GCE 'O' Level Examinations 2020 Chemistry 6092

Paper 2

1	(a)	(i)	calcium hydroxide					
		(ii)	hydrogen and iron	1				
		(iii)	argon / graphite	<mark>1</mark>				
		(iv)	ethanol	1				
		(v)	graphite	1				
	6. 5	(vi)	graphite and hydrogen	1				
	(b)		true	2				
			true					
2	(a)		The temperature in the car anging is yery high and nitrogen and exugen					
~	(4)		molecules gain kinetic energy and move faster.					
			The frequency of collisions increases Mark 11					
			The <u>frequency of collisions increases</u> . More nitrogen and oxygen					
			frequency of effective collisions increases					
			requency of effective comsions increases.					
			For a reaction to take place, the reactant particles must collide with					
			energy that is equal to or greater than the activation energy. At room					
			temperature, the molecules do not have sufficient energy that is equal to					
			or greater than the activation energy, hence, there is no reaction at room					
	(1-)		temperature.					
	(b)	(1)	Equation 1: $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$					
		(ii)	Equation 2. $4\text{INO}_2(g) + 2\Pi_2\text{O}(I) + O_2 \rightarrow 4\text{HINO}_3(aq)$ Sulfur dioxide					
		(")						
3	(2)							
5	(a)		delocalised electron anion					
			(+)(+)(+)(+)(+)					
			(+) $(+)$					
			(-) (-) (-) (-) (-) (-) (-) (-) (-) (-)					
			cation					
	(b)		In metals, the sea of electrons are <u>delocalised and are free to move about</u>	1				
			/ mobile around the positive ions.					
			In ionic compounds, they are able to conduct electricity only in molton or	1				
			aqueous states. Both positively charged cations and negatively charged	'				
			anions are free to move about in molten and aqueous state and act as					
			charged carriers.					
			<u>onargoa oamoro</u> .					

	(c)	(i)	Mild steel is an alloy of iron with carbon atoms. Iron and carbon atoms1are of different sizes.1The regular arrangement of atoms in the pure iron is disrupted with the inclusion of carbon atoms. The layers of atoms cannot slide other easily when the force is applied.1As a result, mild steel is stronger than pure iron.1				
		(ii)	 With reference to the diagram, the size of an iron atom is smaller than the size of a carbon atom. However, this is not accurate as the atomic radius of an iron atom (0.126 nm) is larger than the atomic radius of a carbon atom (0.077 nm). Mild steel is an alloy consisting of iron (99%), carbon (0.25%) and manganese (0.4%) atoms. However, manganese atoms are absent in the diagram. With reference to the diagram, the proportion / percentage of iron atoms (24 atoms) to carbon atoms (4 atoms) is much lesser/lower, which is not an accurate representation of the ratio 99 : 0.25. 	2			
_							
4	(a)		An electrolytic cell is being set up. The <u>anode will be the tin metal</u> and is connected to the positive terminal of the battery. The <u>cathode will be the iron can</u> and is connected to the negative terminal of the battery. Both anode and cathode are placed in an electrolyte which is the <u>aqueous tin(II) nitrate solution</u> .	1 1 1			
	(b)		$Sn(s) + 2 H^+ (aq) \rightarrow Sn^{2+} (aq) + H_2 (g)$	2			
			1 mark – correct ionic equation. 1 mark – correct state symbol				
	(c)	(i)	Poly(ethene) will not corrode and produce toxic substances so that it is safer for consumers to use.	1			
		(ii)	Macromolecule – A <u>very large molecule</u> that are made up of many atoms joined <u>together by covalent bonds</u> .	1			
			Addition polymerisation – A process where <u>many unsaturated monomers</u> join together to form a <u>single large molecule</u> , without losing any <u>molecules or atoms</u> .	1			

5	(a)		Carbon dioxide has a <u>simple molecular structure</u> while silicon dioxide has a <u>giant molecular structure</u> .					
			The <u>weak intermolecular forces of attraction</u> between carbon dioxide molecules can be easily overcome by <u>small amount of energy</u> .	1				
			In silicon dioxide, there are a <u>network of strong covalent bonds between</u> <u>silicon and oxygen atoms</u> in a three-dimensional structure of silicon dioxide. As <u>a lot of energy is required to break</u> strong covalent bonds between the atoms,	1				
			Hence carbon dioxide has <u>low melting and boiling points</u> while silicon 1 dioxide has a <u>high melting and boiling points</u> .					
	(b)		Acidic oxide $- CO_2 / NO_2 / P_2O_5 / SO_2 / SiO_2$ 1Basic oxide $- Li_2O / Na_2O / MgO$ 1					
	(c)	(i)	MgO Mg O 1 mark – correct electronic configuration and number of cations (Mg) 1 mark – correct electronic configuration and number of anions (O) 0 ₂ 0 0	2				
			1 mark – correct number of bonding electrons 1 mark – correct number of electrons not involved in bonding					
		(ii)	In MgO,					
			A magnesium atom <u>loses two outer electrons</u> to an oxygen atom to form 1 Mg ²⁺ and O ²⁻ . The magnesium cations and oxide anions are held by <u>strong electrostatic forces of attraction</u> .					
			In O_2 , Each oxygen atom <u>shares two of its outer electrons</u> with another oxygen atom. A double covalent bond is formed between the oxygen atoms within the molecule.	1				

6	(a)		$2M + H_2 \rightarrow 2MH$	1
	(b)	(i)	Number of moles of LiH = $8.0g / (7 + 1) = 1$ mol Number of moles of NaH = $24.0g / (23+1) = 1$ mol Number of moles of KH = $40.0g / (39+1) = 1$ mol Although the mass of metal hydride produced increases as we go down the group, the <u>number of moles of metal hydride produced from 1 g of</u> bydrogen remains the same. Hence Beth is correct and lean is wrong	1
		(ii)	No. of moles of $H_2 = 1/(1 + 1) = 0.5$ mol No. of moles of RbH = 2 x 0.5 = 1 mol Mass of RbH = 1 x (85 + 1) = 86.0 g	1
			Mass of RbH depends on the molar mass of the substance, hence 86.0 g of rubidium hydride should be produced instead of 56.0 g. Hence Ryan is incorrect.	1
	(c)		Potassium reacts even <u>more violently</u> with hydrogen. The <u>metal glows</u> <u>more brightly</u> and more heat is produced. As we go down Group I, the size of the atom increases. It is easier to lose the valence electron as it is further away from the nucleus. Hence, reactivity increases down Group I. <u>Potassium is more reactive</u> <u>than sodium as potassium has a higher tendency to lose electrons than</u> <u>sodium.</u>	1
	(d)		Oxidation state of oxygen decreases from 0 in O_2 to -2 in H_2O . Thus, oxygen is reduced.	1
			Oxidation state of sodium increases from 0 in Na to +1 in NaH. Thus, sodium is oxidised.	1

7	(a)		From Table 7.1, 30g of sodium chloride can dissolve in 100 cm ³ . 100 cm ³ \rightarrow 30g					
			1 dm ³ \rightarrow 30 × 10 = 300g In 1 dm ³ of water, mass of sodium chloride that can be dissolved is 300g.					
			Moles of sodium chloride in 1 dm ³ of water = <mark>300</mark> / (23+35.5) = 300 / 58.5 = 5.13 mol	1				
			Moles of sodium chloride = <mark>399</mark> / 58.5 = 6.82 mol (range of answers 5.13 to 6.82 mol)					
	(b)		Similarities: 1. Both salts have the same freezing point of -20 °C when 20g of salts is added respectively.	3				
			2. For the first 20g of salts added, the freezing point decreases.					
			<u>Differences:</u> 1. When 40g of CaCl ₂ is added to the water, it increases the freezing point to $+12^{\circ}$ C from -45° C. Whereas when 40g of NaCl is added, it is not fully dissolved.					
			2. CaCl ₂ has the lower possible freezing point, -45° C, when it is added to water compared to NaCl, -20° C.					
			3. After 20g of salts added, the freezing point with the addition of sodium chloride increases from -20 to -15 °C, while the freezing point with the addition of calcium chloride continues to decrease from -20 to -45 °C.					
	(c)		The <u>enthalpy change of solution</u> , ΔH_{sol} , is negative for both <u>CaCl₂ and</u> <u>MgCl₂</u> . This means that the dissolution of the salts in water is a exothermic reaction and the <u>heat energy released helps to melt</u> the solid ice.					
			Both $\underline{\text{CaCl}_2}$ and $\underline{\text{MgCl}_2}$ are also <u>hygroscopic</u> , which attracts water vapour from the air and <u>uses it to form a solution</u> on the surface of the ice, which allows the de-icers to dissolve					
	(d)	(i)		3				
			energy $\begin{array}{ c c } \hline CH_4N_2O(aq) & energy \\ \hline CH_4N_2O(s) & \Delta H_{sol} = +15.0 \text{ kJ/mol} \\ \hline \end{array} \\ \hline \begin{array}{ c } \hline CaCl_2(s) & & \\ \hline \\ \hline CaCl_2(aq) & & \\ \hline \end{array} \\ \hline \end{array} \\ \hline \end{array}$					
			Progress of reaction Progress of reaction					
			1 mark – shape of graph, with energy level of products higher than reactants in urea energy level diagram with correctly labelled products.					

	(e)	(ii)	 1 mark – shape of graph, with energy level of products lower than reactants in calcium chloride energy level diagram with correctly labelled products. 1 mark – correctly labelled enthalpy change (+15.0 kJ/mol) for urea and (-82.9 kJ/mol) for calcium chloride. Urea has low toxicity to plants as compared to calcium chloride which is harmful to plants. Chloride ions. From Table 7.3, compounds like <u>NaCl, CaCl₂, MgCl₂ and KCl</u> contain chloride ions and are harmful to plants as they <u>speed up corrosion of</u> 		
			chloride ions and has low toxicity.		
0	(0)		Some value of Mr (99)	1	
Ö	(a)	(1)			
			Functional group: carboxyl group $ \begin{array}{c} H & H & H & 0 \\ 1 & 1 & 1 & H \\ H & -C - C - C - C - O - H \\ 1 & 1 & 1 \\ H & H & H \end{array} $ Isomer Y Functional group: carboxyl group $ \begin{array}{c} H & H & 0 \\ H & -C - C - C - O - H \\ H & -C - C - O - C - H \\ H & H & H \end{array} $ Isomer Z Functional group: ester linkage group $ \begin{array}{c} H & H & 0 \\ H & H & 0 \\ H & -C - C - C - O - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - C - O - C - H \\ H & -C - C - O - C - C - H \\ H & -C - C - O - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - H \\ H & -C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - C - C - C - C - H \\ H & -C - $		
	(c)		Effervescence observed due to hydrogen in solutions of both isomers due to hydrogen gas [1]. The overall rate of reaction is the same for both isomers, with the highest at the start of the experiment and decreased with time as the concentration decreases.	1	

9	Either			
	(a)		In Table 9.2, the atomic radius of carbon in the largest, followed by oxygen then hydrogen. However in the ball and stick model, all the atoms in the model have the same size which is incorrect. Carbon and oxygen atoms should be larger than hydrogen atoms.	1
			In Table 9.1, the bond length of C-C is the longest, followed by C-O, then C-H and finally O-H. However, the 'dot and cross' diagram and the ball and stick model do not represent the length of bond correctly. Bond length cannot be interpreted in the 'dot and cross' diagram.	1
			The ball and stick model, on the other hand, has all the bond lengths to be about the same, although Table 9.1 clearly shows that the bond lengths are different and C-C bond is the longest.	1
	(b)	(i)	C_2H_5OH / C_2H_6O	1
		(ii)	Both formulae show the simplest ratio of the carbon, hydrogen and oxygen atoms in the compound. The molecular formula cannot be simplified further.	1
	(c)	(i)	Number of moles of ethene = 1000/24 = 41.667mol Theoretical mole of ethanol formed = 41.667 mol	1
			Actual mole of ethanol formed = $5/100 \times 41.667$ = 2.083 mol	1
			Mass of ethanol formed	1
			= 95.8 g	1
		(ii)	Ethene can be reused by placing the unreacted ethene back into the reactor to produce more ethanol.	1

9	OR			
	(a)	(i)	Mr of $(NH_4)_2SO_4 = 132$ Mr of $CaCO_3 = 100$	1
			Atom economy = [132 / (132 + 100)] × 100% = 56.9%	1
		(ii)	Ammonium sulfate is the <u>only product</u> in process 1. Hence atom economy is 100%.	1
			carbonate and <u>calcium carbonate is not a useful product</u> . Hence, the atom economy is lower (>50%).	1
	(b)		Number of moles of ammonia = 1000/24 = 41.667 mol	1
			Number of moles of sulfuric acid = $41.667 \div 2$ = 20.83 mol	1
			Mass of sulfuric acid = [2+32+4×16] × 20.83 = 2041.34 g ≈ 2040 g	1
	(c)	(i)	<u>Filter the mixture. The residue will be calcium carbonate</u> and the <u>filtrate</u> is the ammonium sulfate solution. <u>Heat</u> the solution until it is <u>saturated</u> .	1
			Allow the mixture to <u>cool to form crystals</u> . <u>Filter</u> to collect crystals as residue. Wash the <u>crystals with little, cold distilled water</u> . <u>Dry the</u> <u>crystals</u> between sheets of filter papers.	1
		(ii)	There are more reactants used in process 2 than process 1. Furthermore, <u>calcium sulfate, an insoluble salt</u> , may be formed which will lower the yield further.	1

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Suggested Answers

Paper 2

1	(a)		D, G	1
	(b)		A, E	1
	(c)		C	1
	(d)		G	1
	(e)		A	1
2	(a)		Isotope 1, 2 and 3 are atoms of the same element having the same	
	()		number of protons and electrons (16) but different number of neutrons.	1
			13. 14 and 15 respectively.	1
	(1.)		There have the server number of values as a lestrone (0). Others the share is a	
	(a)		I ney nave the same number of valence electrons (6). Since the <u>chemical</u>	1
			properties are dependent on the number of valence electrons, they will	
	(-)	(1)	nave the same chemical reactions.	
	(C)	(1)	X - sulfur	1
			Y - oxygen	
		(::)	Z - ZINC	4
		(11)	Lowest meiting point - Y	1
			A Highest malting point 7	
			Highest melling point - 2	
			Zing has a gight matellin structure. Honor, the largest amount of operativ	
			Line has a giant metallic structure. Hence, the largest amount of energy	1
			Is required to overcome the strong electrostatic forces of attraction to	
			bleak the metallic bonds, causing zinc to have the highest metaling point.	
			Both sulfur and avvidan have simple melocular/covalent structures	
			However, sulfur molecules have a stronger intermolecular forces of	1
			attraction than oxygen molecules, requiring more energy to overcome the	
			weak intermolecular forces of attraction than oxygen	
		(iii)	Ζ.	1
			Zinc is a <u>moderately reactive metal</u> that can react with acids to form salts	1
			and hydrogen gas only.	
3	(a)		Gold is an unreactive metal and it is below hydrogen in the reactivity	1
			series, hence it is <u>unable to react with acids to displace hydrogen</u> .	
			However, lead is above hydrogen in the reactivity series, it is able to react	1
			with acids to displace hydrogen	
	(b)		When reacted with lead compounds, dilute hydrochloric acid and sulfuric	
			acid form insoluble lead(II) chloride and lead(II) sulfate salts which coats	1
			the reactant and prevents further reaction from taking place.	
			All nitrate salts are soluble and hence can be separated from the gold	1
			easily, <u>via filtration</u> .	

