_3)_2$. Based on this information, only the formation of anhydrous salt is accepted.

Common mistakes:

1. If heated to dryness, $Ni(NO_3)_2$ will evaporate and lesser crystals will be collected.

(ii) 25.0 cm^3 of 1.00 mol/dm^3 dilute hydrochloric acid was reacted with excess nickel(II) carbonate in an experiment to produce hydrated nickel(II) nitrate. **[3]**

Given that 2 moles of hydrochloric acid is required to react to produce 1 mole of hydrated nickel(II) nitrate, calculate the percentage yield if 5.00 g of hydrated nickel(II) nitrate crystals were obtained at the end of the reaction.

No. of moles of HCl added = $\frac{25.0}{1000} \times 1.00 = 0.0250$ mol **[1]**

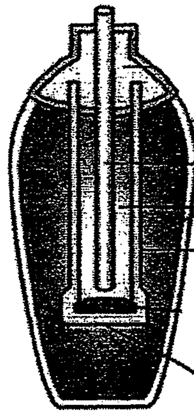
No. of moles of nickel(II) nitrate produced = $0.0250 \times 2 = 0.0125$ mol

Mass of nickel(II) nitrate = 0.0125 x [28 + 2(14) +6(16) + 6(18)] = 3.6375 g **[1]**

Common mistake:
Students used Mr of $Ni(NO_3)_2$ used instead of Mr of hydrated $Ni(NO_3)_2.6H_2O$

(a) During 500 B.C., a clay jar with an iron rod placed inside a copper cylinder was used to generate electricity. The clay jar was filled with vinegar solution.

The diagram below shows a simplified representation of the clay jar used.



(i) Which metal acts as the negative electrode in this electric cell? Explain your answer. **[2]**

Iron rod [1] acts as the negative electrode as it is the **more reactive metal**, hence **loses electrons/ gets oxidised more easily** [1] than copper.

General Comments:

1) Generally quite well-attempted.
2) However, there are a group of students who have mixed up electric cell with electrolysis, thinking that the negative electrode is the one that gets reduced.

(ii) Bubbles of gas are observed at the copper electrode. **[2]**
With a suitable ionic half-equation, with state symbols, explain the formation of this gas.

Hydrogen gas is produced. **[1]**.

It will **extinguish a lighted splint with a 'pop' sound.** [1m]

General Comments:

1) Generally quite well-attempted.

(b) A methanol fuel cell is a modern version of an electric cell. Electrical energy is produced from a reaction between methanol and oxygen.

The following ionic half-equations show the reaction that takes place at the respective electrodes:

Anode: $CH_3OH\ (aq) + H_2O\ (l) \rightarrow 6H^+\ (aq) + CO_2\ (g) + 6e^-$

Cathode: $O_2\ (g) + 4H^+\ (aq) + 4e^- \rightarrow 2H_2O\ (l)$

(i) Give the overall equation, with state symbols, for the reaction that takes place in the methanol fuel cell. **[1]**

<u>$2CH_3OH\ (aq) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 4H_2O\ (l)$</u> [1m; with state symbols]

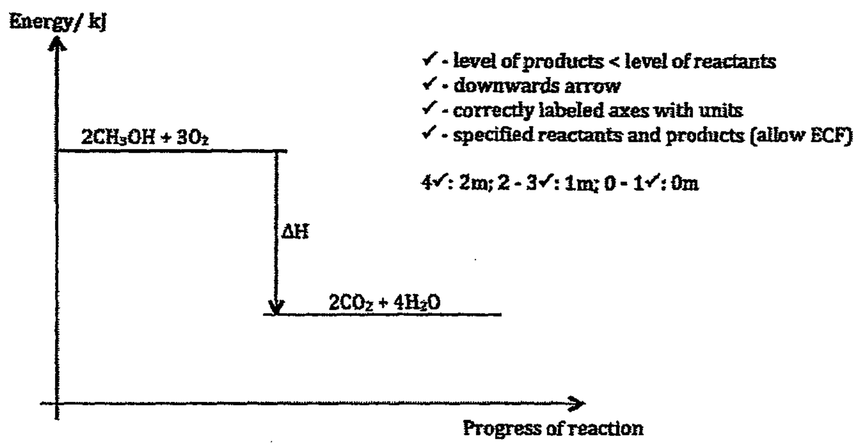
<u>General Comments:</u>

1) Not very well-attempted.

<u>Common mistakes:</u>

1. For students who managed to combine both equations correctly, they did not manage to simplify the equation, leaving H_2O at both sides of equation i.e. $2CH_3OH\ (aq) + 2\ H_2O\ (l) + 3O_2\ (g) \rightarrow 2CO_2\ (g) + 6H_2O\ (l)$

(ii) Draw an energy level diagram for the overall reaction that occurred in the the methanol fuel cell. **[2]**



<u>General Comments:</u>

1) Not very well-attempted for a question that has been commonly practiced/ discussed.