	(c)	(i)	Only zinc ions can be identified because they form a white precipitate which is soluble in excess aqueous ammonia to give a colourless solution.					
			Both lead(II) and aluminium ions form a <u>white precipitate</u> which is insoluble in excess aqueous ammonia.	1				
		(ii)	Add sulfuric acid / any soluble sulfate salt / hydrochloric acid / any soluble chloride to solutions of each ion. Lead ions will form a <u>white precipitate</u> of lead(II) sulfate/chloride while aluminium ions will form <u>colourless</u> <u>solutions</u> .	1				
		(iii)	Add an equal volume of <u>aqueous sodium hydroxide</u> , followed by a piece <u>of aluminium foil to the nitrate solution</u> .	1				
			On gentle heating, <u>effervescence of gas produced</u> which turns <u>damp/moist red litmus paper blue</u> . Gas produced is ammonia.	1 1				
4	(a)		$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)/$	2				
			$NH_{3} (g) + HCl (g) \rightleftharpoons NH_{4}Cl (s)$ $1 \text{ mark} - \text{balanced chemical equation}$ $1 \text{ mark} - \text{correct state symbols}$					
	(b)	(i)	Mr of NH ₃ : <u>17</u> 1 Mr of HCl: <u>36.5</u>					
		(ii)	Yes. For the same period of time, ammonia with a <u>lower relative</u> <u>molecular of 17, travelled a further distance of 60 cm, while hydrogen</u> <u>chloride with a higher relative molecular mass of 36.5, travelled a shorter</u> <u>distance of 40 cm</u> , indicating that the rate of diffusion is inversely proportional to the relative molecular mass.					
			When the relative molecular mass <u>increases by about twice, the distance</u> travelled decreases by about half.	1				
	(c)		Similarity: The white ring forms at the <u>same place/position</u> in the tube.	1				
			Difference: The <u>white ring takes a shorter time to form</u> in Experiment A as compared to experiment B.	1				
_								
5	(a)		presence of hydroxide ions produced in NaOH formed in water.	1				
			experiment using sulfur: Solution of <u>red litmus remains</u> due to the <u>presence of hydrogen ions</u> produced from the <u>acidic oxide/sulfurous</u> 1 <u>oxide ionised in water</u> .					
	(b)		$\begin{bmatrix} \bullet \bullet$	2				

	(c)	(i)	Chemical equation: 4Na	$+ O_2 \rightarrow 2Na_2O$		
			No of mol of Na = $=\frac{0.56}{23}$	$\frac{0}{2} = 0.021739$ [1]		1
			No. of mol of Na ₂ O = $\frac{0.0}{100}$	$\frac{021739}{2} = 0.0108695$		
			Mass of Na ₂ O $= 0.010$	$8695 \times (2 \times 23 + 16)$	= 0.674 g (3 s.f.) [1]	1
		(ii)	Mass of Na ₂ O $= 94.82 -$	94.50 = 0.32g		1
			Percentage yield $=\frac{0.32}{0.67}$	$\frac{2}{4} \times 100 = 47.5\%$		1
		(iii)	The 0.50 g of sodium used could be <u>impure</u> , which will lead to a calculated theoretical yield that is lower than expected.			
6	(-)		Magnapium in more reactive then iron and acts as a conficial match			
O	(a)		Magnesium is more reactive than iron and acts as a sacrificial metal, which will corrode in place of iron. Mg \rightarrow Mg ²⁺ + 2e ⁻			
	(b)	(i)	Oil and paint acts as a <u>protective barrier</u> that prevents <u>oxygen and water</u> , which are essential conditions for rusting, in the atmosphere/ soil from <u>coming into contact with iron</u> .			
		(ii)	They are not permanent sealants, with <u>wear and tear</u> after a long period of time, oil can <u>seap into the soil/washed away</u> and paint may crack. This results in the pipes <u>exposed to oxygen and water</u> , causing rusting.			
7	(a)		Difference in voltages is	due to the <u>difference in</u>	reactivity of the metals.	1
			The further apart the metals in terms of reactivity, <u>the greater the tendency to lose electrons by the more reactive metal</u> , generating a <u>higher voltage</u> .			
	(b)				· · · · · · · · · · · · · · · · · · ·	2
			metal 1	metal 2	predicted voltage / V	
			silver	magnesium	1 75 (1 57 to 4 00)	
				magnesium	1.73 (1.57 to 4.00)	

8	(a)		It is a negatively charged ion with an oxygen atom in it.					
	(b)	(i)	$\begin{array}{l} NH_2Cl + NaOCl \rightarrow NHCl_2 + NaOH \\ NHCl_2 + NaOCl \rightarrow NCl_3 + NaOH \end{array}$	1				
		(ii)	The oxidation state of N is -1 in NH ₂ C <i>l</i> . The oxidation state of N is $+1$ in NHC <i>l</i> ₂ .	1 1				
			The oxidation state of N is +3 in NCl ₃ .					
			Hence, NaOC <i>l</i> acts as an oxidising agent in all three equations as it oxidises the nitrogen compounds, with oxidation state of N increasing from -1 in NH ₂ C <i>l</i> to $+1$ in NHC <i>l</i> ₂ to $+3$ in NC <i>l</i> ₃ .					
	(c)		∠ ★★★ → - Legend:	2				
			Electron of CI					
			Electron of O					
			Electron from another atom					
			1 – correct number of shared electrons and charge					
	(1)		1 – correct number of non-bonded electrons					
	(a)		$\frac{11}{10} \text{ of } C_1(C) = 35.5 + 16 = 51.5$					
			Mr of NaClO = $23 + 51.5 = 74.5$	1				
			Percentage by mass of CIO in Ca(CIO) ₂					
			$=\frac{2\times51.5}{\times100\%}$	1				
			143					
			= 72.0%					
			Percentage by mass of C/O in NaC/O					
			51.5					
			$=\frac{710}{745} \times 100\%$					
			= 69.1%					
	(e)		CaO ₂	1				
	(f)		Hydrogen peroxide bleaches break down compounds and produce	1				
	(.)		water, which is harmless but hypochlorite bleaches can react with	•				
			ammonia in human waste to form compounds of nitrogen and chlorine,					
			that are toxic and irritating, as well as NaOH which is a strong alkali					
			that is corrosive.					
9	(a)		Stage 2: Carbon monoxide gas molecules adsorb onto the surface of the catalyst.	1				
			Stage 3: Oxygen atom reacts with carbon monoxide gas on the catalyst surface and oxygen-carbon-oxygen double bonds of carbon dioxide are formed.	1				
				1				
			Stage 4: The adsorbed molecules of CO_2 gas detach and are released from the surface of the catalyst to form gaseous CO_2 .					

	(b)				3
			re [0] represents an oxygen atom "om an oxidising agent.	rπ	
			nergy Henergy	legend	
			Eat Depend HEat OF	AH: enthalpy	
			$H = \left(\frac{O_2 + 2CO}{2} \right) = \left(\frac{O_2 + 2CO}{2} \right)$	Ea = activation	
			ethanal ethanal ethanal ethanalcacit	energy	
			Variation of the section of the sec	2002	
			program in the second program in the second program in the program of the second		
			progress of reaction	121	
			Shad ross (reaction without catalyst		
			1 – general shape of graph, with energy level of products I	lower than	
			1 – correctly labelled activation energy, enthalpy change a	and products	
			1 - higher activation energy for reaction with catalyst as co	ompared to	
			reaction without catalyst		
	(c)		The catalyst provides an <u>alternative pathway which</u>	has a lower	1
			activation energy. Hence, more particles have energy eque	trequency of	1
			effective collisions to increase, and increasing the rate of r	reaction.	
10	EITH	IER			
	(a)		Acidified potassium manganate (VII) / atmospheric oxyge	'n	2
	(b)	(i)			2
			Name of alcohols carboxylic acids		
			Name of propagol propagoic acid		
			series Name of third propanol		
			series Name of third member		
			series propanol Name of third propanol member propanoic acid Displayed H H H		
			series propanol Name of third propanol member propanoic acid Displayed H H H formula of H - C - C - C - C - H H - C - C - C - C - C - C - C - C - C -		
			series propanol Name of third propanol third propanoic acid Displayed H formula of I H H		
			seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of thirdH H H I I I H H C - C - C - C - O - H H H HH H O H - C - C - C - C - C - C - C - H H H O	-H	
		(ii)	seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of third memberHHH	-H	
		(ii)	series propanol propanoic acid Name of third propanol propanoic acid member Displayed H H H O Displayed H H H H O H H H O H H H H O H	-H	1
		(ii)	seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of third memberHH	-H	1
	(c)	(ii) (i)	seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of 	-H	1
	(c)	(ii) (i)	seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of 	-H	1
	(c)	(ii) (i) (ii)	seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of third memberH H H H - C - C - C - O - H 	-H	1 1 1 1 1 1 1
	(c)	(ii) (i) (ii)	series propanol propanoic acid Name of third propanol propanoic acid Displayed H H H formula of I I H third H - C - C - C - O - H H - C - C - C - C - C - H H - C - C - C - C - C - C - C - C - H member H - H + H H - C - C - C - C - C - C - H H - C - C - C - C - C - C - C - H H - C - C - C - C - C - C - H Member H + H + H H - C - C - C - C - C - C - H H - C - C - C - C - C - C - C - H H - C - C - C - C - C - C - C - H Member H + H + H H - H - H H - C - C - C - C - C - C - C - C - C -	-H	1 1 1 1 1
	(c) (d)	(ii) (i) (i) (i)	seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of third memberH H H H - C - C - C - O - H H H H HH H O H - C - C - C - C - C - C - C - C - C -	-H	1 1 1 1 1
	(c) (d)	(ii) (i) (i) (i)	seriespropanolpropanoic acidName of third memberpropanolpropanoic acidDisplayed formula of third memberHHHH - C - C - C - O - H H - HH - C - C - C - O - H H - C - C - C - C - C - C - C - C - C -	-H	1 1 1 1 1 1
	(c) (d)	(ii) (i) (i) (i)	seriespropanolpropanoic acidName of third memberpropanolpropanoic acidDisplayed formula of third memberHHHH - C - C - C - O - H H + HH - HHH - C - C - C - O - H H + HH - C - C - C - C - C - C - C - C - C -	-H	1 1 1 1 1 1 1 1
	(c) (d)	(ii) (i) (i) (i)	seriespropanolpropanoic acidName of third memberpropanoic acidDisplayed formula of third memberH H H H - C - C - C - O - H H - C - C - C - O - H H H HH H H H - C - C - C - C - C - H H - C - C - C - C - C - C - H H H H O - H - C - C - C - C - C - H H H O - H - C - C - C - C - C - H 	-H	1 1 1 1 1

10	OR							
	(a)		Isomers 1 and 2 a ionise to give a low Indicator to turn fro	re <u>weak acids</u> that concentration of <u>concentration</u> of <u>concentration</u>	contains the <u>carb</u> hydrogen ions, cau <u>//orange</u> .	<u>oxyl group</u> and will using the Universal	1 1	
			Isomer 3 is a neutral ester and the universal indicator will remain green.					
	(b)		H + C - O - H + H = O + H + O + H + O + H + O + H + O + H + O + H + H	l structures			3	
	(c)	(i)	Number of moles Mole ratio Empirical formula:	C $\frac{62.1}{12} = 5.175$ $\frac{5.175}{1.725} = 3$ C ₃ H ₆ O	$\frac{H}{\frac{10.3}{1}} = 10.3$ $\frac{10.3}{1.725} = 6$	$ \begin{array}{r} 0 \\ \frac{27.6}{16} = 1.725 \\ \frac{1.725}{1.725} = 1 \end{array} $	1 1 1	
		(ii)	$C_6H_{12}O_2$				1	

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Suggested Answers

Paper 2

1	(a)	(i)	carbon dioxide and ammonia						1	
		(ii)	silicon dioxide						1	
		(iii)	ammonia							1
		(iv)	lead(II) nitrate							1
		(v)	ammonia							1
	(b)									
								true	false	
			It is an amp	photeric c	xide				\checkmark	
			It is a poll	utant wh	ich leads to	the	e erosion of	\checkmark		
			buildings.					/		
				ed from ve	oicanoes.			v		
			It changes	the colo	ur of potass	ium	manganate		\checkmark	
			(VII) from	colouries	s to purple.]
2							product of	prov	huot of	2
2							reaction at	read	tion at	5
			substa	nce	electrode		nositive	nea	native	
							electrode	elec	ctrode	
			concent	rated			010001000			
			aqueo	DUS	carbon		chlorine	со	pper	
			copper(II)	chloride						
			concent	rated						
			aqueo	ous	copper	С	copper(II) ions	co	pper	
			copper(II)	sulfate						
			molten s	odium						
			chlor	ide	platinum		chlorine	SO	dium	
3			formula	for	mulae of					4
J			of salt	read	ents used		me	thod used		
			or suit				addition of e	excess soli	d to acid	
				<u>CuO(s)</u>	<u>/ Cu(OH)₂(s</u>	<u>s)</u>				
			CuC/ ₂ (s)	<u>/ (</u>	<u>;uCO₃(S)</u>		f	filtration		
				L						
							evaporation	and crysta	allisation	
				K	OH(aq)		<u>t</u>	itration		
			<u>KNO₃(s)</u>							
				Н	NO₃(aq)		evaporation	and crysta	allisation	
				Dh/						
				<u>רט(</u>	<u>103/2(ay)</u>		nre	cinitation		
			PbSO ₄ (s)	Ha	SO₄(aɑ) /					
				Na	SO4(aa) /		f	iltration		
				K ₂	SO₄(aq)		-			
	1	1	1							

4	(2)		Motale are made of a lattice of positive ione surrounded by 'coas of	1				
4	(a)		delocalised' electrons which are mobile and can act as charge carriers	I				
			when a potential difference is applied across the two ends of the metals					
			Ionic compounds, when in molten or in aqueous state, have mobile ions					
			which will move to the electrodes of opposite charges. Hence they act as					
			charge carriers.					
	(b)		Conduction of electricity has no effect on the chemical properties of the	1				
			metals while it changes the solutions of ionic compounds chemically by					
			forming new products / ionic compounds will decompose.					
5	(a)		density of pure gas at room	1				
	• •		gas temperature and pressure in percentage volume					
			g/dm ³ composition of dry air					
			helium 0.17 0					
			nitrogen 1.17 <u>78</u>					
			oxygen 1.33 <u>21</u>					
			argon <1					
	(b)	(i)	Helium has the lowest density of 0.17g/dm ³ and hence diffuse at a high	1				
			rate. Thus it will leave the atmosphere easily, making hard to recover.					
		(ii)	Density of argon = 40/24	1				
		• •	$= 1.67 \text{ g/dm}^3$					
		(iii)	Helium is an important resource used in the medical field and healthcare	1				
			industry like MRI scanners.					
			As such, the use of helium to fill party balloons will deplete the finite	1				
			resource of helium and there is greater value in the use of helium in the					
	(-)	(:)	<u>medical industry</u> than to be used than to be used for party balloon.	4				
	(C)	(1)		I				
			Helium nucleus contains					
			2 notons					
			27 neutrons	1				
			2 neutrons 22 neutrons	-				
		(ii)	Their atoms have completely filled valence shells. The electronic	1				
			structure of He and Ar are 2 and 2, 8, 8 respectively. Hence they are					
			chemically stable and do not gain, lose or share electrons to form	1				
			compounds.					

6	(a)		Stage 2 requires lesser energy because it requires a lower temperature of 450°C as compared to stage 1 of 800°C to maintain.	1
			Stage 2 also requires lesser energy because it is an exothermic reaction where <u>heat energy is released to the surroundings</u> , whereas stage 1 is an <u>endothermic reaction which absorbs more heat energy</u> from surroundings.	1
	(b)		Carbon monoxide is a toxic gas. It will combine with haemoglobin in our blood to reduce its ability to bind with oxygen to be transported around our bodies, leading to death.	1
			Carbon monoxide needs to be <u>burned to form carbon dioxide</u> which is not harmful.	1
	(c)	(i)	The stoichiometric mole ratio is 1:3. Every mole of nitrogen will react with 3 moles of hydrogen. Hence, based on Avogadro's law, the two gaseous reactants will react in the volume ratio of 1:3.	1
			The ratio of the relative molecular masses of the gases are not the same as the stoichiometric mole ratio.	1
		(ii)	Both gases have different relative molecular masses M_r of $N_2 = 28$ and M_r of $H_2 = 2$. Since mass is dependent on the molecular masses, the percentage by mass would be different.	1
			However, since the volume of 1 mole of gas is 24 dm ³ , the volume ratio would still be 1:3.	1
		(iii)	To conserve resources so that nitrogen and hydrogen will not be wasted by recycling them. Less raw materials need to be processed. This save cost and energy.	1
			Recycling the unreacted gases help to improve and maximise the yield of ammonia.	1
	(d)	(i)		2
			 Electrons of S Electrons of C X Electrons of H 	
			1m for bonding electrons 1m for non-bonding electrons	
		(ii)	It will slow down / slower speed of reaction or the reaction will stop.	1
7	(a)		Hydrogen and group I metal atoms have 1 valence electron. Both their atoms can lose 1 electron to form ions of charge of 1+.	1 1
	(b)		Hydrogen is a non-metal but group I elements are metals. Hydrogen exists as a gas at room temperature and pressure whereas all other Group I metals exists as solids.	2

		Hydrogen does not conduct electricity at room temperature and pressure whereas all other group I metals conduct electricity in any state. Hydrogen gain electrons to form hydride ions (H ⁻) whereas group I metal elements only cannot gain electrons to form negative ions. Hydrogen reacts with halogens by sharing electrons to form covalent compounds while group I elements can only lose electrons to form ionic compounds.	
 (-)	(1)		0
(C)	(1)	$Ag_2O(s) + H_2(g) \rightarrow ZAg(l) + H_2O(g)$	2
		Im for balanced equalion	
	<i>(</i>)	The for correct state symbols.	
	(11)	Silver in silver(I) oxide is reduced to silver as oxidation state of silver decreases from +1 in Ag ₂ O to 0 in Ag.	3
		Hydrogen in H_2 is oxidised to H_2O . Oxidation state of hydrogen increases from 0 in H_2 to +1 in H_2O .	
		1m for stating the correct substanced oxidised and reduced	
		2m for the correct reasons	
 	(iiii)	Observations	
	(,	Magnesium oxide remains unchanged (white) while conner(II) oxide	
		changed from black to pink/reddish brown	1
			•
		Reasons:	
		Hydrogen is less reactive than magnesium and hence cannot reduce	1
		magnesium oxide to magnesium.	
		Hydrogen is more reactive than copper and hence can reduce copper(II)	1
		oxide to copper.	
			1

8	(a)		There is no distinct differences in the colours of the flames from the different elements. In a mixture of K, Rb and Cs, the colours will blend / overlap into different shades of violet, making it hard to identify.	1
			In addition, the yellow-orange colour of sodium would mix with the colours of the different Group I metals, making the variety of colours harder to identify and differentiate.	1
	(b)	(i)	This mixture contains rubidium and sodium as the spectrum has	
			emission lines matching those of the spectra of rubidium and sodium.	
			The mixture contains the matching 4 emission lines of rubidium (2 lines	1
			of sodium around the arbitrary scale of around 500.	
			Lithium and potassium are absent as there are no matching emission lines with those in the spectra of lithium and potassium	1
			This mixture has an unknown element as there are 3 emission lines	1
			alound 550 to 650, which is not a group I, element.	
		(ii)	Emission spectra of the Group I and all the elements in the Periodic	1
	(c)	(i)	Salt 1: NaC/	2
	(-)	(-)	Salt 2: NaBr	_
			Salt 3: Na ₂ SO ₄	
			1 or 2 correct formulae award 1m	
			All 3 correct award 2m	
		(ii)	0.6 relative intensity \rightarrow 0.00420 mol/dm ³	
			Concentration of sodium ions = $0.00420/0.6$	
			= 0.00700 mol/dm ³	1
			Concentration of magnesium ions = $0.00420/0.6 \times 0.15$	
			$= 0.00105 \text{ mol/dm}^3$	1
	(d)		Ion chromatograms can be used to provide the <u>concentration</u> of ion	1
			and identity of ions, whereas emission spectrum only provides the	
			Identity of the group I metal.	
			Ion chromatogram can be used to identify <u>different types of positive</u>	1
			and negative ions, whereas emission spectrum can only be used to identify only Group I metals	
9	(a)		Each molecule of the vegetable oil has 3 ester functional group,	1
			-COO	
	(b)		0	2
			$H_{3}C - O - C - V = 0$	
			$H - C - O - C - \mathbb{Z}$	
			H_{3} , T	

	(c)		If the oils are not treated, the acids present will <u>neutralise the alkaline</u>	1
			if the catalyst is removed, the reaction will <u>slow down</u> .	1
	(d)		Average volume of KOH used = 21.55 cm^3	1
			= 0.02155q	1
			Mass of KOH needed to neutralise 1 kg of oil	
			$= 0.02155/10 \times 1000$ = 2.155 g	
			≈ 2.16 g	1
10	EITH	IER	In the furness, calls reacts with avvisor in the air fad in poor the better	1
	(a)		to produce carbon dioxide gas.	
			$C + O_2 \rightarrow CO_2$	1
			The carbon dioxide formed reacts with more coke to form carbon monoxide.	
			$CO_2 + C \rightarrow 2CO$	1
			The carbon monoxide reduces the iron(III) oxide in haematite to iron, forming carbon dioxide as well.	
			$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$	1
			Explanations for all 3 equations	1
	(b)	(i)	Sand present in the ore / haematite	
		(11)		
			The <u>different sizes</u> of the atoms that made up the impurities <u>disrupt the</u> <u>orderly and layered arrangement</u> of the iron atoms which are identical in size.	1 1
			The atoms <u>can no longer slide over one another</u> in layers when a force is applied on them. Hence the impure iron becomes harder and stronger but more brittle than the pure iron.	1
	(c)		Scrap steel is being recycled and provides a source of iron instead of being discarded and putting a strain on <u>a finite resource</u> which needs to be conserved before it gets depleted.	1
			Discarding scrap steel leads to build up of <u>waste in landfills sites</u> which could otherwise be used for agriculture and housing. It may also cause water pollution when metal ions dissolve in the water that seeps into the soil.	1

10	OR			
	(a)		Crude oil is heated and vaporised completely in a furnace.	1
			The vapor is passed into the fractionating column with a temperature gradient where the top of the fractionating column is the coolest and the bottom of the fractionating column is the hottest.	1
			The hot vapour cools and condenses as it rises up the column through selective condensation.	1
			Petrol, a lighter fraction with a lower boiling point, is collected at the	1
			higher outlet in the column while diesel, a heavier fraction with a higher boiling point, is collected at the lower outlet at the same time.	1
	(b)	(i)	Process A is isomerisation. Pentane and the product formed are isomers since they have the same molecular formula, C_5H_{12} , but different structural formulae.	1
			Process C is cracking. Heptane can be cracked into ethene and C_5H_{12} which are shorter chained hydrocarbons like alkene, C_2H_4 and alkane.	1
			Process B is neither as the molecular formula of the product is $\underline{C_6H_{12}}$, which is <u>different from the molecular formula of hexane</u> , $\underline{C_6H_{14}}$, and the molecule contains the same number of carbon atoms / not shorter chained fraction.	1
	(c)		Cracking of longer chain hydrocarbons which are lower in demand helps to meet the higher demand in shorter chain hydrocarbons which are lower in supply as they are more useful and often use as fuel.	1

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Suggested Answers

Paper 2

1	(a)	(i)	Fe	1
		(ii)	H ₂	1
		(iii)	Cu	1
		(iv)	O ₂	1
		(v)	Zn	1
	(b)	(i)	Cu, Fe, Zn	1
		(ii)	They form coloured compounds.	2
			They have variable oxidation states.	
			They have high densities/melting points/ melting points.	
			All 3 correct : 2m	
2	(2)	(i)	1-2 correct. IIII AgNO (2g) + KY (2g) \rightarrow AgY (c) + KNO (2g)	2
2	(a)	(1)	$Ag_1O_3(\underline{aq}) + KA(\underline{aq}) \rightarrow Ag_1A(\underline{s}) + KiO_3(\underline{aq})$	2
			Every 2 correct state symbols – 1m	
		(ii)	Reaction 1 is not a redox reaction. Oxidation states of Ag. N. O. K remain	1
		()	as +1, +5, -2, +1 and -1 respectively.	
			Reaction 2 is a redox reaction. Oxidation state of Ag decreases from <u>+1</u>	1
			in AgX to 0 in Ag and oxidation states of X increases from <u>-1 in AgX to 0</u>	
			<u>in X₂.</u>	
	(b)	(i)	pale yellow / yellow	1
		(ii)	The more reactive the halogen, the higher the rate of breakdown of the	1
			silver halide.	
3	(a)		complete combustion	1
	(h)	(i)	photosynthesis : $6CO_2 + 6H_2O \rightarrow C_2H_2O_2 + 6O_2$	1
	(5)	(1)	respiration : $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O_2$	1
		(ii)	During photosynthesis, plants absorbs carbon dioxide while during	1
		. ,	respiration, plants and animals releases carbon dioxide.	
			common error was to say that plants remove carbon dioxide and animals release	
	(0)		It.	1
	(0)		of burning fossil fuels is much more than the amount that can be	1
			removed by photosynthesis.	
			Burning more fuels is a result of rapid industrialisation . Trees take a	
			long time to mature, hence it is not a long term solution.	1
Δ	(2)	(i)	catalytic cracking	1
-	(4)	(1)	outlight ordoning	· ·