<u>Common mistakes:</u>

1. A group of students were unable to recognise that the reaction is an exothermic reaction (combustion; fuel cell)
2. Students were unable to score full marks for the question as marking points such as correct labelled axes with units etc were missing
3. Many students incorrectly labelled x-axis as time instead of progress of reaction

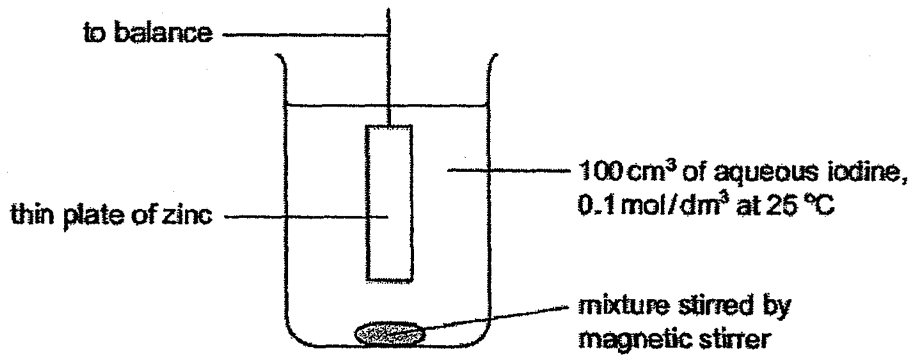
(iii) State one possible effect on the environment that may result from the use of the methanol fuel cell. **[1]**

Carbon dioxide gas produced will result in **<u>global warming</u>**, leading to **<u>flooding of low-lying areas due to rising sea levels</u> [1m; or other effects of global warming]**

<u>General Comments:</u>

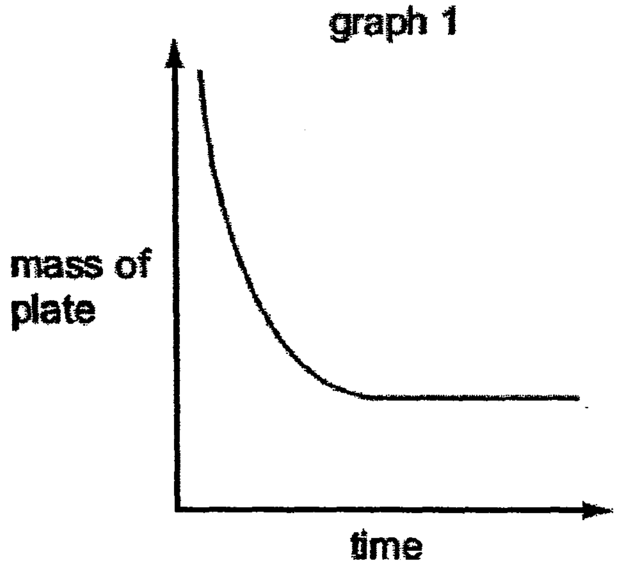
1) Not very well-attempted.
2) Students did not elaborate on the effect of global warming – which is a key point when answering related questions.

Zinc reacts with aqueous iodine to form zinc iodide. The following apparatus was used to measure the rate of the reaction between zinc and aqueous iodine at 25 °C.



The mass of the zinc plate was measured every minute until the reaction was complete.

(a) From the results obtained, graph 1 (below) was obtained.



(a) With reference to graph 1, deduce the reagent that was used in excess. **[1]**
<u>Zinc</u>

(b) **(i)** The experiment was repeated with 100 cm^3 of 0.05 mol/dm^3 iodine and keeping all other conditions the same. Sketch the curve that would be obtained on graph 1 and label it '**X**'. **[1]**

(ii) Explain the shape of the graph obtained in **(b)(i)**. **[2]**
Gradient is less steep as the **<u>concentration of iodine is lower</u>**, resulting in a **<u>slower speed of reaction</u>** [1].

Half the amount of zinc reacted since only **<u>half the amount of the limiting reagent</u>** [1], iodine is present.

The Periodic Table of the Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										4 He helium 2
7 Li lithium 3	9 Be beryllium 4											11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	64 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	– Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La lanthanum 57 *	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	– Po polonium 84	– At astatine 85	– Rn radon 86
– Fr francium 87	– Ra radium 88	– Ac actinium 89 †															

*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	– Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	162 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	– Pa protactinium 91	238 U uranium 92	– Np neptunium 93	– Pu plutonium 94	– Am americium 95	– Cm curium 96	– Bk berkelium 97	– Cf californium 98	– Es einsteinium 99	– Fm fermium 100	– Md mendelevium 101	– No nobelium 102	– Lr lawrencium 103

Key: a / X / b

a = relative atomic mass

X = atomic symbol

b = proton (atomic) number

General Comments:

1) Badly attempted.

Common mistakes:

1. Large majority of the students focused on explaining why the speed of reaction is slower in terms of collision theory, which was not required in question. Hence, students did not explain the 2nd marking point on the effect of changing the quantity of limiting reagent, iodine.
2. Some students assumed that changing concentration of reagent will result in changing the amount of reagent. This is not true. The no of moles of I_2 will be the same as experiment 1 if 200 cm^3 of 0.05 mol/dm^3 of solution is used instead.

(c) Explain, in terms of collision theory, the effect on the speed of reaction if the experiment was repeated at 15 °C with all other conditions kept constant. **[2]**

At 15 °C, the particles have **lower kinetic energy** (✓). Hence, **less particles have energy greater or equal to the activation energy** (✓). The **frequency of effective collisions between particles decreases** (✓). Hence, **speed of reaction is slower** (✓).

4(✓): 2m; 1 - 3(✓): 1m

(d) Describe and explain what would be observed if aqueous chlorine was bubbled into the resulting zinc iodide solution obtained. **[2]**

The **colourless zinc iodide solution will turn brown** [1].

Chlorine displaces the iodine from iodide solution as **chlorine is more reactive** [1].

Common mistakes:

1) Students mistook the colour of aqueous iodine as reddish-brown or purple.
2) Some stated that iodine vapour will be formed. However, as iodine is soluble in water and exists as solid state in room temperature, it will most likely form as aqueous iodine.
3) Many students are still not stating the original colour of solution when describing colour change.

[Total: 8 marks]

☺ End of Paper ☺