		(ii)	Cracking involves breaking down	n of <u>larger c</u>	<u>chain alkanes</u> , which are <u>less</u>	1
			useful and lower in demand, i	nto <u>shorte</u> iseful to be	r chain alkanes which are	1
			supply.			•
	(b)		нн			2
			H = C = C = H	H	H H I I	
			Ц Н-с-с=	с-с-н	н-с-с-с-н	
				н н Н Н	$\begin{array}{cccc} \mathbf{I} & \mathbf{I} & \mathbf{I} & \mathbf{I} \\ \mathbf{H} & \mathbf{H} & \mathbf{H} & \mathbf{H} \end{array}$	
			H			
	(c)		any two			2
	(0)		reagent observation fo	r ethane	observation for propene	2
			aqueous bromine remains reddis	sh-brown	<u>changes from reddish-</u> brown to colourless	
	(d)	(i)	similarity:			1
			Both contain <u>carbon – carbon d</u>	ouble bond	<u>s / C=C double bonds / C–H</u>	
			single bonds.			1
			difference:			•
			Vegetable oils are polyunsatur	ated which	contain multiple carbon-	
			carbon double bonds.	ver, alkene	es only have <u>one carbon-</u>	
		(ii)	Hydrogen gas is passed throu	gh vegetab	ble oils at a temperature of	1
			200 °C and in the presence of n	ickel catalys	<u>st.</u>	1
5	(a)		most reactive: magnesium			1
			cobalt			
			least reactive: copper			
	(b)		least reactive: copper		molour of colution	2
	(b)		metal sulfate		molour of solution	2
	(b)		least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate		molour of solution blue pink	2
	(b)		least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate		molour of solution <u>blue pink green</u>	2
	(b)		least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate		molour of solution blue pink green	2
	(b)		least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate All 3 correct: 2m 1-2 correct : 1m		molour of solution <u>blue</u> <u>pink</u> <u>green</u>	2
	(b) (b)	(i)	least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate All 3 correct: 2m 1-2 correct : 1m		molour of solution blue pink green	2
	(b) (b)	(i)	least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate All 3 correct: 2m 1-2 correct : 1m		molour of solution blue pink green	2
	(b) (b)	(i)	least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate All 3 correct: 2m 1-2 correct : 1m energy chromium + cobalt(II) sulfate	Ea	molour of solution <u>blue</u> <u>pink</u> <u>green</u>	2
	(b) (b)	(i)	least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate energy chromium + cobalt(II) sulfate	E _a	molour of solution blue pink green Legend: E₁ activation energy ΔH: enthalpy change	2
	(b) (b)	(i)	least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate All 3 correct: 2m 1-2 correct : 1m energy chromium + cobalt(II) sulfate		molour of solution blue pink green Legend: a: activation energy AH: enthalpy change	2
	(b) (b)	(i)	least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate All 3 correct: 2m 1-2 correct : 1m energy chromium + cobalt(II) sulfate	E _a	molour of solution blue pink green Legend: a, activation energy ∆H: enthalpy change It + chromium(III) sulfate	2
	(b) (b)	(i)	least reactive: copper metal sulfate copper(II) sulfate cobalt(II) sulfate chromium(III) sulfate All 3 correct: 2m 1-2 correct : 1m energy chromium + cobalt(II) sulfate	E _a coba	molour of solution blue pink green Legend: E _a : activation energy ΔH: enthalpy change It + chromium(III) sulfate	2

		(ii)	$2Cr(s) + 3Co^{2+}(aq) \rightarrow 2Cr^{3+}(aq) + 3Co(s)$	2
	(d)		Calcium reacts with the water in the solutions to produce hydrogen gas, causing the fizzing to be observed.	1
6	(a)	(i)	Cl Cl Cl Cl Cl Cl Cl Cl Cl Cl Cl Cl Cl C	2
		(ii)	F FCI F	1
		(iii)	Freon-14	1
		(iv)	No. CFCs are made of chlorine, fluorine and carbon. CF ₄ is made up of only carbon and fluorine.	1
	(b)		Breaking a C-F bond (485 kJ/mol) <u>requires more energy</u> than breaking a C-CI bond (327 kJ/mol). When energy from sunlight is absorbed by CFCs molecules, the <u>probability of breaking C-CI bond is therefore higher</u> , resulting in <u>many more chlorine atoms</u> than fluorine atoms.	1
	(c)	(i)	$2O_3 \rightarrow 3O_2$	2
		(ii)	Every time a chlorine atom is used up in the reaction in the first step, it is regenerated in the second step.	1

7	(a)	(i)								2
				vetal Metal	Lovide	oxygen	% of r	notal	% of oxygen	
				20.0 2	8.6	8.6	69	.9	30.1	
			Iron	30.0 4	2.7	12.7	70	.3	29.7	
			mercury	25.0 2	7.0	2.0	92	.6	7.4	
			2	10.0 4	1.6	1.6	96	.2	3.8	1
			Iron obeys th approximately different (7.4%	e law since equal. Mero and 3.8%).	the cury d	percentag oes not a or	ges of iro as the pe	on an ercent	id oxygen ar ages are vei	e y 1
				Metal (g) M(0)	etal (ide	oxygen	Mas Oxy grar	s of gen per n of metal	
			Iron	20.0	28	3.6	8.6	0.43	0	
				30.0	42	2.7	12.7	0.42	3	2
			mercury	25.0	27	' .0	2.0	0.08		
				40.0	41	.6	1.6	0.04		
			Iron obeys the metal oxide is of oxygen per second metal	e law since t approximate gram of mero oxide.	he ma ely the cury in	ss of oxy same. M the first r	/gen per (lercury do netal oxic	gram bes no le is ty	of iron in bot ot as the mas wice that of th	h is ie 1
		(ii)								
				Ph			Ph		0	7
			Mass	25.0	19		30		23	-
			No. of moles	25.0/207	1.9/	/16	30/207		2.3/16	
				= 0.1268	= 0.	1188	= 0.1449	9	= 0.1438	
			Simplest ration	1	1		1		1	
			Lead(II) oxide	was formed						
	(b)	(i)	Dalton's formu	lla for water i	s <u>HO</u> v	vhich is o	ne hydrog	gen at	om lesser tha	n 1
			the modern for	rmula is <u>H₂</u> O						
			Dalton's formu	ila for <u>hydrod</u>	<u>chloric</u>	acid is H	<u>lO</u> ₃ which	did n	not contain an	y 2
			chlorine atom,	while the mo	odern	formula is	s <u>HC<i>l</i></u> .			
			N 112							
			Nitrogen mon	oxide (NO)	is the	same to	or both D	alton	s and moder	n 1
		()	formula.							
		(ii)	name: <u>sodiun</u>	n chloride						1
			Hooser. The f				nhal 🔿 -	ام ما		
			hydro sodiu	ornula snow ochloric acid um chloride		indicating	the form	ation	of	
			note: sodium hy	droxide is not	t a salt					

8	(a)		fuel	Boiling point/ °C	Density at room temperature and pressure in g/cm ³	Volume of 1 mol of fuel at room temperature and pressure / dm ³	Enthalpy change when 1 mol of fuel is completely burned in kJ/mol	Enthalpy change when 1 kg of fuel is completely burned in kJ/kg	5
			Octane	125	703	$\frac{8 \times 12 + 18}{703} = \frac{0.162}{100}$	-5075	$\frac{\frac{5075}{114}}{= -44500} \times 1000$	
			hydrogen	-253	0.083	24	-286	$\frac{\frac{286}{2} \times 1000}{= -143\ 000}$	
	(b)		Octane is a point 253 ° occupies a hydrogen ga to hydrogen	liquid (boilir <u>C)</u> at roon much <u>sma</u> is. Hence, a for the sam	ig point 125 n temperatu iller volume i larger mass e volume.	<u>°C)</u> while hy ure. At roon compared s of octane o	drogen is a n temperat to the san can be store	gas (boiling ure, octane ne mass of ed compared	1
			It is <u>more dif</u> order to fit in	ficult to stor ito a tank th	<u>e hydrogen</u> at holds an	as it <u>needs</u> equal mass	<u>to be compr</u> of octane.	<u>essed</u> in	1
			Hydrogen (1 octane (445) combusted.	4300 kJ/kg) 00 kJ/kg). H) has <u>more t</u> lence it can	<u>han 3 times</u> produce <u>mo</u>	the energy re heat ene	<u>content</u> of <u>rgy</u> when	1
0	СІТЦ								
9	(a)	ICK	Cu(NO ₃) ₂						
	(<u>)</u>	(i)	Experiment	3. The acid	is the limiti	ng reactant	in all 4 exp	eriments. In	
			experiment a acid used pr produces it in	experiment 1, 3 and 4, the <u>same concentration</u> and <u>number of moles of</u> <u>acid</u> used produce the same volume of gas (150 cm ³) but experiment 3 produces it in a shorter time (7s compared to 15 s).					1
		(ii)	At a higher	temperatu	re, the rea	cting particl	es have <u>hi</u>	gher kinetic	1
			energy and I	move faster	ida with an	orav arosto	r or oqual f	to activation	1
			energy. The will increase	frequency . Hence the	of effective of read	collisions be tion increas	tween react <u>e</u> .	ing particles	1
	(c)								
				Time	taken to col of gas /	lect 10 cm ³ s	Total volution of gas / of gas	ume cm ³	
			ethanoic a	cid	<u>375</u>		<u>150</u>		2
			sulfuric ac	id	<u>6</u>		<u>300</u>		_
			Sulfuric acid <u>ions in 0.5 n</u> <u>taken</u> to colle	used in exp nol/dm ³ of i ect 10 cm ³ a	periment 6 is <u>t in 1.0 mol</u> . are <u>the sam</u> e	<u>dibasic</u> . <u>Th</u> Hence the <u>e</u> as in expe	<u>e number of volume of g</u> riment 2.	⁻ moles of H⁺ las and time	1
			For experiment mol. Thus <u>th</u> 3 and 4. Ho produced slo instant of time	ent 5, the <u>n</u> ne volume o wever, sinc owly. Only ne so the tin	umber of ma f gas produc e <u>ethanoic a</u> about 4% o ne taken will	oles of H ⁺ io ced is the sa acid is a we f the molec be 100/4 ×	ns in 0.5 ma ame as in ex ak acid, the ules are ior 15 = 375s.	ol/dm ³ is 0.5 xperiment 1, H ⁺ ions are hised at any	1

9	OR		
	(a)	empirical formula of poly(propene): \underline{CH}_2 molecular formula of propanol : $\underline{C}_3\underline{H}_2\underline{OH}$	1 1
	(b)	Both poly(propene) and silicon dioxide have giant covalent structures while propanol has a simple covalent structure with discrete molecules. Poly(propene) contains many small propene molecules as repeating units joined together by strong covalent bonds to form a long-chain addition polymer. The polymer layers are held by weak intermolecular forces of attraction.	1
		Silicon dioxide contains a network of <u>silicon and oxygen atoms</u> joined by strong <u>covalent bonds</u> . Propanol contains molecules of propanol held together by <u>weak</u> intermolecular forces of attraction.	1
	(c)	Propanol has a low melting point because <u>little energy is needed to</u> overcome the weak intermolecular forces of attraction between the molecules.	1
		Poly(propene) has a low melting point but the melting point is higher than propanol but lower than silicon dioxide.	1
		The polymers in poly(propene) are held by <u>weak intermolecular forces of attraction</u> . However, these <u>forces are stronger</u> than those in propanol, hence the <u>amount of energy to overcome the forces of poly(propene) is larger</u> than propanol.	1
		Silicon dioxide has the highest melting points because it requires the largest amount of energy to break the numerous strong covalent bonds between the atoms in its giant structure.	1

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Suggested Answers

Paper 2

A1	(a)							
			trend	only true	only true	true for	2	
			The number of electron shells	√		both		
			The number of valency electrons increases.		✓			
			Proton number increases.			✓		
			There is a change in character from metallic to non-metallic.		✓			
	(b)	(i)	The melting point of <u>Group I</u> e The melting point of <u>Group VI</u>	lements <u>decrea</u> s I elements <u>incre</u>	ses down the grou ases down the grou	ıp. oup.	1	
		(ii)	The reactivity of <u>Group I</u> element The reactivity of <u>Group VII</u> ele	The reactivity of Group I elements increases down the group. The reactivity of Group VII elements decreases down the group. 1				
	(c)		 Catalyst will help to increate alternative pathway with a processes can be <u>com</u> fuel/energy, saving the c 	ease the rate of lower activation pleted in a s ost	of reaction by pro energy. This mea shorter time us	oviding an ns that the sing less	1	
			 Catalysts are <u>chemically u</u> they can be <u>regenerated a</u> Students must link the knowledge reduction in the long run. 	<mark>inchanged</mark> at th and reused to a e of catalysts to th	e end of the reacti void recurring cos e question, which a	on. Hence it. sks for <u>cost</u>	1	
A2	(a)		Extraction is a <u>reduction pr</u> oxidation state of iron from <u>+3</u>	<u>ocess</u> as it inv in Fe ₂ O ₃ to 0 in	olves the <u>decrea</u> Fe.	ase in the	1	
			Rusting is an oxidation pro oxidation state of iron from <u>0 in</u>	o <mark>cess</mark> as it inv n Fe to +3 in Fe	olves the <u>increa</u> 2 <u>0</u> 3.	ise in the	1	
	(b)	(i)	Alloy is a mixture of a metal ar	nd <mark>one or more</mark>	other elements.		1	
		(ii)	As <u>oxygen and water</u> are <u>e</u> coating and oil act as a <u>prote</u> from <u>coming into contact</u> wit	ssential condition active barrier to h the steel.	o <u>ns</u> for rusting, th prevent oxygen	e layer of and water	1 1	
		(lii)	Steel is an alloy of iron. Since provides a sacrificial protect	e zinc is a <u>more</u> i on by <u>corrodin</u>	e reactive metal th g in place of iror	<u>nan iron</u> , it <u>1</u> .	1 1	
			"zinc rust in place of iron" is incor	rect.				

A3	(a)		The predicted surface temperature on Mercury is <u>very close</u> to that of the actual surface temperature.	
			However, the predicted surface temperature of Earth and Venus are much lower than the actual due to the presence of CO ₂ in the atmosphere which acts as a greenhouse gas to trap heat in the planet.	1
			The difference between the predicted and actual temperature is much higher in Venus than on Earth as it has a <u>much higher percentage (97 %) of CO₂</u> than Earth (0.04 %).	1
			A common incorrect statement was that 'the more carbon dioxide the higher the surface temperature'. This is incorrect because the data for Mercury does not fit this trend.	
	(b)	(i)	volcanic eruptions	1
		(ii)	The <u>pH of the water will be lower than 7</u> as sulfur dioxide is an acidic gas.	1
		(iii)	The actual surface temperature of Venus is 462 °C, which is much <u>higher</u> than the boiling point of water. Hence the rainwater would <u>remain as vapour</u> .	1
		(:)	Distantiation in plants requires / showing our light and some disting	
	(C)	(1)	This process produces oxygen.	1
			Hence, plant life <u>reduces</u> the percentage of CO_2 and increases the percentage of O_2 on Earth.	1
		(ii)	Due to large scale deforestation which reduces the uptake of CO_2 by plants	
			for photosynthesis and the <u>burning of fossil fuels</u> in the industry, the percentage of CO_2 on Earth is now increasing rapidly.	1
		(iii)	Legend X - electron of C • - electron of O	3
			Legend X - electron of O • - electron of O	
A4	(a)		name of salt formula name of name of other	
			acid compound	

			potassium su	ulfate	K2SO4	<u>sulfuric</u> <u>acid</u>	potas potas	sium hyd ssium car	roxide / bonate		1
			potassium pł	nosphate	K ₃ PO ₄	phosphoric acid	potas potas	<u>sium hyd</u> ssium car	roxide / bonate		1
			ammonium n	itrate	NH4NO3	<u>nitric</u> acid	aque ammo	eous amn onium ca	nonia / rbonate		1
			calcium phos	sphate	<u>Ca₃(PO₄)₂</u>	phosphoric acid	ca	lcium hydro	oxide		
	(b)		ammonium r	itrate and	d potassium	phosphate					1
	(c)	(i)	salt: calcium	n phosph	ate	PricePrice					1
			reason: It <u>d</u> percentage o It <u>contains p</u>	l <mark>oes not</mark> composition composition	contain these ons of these rus (20 % by	ne element elements ir / mass).	<u>s N an</u> calcium	<u>d K</u> and phospha	hence th te are zer	ie 0.	1
		(ii)	Percentage t = $\frac{31}{3(39)+31+4(10)}$	by mass $\frac{1}{5} \times 100\%$	of phosphoru % = 14.6%	IS					1
			$=\frac{3\times39}{3(39)+31+4(10)}$	$\frac{-}{5} \times 100\%$	6 = 55.2 %						1
			Ratio N : P :	K = 0 : 1	4.6 : 55.2 ≈	0 : 15 : 55					1
A5	(a)		salt: <u>silver ch</u>	loride, ba	arium sulfate	and lead su	<u>llfate</u>				1
			reason: They <u>two aqueous</u>	are <u>insol</u> solutions	uble in water s of soluble s	<u>r</u> and can be salts.	prepare	d by reacti	on betwee	en	2
	(b)				to ma	ke l					
			compound	to mak deterge	te polyme nts for packag	ers for flu desulfu	ie gas irisation	as a solvent in inks	for road surfacing		3
			bitumen						\checkmark		
			sulfuric acid	~							
			ethene		✓						
			ethyl ethanoate					\checkmark			
			calcium carbonate				/				
A6	(a)		The memThe mem	bers hav	e a general i e a common	formula of C	nH₂n+1C⊦ Iroup –C	io. Ho.			2
			Successi	ve memb	ers differ by	–CH ₂ – grou	p.				
	(b)		C ₃ H ₇ CHO;								1
			76 °C (answe and pentana	er should I.)	be around th	e midpoint c	f the boil	ing points	of propan	al	1
			Do not leave o	out the uni	ts.						

(c)	(i)	Isomers are compounds with the same molecular formula but different structural formulae.	1
		Ethanol and methoxymethane are isomers of each other as they have the same number of C, H and O atoms (same molecular formula of C_2H_6O) but arranged differently (different structural formulae).	1
		<u>Ethanal is not an isomer</u> of ethanol and methoxymethane as it has a different molecular formula of C_2H_4O .	1
		Remember to link the answer to the definition of isomers and not just identify them	
	(ii)	$2C_2H_4O + 5O_2 \rightarrow 4CO_2 + 4H_2O$	2
		Correct formulae of products – 1m Balanced equation – 1m	
	(iii)	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1
		The question asked candidates to 'Show the organic compounds as displayed formulae'. This instruction was very often ignored.	

Section B [30 marks]

B7	(a)	nylon X: nylon 4,6 nylon Y: nylon 11	3
	(b)	H H	2
		$H - N - (CH_{\gamma})_{\varsigma} - N - H$	
		2 5	
		O O II II	
	(c)	Mr of repeating unit	2
	(0)	$= (14 \times 2) + (1 \times 2) + (14 \times 6) + (14 \times 4) + (16 \times 2) + (12 \times 2)$	2
		$= \underline{220} [1]$	
		$= 10\ 000\ /\ 226 = 44.247$	
		≈ <u>45</u> [1]	
		Candidates need to round up their final answer to the next whole number for minimum number of repeating units.	
	7 I		0
	(d)	The longer the chain lengths of diamine, the lower the melting point. (1 mk	3
	(d)	The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275°C in nylon</u> <u>4,6 to 269°C in nylon 6,6</u> . (1 mk pt)	3
	(d)	The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275°C in nylon</u> 4,6 to 269°C in nylon 6,6. (1 mk pt) Dicarboxylic acid:	3
	(d)	The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275°C in nylon</u> <u>4,6 to 269°C in nylon 6,6</u> . (1 mk pt) Dicarboxylic acid: The <u>longer the chain lengths of dicarboxylic acid</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 269°C in</u>	3
	(a)	The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275°C in nylon</u> 4,6 to 269°C in nylon 6,6. (1 mk pt) Dicarboxylic acid: The <u>longer the chain lengths of dicarboxylic acid</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 269°C in</u> nylon 6,6 to 220 in nylon 6,10 to 218 in nylon 6,12. (1 mk pt)	3
	(a)	The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275°C in nylon</u> <u>4,6 to 269°C in nylon 6,6</u> . (1 mk pt) Dicarboxylic acid: The <u>longer the chain lengths of dicarboxylic acid</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 269°C in</u> <u>nylon 6,6 to 220 in nylon 6,10 to 218 in nylon 6,12</u> . (1 mk pt) 4 mk pts – 3m 2-3 mk pts – 2m	3
	(a)	Diamine: The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275°C in nylon</u> 4,6 to 269°C in nylon 6,6. (1 mk pt) Dicarboxylic acid: The <u>longer the chain lengths of dicarboxylic acid</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 269°C in</u> nylon 6,6 to 220 in nylon 6,10 to 218 in nylon 6,12. (1 mk pt) 4 mk pts – 3m 2-3 mk pts – 2m 1 mk pt – 1m	3
	(d) (e)	Diamine: The longer the chain lengths of diamine, the lower the melting point. (1 mk pt) This can be observed in the decrease in melting point from 275°C in nylon 4,6 to 269°C in nylon 6,6. (1 mk pt) Dicarboxylic acid: The longer the chain lengths of dicarboxylic acid, the lower the melting point. (1 mk pt) This can be observed in the decrease in melting point from 269°C in nylon 6,6 to 220 in nylon 6,10 to 218 in nylon 6,12. (1 mk pt) 4 mk pts – 3m 2-3 mk pts – 2m 1 mk pt – 1m Candidates need to reflect the relationships shown by the data. 1 kg of nylon 6 = 1000 g	2
	(d) (e)	Diamine: The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275^oC in nylon</u> <u>4,6 to 269^oC in nylon 6,6</u> . (1 mk pt) Dicarboxylic acid: The <u>longer the chain lengths of dicarboxylic acid</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 269^oC in</u> <u>nylon 6,6 to 220 in nylon 6,10 to 218 in nylon 6,12</u> . (1 mk pt) 4 mk pts – 3m 2-3 mk pts – 2m 1 mk pt – 1m <u>Candidates need to reflect the relationships shown by the data</u> . 1 kg of nylon 6 = 1000 g Number of repeating units = 1000 / (113) = <u>8.8495 [1]</u>	2
	(d) (e)	Diamine: The longer the chain lengths of diamine, the lower the melting point. (1 mk pt) This can be observed in the decrease in melting point from 275°C in nylon 4.6 to 269°C in nylon 6.6. (1 mk pt) Dicarboxylic acid: The longer the chain lengths of dicarboxylic acid, the lower the melting point. (1 mk pt) This can be observed in the decrease in melting point from 269°C in nylon 6,6 to 220 in nylon 6,10 to 218 in nylon 6,12. (1 mk pt) 4 mk pts – 3m 2-3 mk pts – 2m 1 mk pt – 1m Candidates need to reflect the relationships shown by the data. 1 kg of nylon 6 = 1000 g Number of repeating units = 1000 / (113) = 8.8495 [1] Since each repeating unit has 6 carbon atoms to produce 6 CO ₂ molecules,	2
	(d) (e)	Diamine: The longer the chain lengths of diamine, the lower the melting point. (1 mk pt) This can be observed in the decrease in melting point from 275° C in nylon 4,6 to 269° C in nylon 6,6. (1 mk pt) Dicarboxylic acid: The longer the chain lengths of dicarboxylic acid, the lower the melting point. (1 mk pt) This can be observed in the decrease in melting point from 269° C in nylon 6,6 to 220 in nylon 6,10 to 218 in nylon 6,12. (1 mk pt) 4 mk pts – 3m 2-3 mk pts – 2m 1 mk pt – 1m Candidates need to reflect the relationships shown by the data. 1 kg of nylon 6 = 1000 g Number of repeating units = 1000 / (113) = 8.8495 [1] Since each repeating unit has 6 carbon atoms to produce 6 CO ₂ molecules, Mass of CO ₂ given out	2
	(d) (e)	Diamine: The <u>longer the chain lengths of diamine</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 275^oC in nylon</u> <u>4.6 to 269^oC in nylon 6.6</u> . (1 mk pt) Dicarboxylic acid: The <u>longer the chain lengths of dicarboxylic acid</u> , the <u>lower the melting point</u> . (1 mk pt) This can be observed in the <u>decrease in melting point from 269^oC in</u> <u>nylon 6.6 to 220 in nylon 6.10 to 218 in nylon 6.12</u> . (1 mk pt) 4 mk pts – 3m 2-3 mk pts – 2m 1 mk pt – 1m <i>Candidates need to reflect the relationships shown by the data</i> . 1 kg of nylon 6 = 1000 g Number of repeating units = 1000 / (113) = <u>8.8495</u> [1] Since each repeating unit has 6 carbon atoms to produce 6 CO ₂ molecules, Mass of CO ₂ given out = 8.8495 x (6)(12+16+16) = 2336.283 g	2

B8	(a)	N ₂ (9	g <mark>) + 3H₂ (g</mark>)) ≓ 2NH ₃ (g) [1]		2		
		Acco toge <u>tem</u> requ	ording to the ther. <u>Since</u> perature a ires 3 volur	ding to the equation, 1 mole of nitrogen requires 3 moles of hydrogen to react er. <u>Since 1 mole of any gas has the same volume (24 dm³) at room</u> erature and pressure, based on Avogadro's Law, 1 volume of nitrogen es 3 volumes of hydrogen to react together.					
	(b)	(i)	A <u>lower p</u> (1 mk pt)	oressure wi	Il lead to a de	crease rate of reaction in the reactor.	2		
			At a lower (1 mk pt), to a lowe	[·] pressure, t resulting in r frequency	here are <u>fewer</u> less frequency / of effective c	number of particles per unit volume of collisions between particles, leading ollision. (1 mk pt)			
			3 mk pts - 1-2 mk pts	- 2m s – 1m					
			A few ca pressure	few candidates gave irrelevant explanation of the effect of a higher ressure leading to a faster reaction.					
		(ii)	A lower p	ressure will	lead to a <u>lowe</u>	r percentage yield and lower rate of	1		
			Hence, the ammonia	e <mark>relative a</mark>	mounts of nitro	o <mark>gen and hydrogen</mark> will be <u>higher</u> than	1		
		(iii)	The final a	amount of a	mmonia made y d hydrogen are	will <u>remain the same</u> as <u>the number of</u> the same .	1		
			This is b recycled	ecause un <u>back</u> into th	reacted nitroge	en and hydrogen will be <u>constantly</u>	1		
EIII R9	$\frac{1ER}{a}$								
20	(4)	5	solution	name o	of products	ionic equation			
		cor aqu	centrated	negative electrode	<u>copper</u>	<u>Cu²+ (aq) + 2e⁻ → Cu (s)</u>	1		
		cop chl	oper(II) oride	positive electrode	<u>chlorine</u> <u>gas</u>	2C <i>l</i> ⁻ (aq) → C <i>l</i> ₂ (g) + 2e⁻	1		
		dilu aqu	ited Jeous	negative electrode	<u>copper</u>	<u>Cu²+ (aq) + 2e⁻ → Cu (s)</u>	1		
		cop chle	oper(II) oride	positive electrode	oxygen gas and water	4OH⁻ (aq) → 2H₂O (<i>l</i>) + O₂ (g) + 4e⁻	1		
	(k)	(:)	Degraphe	A and D			4		
	(a)	(1)	Reagents	A and D					

		(ii)	Reagent A:	
			When reagent A was added to fresh samples of aqueous copper(II) chloride and aqueous copper(II) sulfate, both solutions turned from blue to	
			<u>colourless, with reddish-brown deposits</u> formed at the bottom of the beaker	1
			Reagent B: When reagent B was added to fresh samples of aqueous copper(II) chloride	
			and aqueous copper(II) sulfate, <u>white precipitate was formed in</u> <u>copper(II) chloride, while no visible change could be seen in copper(II)</u> sulfate	1
			Reagent C:	
			When reagent C was added to fresh samples of aqueous copper(II) chloride and aqueous copper(II) sulfate, <u>white precipitate was formed in</u> copper(II) sulfate, while no visible change could be seen in copper(II)	1
			<u>chloride</u>	
			Reagent D: When reagent D was added to fresh samples of aqueous copper(II) chloride	
			and aqueous copper(II) sulfate, both solutions produce light blue precipitate that is insoluble in excess aqueous sodium hydroxide .	1
OR				
B9	(a)	(i)	Iron reacts / dissolves and the solution changed from blue to green .	1
			Reddish brown deposits were observed.	1
		(ii)	Metals are <u>finite resources</u> . By using displacement reaction to extract metal, we can <u>conserve</u> our <u>resources</u> .	1
			By using displacement reaction to extract metal, less energy is required as	
			compared to mining. Hence, less fossil fuels are required to be burnt to	1
			supply the energy, reducing air pollution.	
	(b)	Cl ₂ (g) + 2Br ⁻ (aq) → Br ₂ (aq) + 2C l^- (aq)	2
		Corr	ect state symbol – 1m	
		Bala	nced chemical equation –1m	
		Many unba	y candidates incorrectly represented bromine as Br ₂ (l) or to show an alanced equation.	

(c)	Similarities:	
	Both reactions involve the <u>displacement of a less reactive element in the</u> compound with a more reactive element.	4
	Or	
	Both reactions involve reduction and oxidation / are redox reactions.	
	or Both reactions result in <u>colour change</u> in the reaction mixture.	
	Differences:	
	The technique involved in extracting copper is a <u>metal displacement reaction</u> (where a more reactive metal displaces a less reactive metal from its aqueous solution), whereas the technique involved in extracting bromine involves <u>halogen</u> <u>displacement reaction</u> (where a more reactive halogen displaces a less reactive halogens from its aqueous solution.)	
	or	
	Copper(II) ions are reduced while bromide ions are oxidised.	
	Or Extraction of conner results in the formation of a solid, but the extraction of	
	bromine results in the formation of a liquid.	
	Some candidates only compared a reactant or product, for example, stating 'copper is a solid'.	
	Any two similarities – 2m	
	Any two differences – 2m	

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Suggested Answers

Paper 2

1	(a)		A: non-metal;	1		
	.,		B: metal;			
			D: metal;			
			E: non-metal			
			Students have to be careful not to let element C mislead them to invert			
			every selection.			
	(b)	(i)	C	1		
		(ii)	Α	1		
		(iii)	В	1		
	(c)		Group 0 elements have fully filled valence electron shells .			
	(-)		They are chemically unreactive / inert and do not gain, share or lose	1		
			any electron			
			Hence they do not form compounds like the elements in the table	1		
				•		
			Group 0 elements show an oxidation state of 0 is incorrect as it does not			
			explain the inability to form compounds.			
2	(a)	(i)	The more reactive the metal, the higher the temperature required for the	1		
	()	(-)	reduction of its metal oxide.	-		
		/ ;;;)	$700 \circ C$ (any temperature between $400 \circ 000 \circ C$)			
			1 AUU IVI I AUVIEU DE LA LUTE DE LWEEU 400 - 900 IVI	1		
		(11)	700 C (any temperature between 400 - 900 C)	1		
		(11)	Iron has a <u>reactivity between zinc and lead</u> .	1 1		
		(11)	Iron has a <u>reactivity between zinc and lead</u> . Therefore, the temperature required would be between that of zinc oxide	1		
		(")	Iron has a <u>reactivity between zinc and lead</u> . Therefore, the temperature required would be between that of zinc oxide and lead oxide.	1		
		(11)	Iron has a <u>reactivity between zinc and lead</u> . Therefore, the temperature required would be between that of zinc oxide and lead oxide.	1		
		(11)	Iron has a <u>reactivity between zinc and lead</u> . Therefore, the temperature required would be between that of zinc oxide and lead oxide. <i>Common error: to discuss the reactivity of the oxides rather than the</i>	1		
		(")	 Iron has a <u>reactivity between zinc and lead</u>. Therefore, the temperature required would be between that of zinc oxide and lead oxide. Common error: to discuss the reactivity of the oxides rather than the metals or by referring to iron being 'between zinc and lead' without referrence to reactivity. 	1		
		(11)	 Iron has a <u>reactivity between zinc and lead</u>. Therefore, the temperature required would be between that of zinc oxide and lead oxide. <i>Common error: to discuss the reactivity of the oxides rather than the metals or by referring to iron being 'between zinc and lead' without reference to reactivity.</i> 	1		
	(b)	(11)	 Iron has a <u>reactivity between zinc and lead</u>. Therefore, the temperature required would be between that of zinc oxide and lead oxide. <i>Common error: to discuss the reactivity of the oxides rather than the metals or by referring to iron being 'between zinc and lead' without reference to reactivity.</i> magnesium and silver oxide 	1		
	(b)	(11)	 Iron has a <u>reactivity between zinc and lead</u>. Therefore, the temperature required would be between that of zinc oxide and lead oxide. <i>Common error: to discuss the reactivity of the oxides rather than the metals or by referring to iron being 'between zinc and lead' without reference to reactivity.</i> magnesium and silver oxide 	1		
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	(b) (c)		 Iron has a <u>reactivity between zinc and lead</u>. Therefore, the temperature required would be between that of zinc oxide and lead oxide. <i>Common error: to discuss the reactivity of the oxides rather than the metals or by referring to iron being 'between zinc and lead' without reference to reactivity.</i> magnesium and silver oxide <i>A more reactive metal will displace a less reactive metal from its metal oxide.</i> zinc oxide [1] and hydrogen gas [1] 	1 1 1		
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	(b) (c)	(11)	 Iron has a <u>reactivity between zinc and lead</u>. Therefore, the temperature required would be between that of zinc oxide and lead oxide. <i>Common error: to discuss the reactivity of the oxides rather than the metals or by referring to iron being 'between zinc and lead' without reference to reactivity.</i> magnesium and silver oxide <i>A more reactive metal will displace a less reactive metal from its metal oxide.</i> zinc oxide [1] and hydrogen gas [1] Note: A metal oxide is produced when a metal reacts with steam while a 	1 1 2		
3	(a)		name of compound <u>ethene</u> poly(ethene)	structural formula $\begin{array}{c} H \\ H \\ H \\ \end{array} = C \\ H \\ H \\ \end{array} \\ \begin{array}{c} H \\ H \\ H \\ \end{array} \\ \begin{array}{c} H \\ H $	process(es) used to manufacture the compound Fractional distillation of <u>crude oil / petroleum</u> followed by catalytic <u>cracking</u> <u>addition polymerisation</u> of ethene.	1
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			ethanol	H H H—C—C—O—H H H	Two separate processes can be used. Process 1: Catalytic <u>addition</u> of <u>steam</u> to ethene. Process 2: <u>fermentation</u> of glucose.	2
			ethanoic acid	H-C-C H O-H	of ethanol.	1
	(b)	(i)	Both reactions	produce salt and wate	er <u>only</u> .	1
		(ii)	At the same co strong acid <u>ion</u> <u>hydrogen ions.</u> Ethanoic acid <u>concentration o</u> hydrogen ions i is slower.	bincentration and temp ises completely to pro- being a weak acid i of H ⁺ / hydrogen ior n <u>ethanoic acid</u> , the ra	perature, hydrochloric acid being a oduce a <u>high concentration of H⁺ /</u> <u>ionises partially</u> to produce a <u>low</u> <u>hs</u> . With a <u>lower</u> concentration of the of reaction between metal oxides	1
4	(a)		660 °C (accept	a range of answers b	etween 600 - 700 °C)	1
	(b)		 <u>Higher temp</u> extraction fro °C). <u>Larger a</u> Extraction of involves a la 	<u>perature</u> of 900 °C is not om bauxite as compar <u>amount of heat energe</u> of aluminium from ba arge amount of <u>electric</u>	required in the main process of the red to the recycling of used can (700 <u>y</u> is required. auxite requires <u>electrolysis</u> , which <u>cal energy.</u>	1
			Students shoul 'more' or 'less'	d <u>not repeat</u> informati energy is needed.	ion in the question, stating only that	
	(c)		Carbon dioxide contributes to g	e is a <u>green house</u> llobal warming.	gas and <u>excessive</u> amount of it	1
			Concentrated s sources, it incr	odium hydroxide is <u>a</u> eases the pH of wate	Ilkaline . When released into water er, causing aquatic life to <u>die</u> .	1
	(d)		Metals / Metal depleted. Recy Students shoul asked for one of	ores, such as bauxit cling metals will help t Id not discussed rela other reason.	te, are <u>finite resources and will be</u> to conserve them. <i>tive energy inputs as the question</i>	1

	(e)	(i)	alloy	1
		(ii)	It is harder and stronger than pure aluminium.	1
			Students should discuss the properties and not arrangement of atoms in	
			the structure of an alloy.	
5	(a)		cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$	1
			anode: $4OH^{-}(aq) \rightarrow O_2(g) + 2H_2O(l) + 4e^{-1}$	1
	(h)	<i>(</i> i)	For every 4 moles of electrons transferred	1
	(5)	(')	2 moles / volumes of H ₂ gas and 1 mole/volume of O_2 gas are formed.	1
			or	
			Each molecule of water $H_{2}O$ contains 2 hydrogen atoms and 1 oxygen	2
			atom. Hence, the decomposition of water will produce a volume of	2
			hydrogen gas to oxygen gas in the ratio of <u>2:1</u> .	
		(ii)	Some of the oxygen produced would dissolve in the water.	1
			Hence a <u>smaller volume of oxygen would be collected</u> , <u>leading to a higher</u>	1
			ratio of hydrogen to oxygen.	
			The underlined points must be mentioned especially how the ratio will be	
			affected.	
		(iii)	After some time, the solution would be saturated with oxygen gas, hence	1
			the amount that dissolves in water decreases.	
	(c)		As hydrogen and hydroxide ions are discharged, water is effectively	1
			removed from the solution, hence the concentration of sodium chloride	
	(d)		Similarity: In both cases, hydrogen is collected at the cathode.	1
	(d)		Similarity: In both cases, <u>hydrogen</u> is collected at the cathode. Difference: <u>Oxygen</u> is collected at the anode during the electrolysis of	1
	(d)		Similarity: In both cases, <u>hydrogen</u> is collected at the cathode. Difference: <u>Oxygen</u> is collected at the anode during the electrolysis of dilute aqueous sodium chloride while <u>chlorine</u> is collected for	1 1
	(d)		Similarity: In both cases, <u>hydrogen</u> is collected at the cathode. Difference: <u>Oxygen</u> is collected at the anode during the electrolysis of dilute aqueous sodium chloride while <u>chlorine</u> is collected for concentrated aqueous sodium chloride.	1 1
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6	(d) (e) (a)		Similarity: In both cases, <u>hydrogen</u> is collected at the cathode. Difference: <u>Oxygen</u> is collected at the anode during the electrolysis of dilute aqueous sodium chloride while <u>chlorine</u> is collected for concentrated aqueous sodium chloride. Students must remember to specify which are the similarity and difference. Platinum is <u>chemically unreactive / inert</u> and <u>will not react with the</u> <u>products</u> of electrolysis or the electrolyte. Quicklime and slaked lime are <u>soluble in water</u> but limestone is <u>insoluble in water</u> . Both quicklime and slaked lime are soluble in water to form <u>alkaline</u> <u>solutions</u> which produce hydroxide ions to neutralise acidity more	1 1 1 1 1
6	(d) (e) (a)		Similarity: In both cases, <u>hydrogen</u> is collected at the cathode. Difference: <u>Oxygen</u> is collected at the anode during the electrolysis of dilute aqueous sodium chloride while <u>chlorine</u> is collected for concentrated aqueous sodium chloride. Students must remember to specify which are the similarity and difference. Platinum is <u>chemically unreactive / inert</u> and <u>will not react with the</u> <u>products</u> of electrolysis or the electrolyte. Quicklime and slaked lime are <u>soluble in water</u> but limestone is <u>insoluble in water</u> . Both quicklime and slaked lime are soluble in water to form <u>alkaline</u> <u>solutions</u> which <u>produce hydroxide ions to neutralise acidity more</u> <u>effectively</u> than limestone.	1 1 1 1
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6	(d) (e) (a)	(i) (ii)	 Similarity: In both cases, <u>hydrogen</u> is collected at the cathode. Difference: <u>Oxygen</u> is collected at the anode during the electrolysis of dilute aqueous sodium chloride while <u>chlorine</u> is collected for concentrated aqueous sodium chloride. Students must remember to specify which are the similarity and difference. Platinum is <u>chemically unreactive / inert</u> and <u>will not react with the products</u> of electrolysis or the electrolyte. Quicklime and slaked lime are <u>soluble in water</u> but limestone is <u>insoluble in water</u>. Both quicklime and slaked lime are soluble in water to form <u>alkaline</u> solutions which <u>produce hydroxide ions to neutralise acidity more effectively</u> than limestone. Students need to select the relevant points and not copy out most of the information in the table. Blast furnace slag is a solid waste which is usually dumped. Using it to make useful products will reduce the amount of waste on earth / Silicates can be used to help promote plant growth*. *Note: Students should be able to explain how they derive how silicates help in plant growth. Group IV and V elements are <u>non-metallic</u>. 	1 1 1 1 1
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(c)	% by mass of Ca in quicklime = $\frac{40}{40+16} \times 100\%$	
	= 71.4%	1
	% by mass of Ca in limestone = $\frac{40}{40+12+3\times16} \times 100\%$	
	= 40.0%	1
	% by mass of Ca in slaked lime = $\frac{40}{40+2(16+1)} \times 100\%$	
	= 54.1%	1
	Hence, quicklime has a higher percentage by mass of calcium than	
	limestone and slaked lime.	
(d)	$CaCO_3 \rightarrow CaO + CO_2$	
	Number of moles of CaCO ₃ = $\frac{25 \times 10^6}{40 + 12 + 3 \times 16}$	1
	$= 2.50 \times 10^5$ mol	I
	Molar ratio of CaCO ₃ : CO ₂ = 1 : 1	1
	Number of moles of $CO_2 = 2.5 \times 10^5$ mol	
	Volume of CO ₂ = 2.5 x 10 ⁵ x 24 = 6 00 x 10 ⁶ dm ³	4

Section B [20 marks]

7	(a)		In general, the melting and boiling points increase with increased number of carbon atoms in each alkane molecule.	1
	(b)		Propane. It has a melting point that is <u>lower than ethane</u> although it has one more carbon atom. This does not follow the trend.	1
	(c)		melting point: -74 °C (-76 to -72 °C); boiling point: 98 °C (96 to 100 °C)	1
	(d)		Both the boiling points and flashpoints of alkanes increase with increased number of carbon atoms in alkane molecules.	1
	(e)		The flashpoint of an alkane decreases when the alkane molecule is branched.	1
			This is evident from the fact that straight chain pentane has a flashpoint of of -49 °C while its branched alkane isomers (branched alkane 1 and 2) have flashpints lower than -49 °C. Similarly, octane has a flashpoint (13 °C) that is higher than branched alkane 3 (4 °C).	1
			The flashpoint is also lowered with more branching in an alkane molecule.	1
			Branched alkane 2 has more branches and thus has a lower flashpoint (-65 °C) as compared to branched alkane 1 (flashpoint = -57 °C)	1
	(f)	<i>(</i> i)	Students should select all relevant information in both Table 2 and 3 .	1
	(י)	(1)	This allows the petrol to burn <u>when the temperature is very low</u> .	
			Pure octane has a <u>higher flashpoint</u> (above 0 °C). Thus, <u>petrol may</u> <u>not be able to burn</u> when the temperature is very low.	1
			as the freezing point of octane is very low.	
		(ii)	In hot weather conditions, pentane and branched alkane 2 will evaporate easily as their boiling point are very low / they are very volatile.	1
			The gaseous hydrocarbons can <u>easily escape from petrol tanks</u> which are <u>not air tight</u> .	1
8	(a)		A lean burn engine will reduce the amount of carbon monoxide and nitrogen monoxide formed.	1
			A higher ratio of air ensures a more <u>complete combustion of the carbon</u> <u>containing fuel</u> and thus less carbon monoxide is formed.	1
			The lower running temperature of the engine reduces the formation of nitrogen monoxide as its formation requires a high temperature .	1
	(b)		$2CO + 2NO \rightarrow N_2 + 2CO_2$	1
			Students need to combine both equations through 2[O].	

	(c)	(i)	As the amount of air is increased, the percentage of <u>CO removed from</u> the converter increases, while the percentage of <u>NO removed</u> decreases.	1
			An increased in the amount of air provided a <u>larger amount of atmospheric oxygen to oxidise the CO</u> to CO ₂ .	1
			However, this <u>reduces the amount of NO that is required to oxidise</u> <u>CO</u> .	1
		(ii)	While the percentage of carbon monoxide removed increases, the percentage of nitrogen monoxide removed remains constantly high.	1
			This suggests that there must be other substances reacting with nitrogen monoxide to remove it.	
-	CIT!			
9	(a)	IER	When LiCL is dissolved in water, the process is exothermic and heat	
	(α)		energy is released to the surroundings, resulting in an increase in temperature. The enthalpy change is negative.	1
			On the other hand, when NaC <i>l</i> is dissolved in water, the process is <u>endothermic</u> and <u>heat energy is absorbed from the surroundings</u> , resulting in a <u>decrease in temperature</u> . The enthalpy change is <u>positive</u> .	1
			The amount of energy change / enthalpy change is higher in LiC <i>l</i> than NaC <i>l</i> , resulting in a larger temperature change observed in LiC <i>l</i> than in NaC <i>l</i> .	1
	(b)	(i)	Heat energy is absorbed from the surrounding when potassium chloride is dissolved in water. The reaction is endothermic.	1
		(ii)	Number of moles in 4.0 g of KC $l = \frac{4.0}{39+35.5} = 0.053691$ mol	1
			Energy change = $+\frac{720}{1000}$ = +0.720 kJ	1
			$\Delta H = \frac{0.720}{0.053691} = +13.4 \text{ kJ/mol}$	1
		(iii)	The particles move away from their <u>neatly and closely packed</u> <u>arrangement</u> to one that is <u>further apart in a disorderly manner</u> .	1
			The particles which <u>vibrate in their fixed position</u> in the solid state <u>move</u> <u>freely within the liquid body / slide past each other</u> when KC <i>l</i> is dissolved in water.	1
			As the question mentioned "what happens", students are required to contrast the arrangement and movement in the solid state.	
1				

9	OR			
	(a)	(i)	Fluorine is more reactive than bromine.	1
			It <u>displaces bromine</u> from the solution of potassium bromide forming <u>aqueous bromine</u> , which is <u>brown</u> in colour.	1
			$F_2(g) + 2Br^-(aq) \rightarrow 2F^-(aq) + Br_2(aq)$	1
			State symbols are insisted.	
		(ii)	When a jet of <u>chlorine</u> gas is used, the <u>filter paper turns brown</u> .	1
			When a jet of <u>iodine</u> gas is used, there is <u>no visible change observed</u> .	1
			Chlorine is more reactive than bromine and will thus displace bromine. Iodine is less reactive than bromine and will not be able to displace bromine.	1
	(b)	(i)	$3F_2(g) + 2Fe(s) \rightarrow 2FeF_3(s)$	2
			1m – balanced equation 1m – state symbols	
		(ii)	Since <u>fluorine causes iron to be oxidised while itself is reduced</u> , <u>fluorine is</u> <u>an oxidising agent</u> . (<i>This phrase is required.</i>)	
			During the reaction, the oxidation state of fluorine decreases from 0 in F_2 to -1 in FeF ₃ . Each fluorine atom gains one electron to form F^- ion. Hence, fluorine is reduced.	1
			At the same time, the oxidation state of iron increases from 0 to +3 in FeF_3 . Each Fe atom loses 3 electrons to form Fe^{3+} ion. Hence, iron is oxidised.	1
			Both oxidation state AND electron transfer must be discussed as mentioned in the question.	

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Suggested Answers

Paper 2

Section A [50 marks]

A1	Topic tested: Ammonia Total: 5 mark	S
(a)	D	1
	The word 'solid' was overlooked and students chose ammonia, C as the incorrect	
(1)	option.	
(b)	C	1
(C)(I)	B and C	1
	D and E ware commonly chosen as the wrong enswer	
	$C_2(OH)_2 + 2NH_NO_2 \rightarrow C_2(NO_2)_2 + 2NH_2 + 2H_2O_2$	
	salt das escapes	
(c)(ii)	(NH ₄) ₂ SO ₄	1
	$H_2SO_4 + 2NH_3 \rightarrow (NH_3)_2SO_4$	
	note that this reaction is neutralisation (acid + alkaline gas)	
(d)	A and E	1
	The word (colid) was everlaplyed and students above emmonic. C so the incorrect	
	ontion	
A2	Topics tested: Properties of allovs, reactivity series Total: 6 mark	S
(a)(i)	In stainless steel, atoms of different sizes [1 mk pt] like chromium are added to	2
	iron for alloying. As such, the orderly arrangement of the atoms is disrupted [1	
	mk pt]. Hence, it is harder for the atoms to slide over one another [1 mk pt]. This	
	makes stainless steel <u>harder</u> than pure iron.	
	Ourstands 101	
	3 mk pts - [2]	
(a)(ii)	1-2 IIIK p(s - [1])	1
(a)(ii) (a)(iii)	The layer of chromium oxide serves as a protective layer to coat the stainless	1
(a)(iii)	steel, to prevent oxygen and water from reaching the iron underneath it and	
	cause iron to rust.	
(b)(i)	The iron will not rust. Chromium is more reactive than iron and serves as a	1
	sacrificial metal and corrodes in place of iron.	
	Some students incorrectly commented that chromium rusts. Rusting is only for	
(1-)(!!)	Iron. Other metals corrode.	
(II)(a)	Electroplating of chromium onto Iron.	1
	Some students incorrectly suggested painting which is not feasible	
A3	Topics tested: Organic Chemistry (Macromolecules) Total: 8 mar	'ks
(a)	Ester linkage	1
	Some students incorrectly suggested carboxylate.	

(b)	Poly(ethene)	1
(b) (c)	Poly(ethene) $\begin{array}{cccccccccccccccccccccccccccccccccccc$	12
	diol structure [1]	
	Some students incorrectly miscounted the carbon backbone in the dicarboxylic acid structure.	
(d)	Addition polymerisation involves monomers that have at <u>least one carbon- carbon double bond (C=C) functional group</u> whereas condensation polymerisation involves monomers that have <u>at least one functional group at</u> <u>each end of the molecule</u> [1]. During addition polymerisation, there is <u>no loss of any molecules or atoms</u> . However, during condensation polymerisation, <u>small molecules such as water</u> <u>are eliminated / released</u> as a by-product of the reaction [1]. <u>Empirical formula of the addition polymer is the same as the monomer</u> but the empirical formula of the condensation polymer is different from its monomer [1] / <u>molecular weight of addition polymer is a multiple of the molecular</u> <u>weight of the monomer</u> whereas molecular weight of a condensation polymer is not a multiple of the molecular weight of the monomer. Some students did not give three separate points. There were ambiguous answers like 'the products have a lower mass than the reactants.' This is incorrect as the law of conservation of mass is not met.	3
(e)	$M_{\rm r} {\rm of monomer} = (12 + 12 + 4)$ = 28	1
	Number of repeating units = $\frac{2800}{28}$ = 100	
	Since each repeating unit has 2 carbon atoms, number of carbon atoms = 100×2 = 200	
	Some students calculated the number of repeating units = 100 and did not find the total number of carbon atoms.	

A4	Topics tested: Energy from chemicals (bond energy), organic chemistry (tren isomerism, homologous series) Total: 12 ma	nds, rks
(a)	Molar mass of propanol = $(12 \times 3 + 8 \times 1 + 16)$ = 60 g/mol [1]	2
	Enthalpy change - 2010kI / mol	
	$=\frac{2010037mol}{60g/mol}$	
	= -33.5 kJ/g [1]	
	Note: Negative sign, units and 3 significant figures are <u>insisted</u> in the final answer.	
	Some students omitted the signs and units or gave an incorrect unit.	
(b)	The <u>total amount of energy absorbed / taken in</u> to <u>break</u> the covalent <u>bonds</u> in <u>alcohols</u> and <u>oxygen</u> [1] is <u>lesser than</u> [1] the total amount of <u>energy released</u> / <u>given out</u> to form the <u>bonds in water</u> and <u>carbon dioxide</u> [1], resulting in an exothermic reaction.	3
	Some incorrect answers include 'energy is needed to form bonds' and omitting oxygen as one of the reactants for bond breaking.	
(c)	The enthalpy change of combustion increases from methanol to butanol due to the <u>increase in the number of carbon atoms.</u> As such, the number of C=O bonds in carbon dioxide formed increases, <u>releasing a larger amount of heat energy from the products</u> . Students found this question <u>challenging</u> and the answers were not specific	1
(d)	 As the molecular size of the alcohols increases down the homologous series, the melting and boiling points of the alcohols increase, the viscosity of the alcohols increases, the density of the alcohols increases, the solubility of the alcohols in water decreases, the flammability of the alcohols decreases. 	2
	Any of the three physical properties 3 properties – [2] 1-2 properties – [1] Note: enthalpy change of combustion must not be mentioned cannot be mentioned as a property as it is specified in the question.	
(e)(i)	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ [1] CH ₂ OCH ₂ + 3O ₂ → 2CO ₂ + 3H ₂ O [1]	2
(e)(ii)	As both isomers have <u>different structural formula</u> [1 mk pt], this means that	2
	the <u>types of bonds and the number of each of the types of bonds</u> present in both isomers are <u>different</u> [1 mk pt]. Thus, the <u>amount of energy</u> required to <u>break the bonds</u> in each isomer is <u>different</u> [1 mk pt]. This results in different enthalpy changes. 3 mk pts – [2] 1-2 mk pts – [1] Students found this question challenging and the answers were not specific	
	enough.	

A5	Topics tested: Electrochemistry (electrolytic cell) Total: 10 ma	rks
(a)	At the positive electrode:	2
	$4OH^{-}(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^{-}$	
	At the negative electrode:	
	$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$	
	[1] – awarded for correct balanced equation at the positive electrode	
	[1] – awarded for correct balanced equation at the negative electrode	
	[1] – awarded for correct state symbols for <u>both</u> equations.	
	Some students reversed the equations for the positive and porative electrodes	
	some students reversed the equations for the positive and negative electrodes	
(b)(i)	As the total time taken increases, the mass of the electrode increases and then	1
	stavs constant after 60 minutes	•
(b)(II)	The mass of the electrode recorded (4.15 g) when the total time is at 20 minutes	2
	is wrong [1]. Record on the general trend, the mass of electrode increases by about 0.4 g	
	based on the general trend, the mass of electrode <u>increases</u> by about <u>0.4 g</u>	
	4 30 g [1]	
(b)(iii)	All of the Cu^{2+} ions in the electrolyte have been discharged to form copper.	1
(~)()		•
	Some students incorrectly stated that 'all the copper had been used up'. Note	
	that it is the copper(II) ions that have been discharged.	
(c)	The mass of the negative electrode recorded does not stay constant / will be	3
	higher and keeps increasing with time (beyond 60 minutes) [1].	
	As copper electrodes are reactive / not inert, the positive copper electrode /	
	anode dissolves to form Cu ²⁺ ions, which enter the solution [1].	
	Thus, the <u>concentration of Cu²⁺ ions in the solution does not change as there will</u>	
	be a <u>continuous supply of Cu²⁺ ions</u> to be <u>discharged</u> to form copper metal,	
	deposited on the negative electrode [1].	
	Note: The question asks (how the results differ) indicating that students should	
	answer how the mass of the electrode recorded would be different (higher or	
	lower) using copper electrode	
	This question was poorly attempted. Many students incorrectly discussed the	
	rate of reaction and use imprecise language like 'copper being discharged to	
	form Cu^{2+} ions.' Some incorrectly described the cathode dissolves to form Cu^{2+}	
	ions. Students who did not perform in this question wrote about electrolysis	
	without answering the question.	
A6	Topics tested: Energy from chemicals (energy profile diagram), organic chemis	stry
	(cracking and isomerism) Total: 9 mar	'ks
(a)	Cracking of <u>long-chain molecules</u> in naphtha produces <u>smaller / short-chain</u>	2
	molecules [1]. Substances with short-chain molecules like petrol are more useful	
	and are in nigher demand than substances with long-chain molecules [1].	
	Some students discussed the uses of nanhtha instead of addressing the	
	demand of smaller fractions.	
1		



Section B [30 marks]

B7	Topic tested: Acids and bases Total: 12 mar	ks
(a)	By calculation:	2
	$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$	
	No. of mol of NaOH	
	$= 0.1 \times \frac{20}{1000}$	
	= 0.00200 mol [1]	
	Comparing molar ratio:	
	$2 \text{ mol NaOH} \equiv 1 \text{ mol } H_2SO_4$ 0.002 mol NaOH = 0.001 mol H_2SO_4	
	Concentration of H ₂ SO ₄	
	$=\frac{0.001}{20}$	
	= 0.0500 mol/dm ³ [1]	
	20.0 cm ³ of 0.05 mol/dm ³ of H_2SO_4 is required to completely neutralise 20.0 cm ³ of 0.1 mol/dm ³ of NaOH.	
	By reasoning:	
	Sulfuric acid is a <u>dibasic acid</u> . For every <u>one mole</u> of H_2SO_4 used, <u>two moles of NaOH</u> is required [1]. Thus, for the <u>same volume</u> of H_2SO_4 and NaOH used in the reaction (20 cm ³), the <u>concentration of NaOH</u> used in the reaction must be <u>twice</u> than that of the <u>concentration of sulfuric acid</u> [1].	
	Some students did not recognise that sulfuric acid is a dibasic acid which releases twice the concentration of hydrogen ions as compared to hydrochloric acid.	
(b)(i)	A strong acid <u>ionises completely in water</u> to give a <u>high concentration of</u> <u>hydrogen ions</u> but a weak acid <u>ionises partially in water</u> to give a <u>low</u> <u>concentration of hydrogen ions</u> .	1
	Some students discussed weak acids as partially dissolving rather than dissociating / ionising.	
(b)(ii)	In the graph of titration 1, the <u>'step' in the pH change</u> occurs from about <u>pH 2</u> <u>to 12</u> , which is <u>larger than</u> the <u>'step' in the pH change</u> that occurs from about <u>pH 8 to 11</u> in the graph of titration 2 [1].	2
	In the graph in titration 1, the pH <u>increases very gently / minimally from pH 1</u> <u>to pH 2</u> when the volume reaches 20.0 cm ³ whereas in the graph in titration 2, the pH <u>increases gradually with a constant gradient from pH 2.5 to about</u> <u>pH 8</u> when the volume reaches 20.0 cm ³ [1].	
	This question was poorly attempted. Students only partially referred to the data given in the graph. Students should give a full description in terms of pH change, reinforcing this by quoting pH and volume readings from the graphs to show that data has been processed effectively.	

-		
(c)(i)	'step 1': $H_3PO_4 \rightarrow H^+ + H_2PO_4^-$ [1] 'step 2': $H_2PO_4^- \rightarrow H^+ + HPO_4^{2-}$ [1]	2
	Note: Hints on how to write the equations can be obtained from the ionisation of	
	sulfuric acid from the graph in titration 3.	
	This question was poorly attempted. Students wrote full equations to produce	
(-)(!)	water. Some students omitted charges from anions or unbalanced equations.	4
(C)(II)		1
	Note: The definition of a salt is the replacement of the hydrogen ions by a metallic	
	or ammonium ion. In this case, H ⁺ ions are replaced by Na ⁺ ions, with no overall	
	net charge.	0
(a)(I)	In the titration between strong acids and dilute sodium hydroxide (titration 1 and 3), the 'step' happens in the pH change from about 2 to 12 [1 mk of]. Methyl	2
	orange changes colour at the pH range from 3 to 5 litmus changes colour at the	
	pH range from 6 to 8 and phenolophthalein changes colour at the pH range from	
	8 to 10 [1 mk pt]. Since all of the indicators changes colour within the pH	
	range in the 'step' [1 mk pt], any of the indicators can be used.	
	3 mk pts – [2]	
	1-2 mk pts = [1]	
	This question was poorly attempted. Students were not clear in explaining why	
	all the indicators could be used. General answers like 'they all change colour'	
	were given without supporting evidence from the pH range of the indicators in	
	the diagram.	
(d)(ii)	In the titration between ethanoic acid and dilute sodium hydroxide, the 'step'	1
	happens in the <u>pH change from 8 to 11</u> . However, <u>methyl orange</u> changes colour	
	from <u>pH 3 to 5</u> , which will remain yellow throughout the entire titration. This	
	makes methyl orange not a suitable indicator.	
	Note: Hints on the choice of the indicator is given on the top of the third page of	
	the data-based question that "an indicator can also be used to see when a 'step'	
	happens in the pH change"	
	Most students did not explain why with clear reference to the data given on the	
	araph and the indicator colour changes.	
(d)(iii)	phenolphthalein	1
B8	Topic tested: Chemical bonding (simple and giant covalent structures)	_
(-)	Total: 8 ma	rks
(a)	Both diamond and graphite are made up of <u>carbon atoms chemically bonded</u>	4
	notecular / diant covalent structures [1]. Both diantonid and graphite have giant	
	In diamond, each carbon atom is covalently bonded to 4 carbon atoms, whereas	
	in graphite, each carbon atom is covalently bonded to 3 other carbon atoms [1].	
	In diamond, all the 4 valence electrons of each carbon atom are used in covalent	
	bonding, whereas in graphite, only 3 out of 4 valence electrons are used in	
	covalent bonding [1], resulting in one delocalised electron from each carbon	
	atom.	
	Come students mentioned that everybits has (starsed that are very used to the U	
	some sudents mentioned that graphite has 'atoms' that are not used in bonding and that graphite has 'free moving ions' which are incorrect	
1	and that graphito hao hoo hoving long, which are mounout.	

(b)	Graphite has <u>high melting and boiling points</u> because a <u>large</u> amount of energy is required to <u>break the strong covalent bonds</u> between carbon atoms [1 mk pt]. Carbon dioxide on the other hand, has <u>low melting and boiling points</u> because a <u>small amount of energy is required to <u>overcome</u> the <u>weak intermolecular forces</u> <u>of attraction</u> between the <u>molecules</u> [1 mk pt]. As only <u>3 out of 4</u> valence electrons are used in covalent bonding in the carbon atoms of graphite, there is <u>one free electron</u> from <u>each carbon atom</u> to <u>become</u> <u>delocalised</u> to <u>move along the layer</u> of carbon atoms to function as charge carriers to allow graphite to conduct electricity [1 mk pt]. However in carbon dioxide, there are <u>no mobile ions or mobile electrons</u> to function as charge carriers to allow carbon dioxide to conduct electricity [1 mk pt]. Graphite is insoluble in water because water is <u>not able to penetrate</u> the <u>giant molecular structure</u> to <u>break the strong covalent bonds</u> [1 mk pt]. Hence, solvation does not occur. Carbon dioxide on the other hand is able to <u>react with water</u> to form <u>carbonic acid</u>, which <u>ionises</u> partially to give <u>hydrogen ions</u>, leading to an acidic solution [1 mk pt].</u>	4
	1 mk pts – [1] Note: Not all the valence electrons in carbon dioxide are used in covalent	
	bonding. Some students did not discuss all the properties. Solubility was often omitted. Some students also confused with the bonds broken in graphite and the weak intermolecular forces of attraction that was overcomed.	
B9E	Topic tested: Chemical bonding, mole concept, redox and Group VII	rks
(a)	$\begin{bmatrix} Br \\ P \\ Br \\ X \\ X \\ Y \\ Y$	2
	[1] – correct number of remaining valence electrons on P and Br	
(b)	$PBr_3 + 3H_2O \rightarrow H_3PO_3 + 3HBr$	1
(c)(i)	Oxidation state of P increases from 0 in P to $+3$ in PBr ₃ .	1
(c)(ii)	No. of mol of PBr ₃ = $\frac{54.2}{31+80+80+80}$ = 0.200 mol [1]	3

	Comparing molar ratio: $\begin{array}{c} 2 \text{ mol } PBr_3 \equiv 3 \text{ mol } Br_2 \\ 1 \text{ mol } PBr_3 \equiv 1.50 \text{ mol } Br_2 \\ 0.2 \text{ mol } PBr_3 \equiv 0.3 \text{ mol } Br_2 \text{ [1]} \end{array}$ Mass of Br ₂				
	Mass of Br_2 = 0.3×(80+80) = 48.0 g [1]				
	Some studen	ts found it challenging to	calculate the Mr of both	h phosphorus	
(d)(i)	The <u>rate of rea</u> of reaction be <u>more reactive</u> Some student reaction, lead led to a slowe	action between <u>chorine and</u> etween bromine and phose than bromine [1]. ts incorrectly explained that ling to a smaller yield of pl or rate of reaction between	<u>I phosphorus</u> will be <u>faste</u> phorus [1]. This is becau chlorine and phosphorus hosphorus trichloride form chlorine and phosphorus	than the rate se chlorine is is a reversible red. This then c. Please note	2
(d)(ii)	that yield of th	ne product is NOT THE SA	ME as the rate of reaction	ction Hence	1
(u)(ii)	the product pl	hosphorus trichloride forme lorine and phosphorus.	ed would <u>dissociate bac</u>	k to form the	
B9OR	Topic tested:	Periodic Table (Group I an	d Group VII)	Total: 10 mai	rks
(a)	element	number of shells of	number of shells of		2
		electrons in atom	electrons in +1 ion	-	
	lithium	2	<u><u>1</u></u>	_	
	sodium	3	2	_	
	potassium	4	<u>3</u>		
	[1] – awarded	for all three correct answe	ers		
	element	number of shells of	number of shells of	7	
		electrons in atom	electrons in -1 ion		
	fluorine	2	<u>2</u>		
	chlorine	3	<u>3</u>	_	
	bromine	4	<u>4</u>		
	[1] – awarded	for all three correct answe	ers		
	Some student	ts had problems identifying	the number of shells in G	iroup I and	
(b)	Some students had problems identifying the number of shells in Group I and Group VII. Down Group I, the atomic radii increase from lithium to potassium [1]. This is due to the increase in the number of electron shells down the group. There is an increase in 1 electron shell down the group of each element, leading to an increase in the atomic radius [1]. Some students identified the trend but did not answer the second part of the				2
	question to ex	plain the trend.			

(c)(ii)	As lithium loses its only electron in the valence electron shell to form a lithium ion, the number of electron shells decreases from 2 to 1, leading to a smaller	1
	radius.	
(c)(iii)	Li atom	2
	(2, 1) (2)	
	[1] – correct structure of lithium atom [1] – correct structure of lithium ion	
(d)	Prediction: <u>115 pm</u> (any possible range from 115 to 196 pm) [1]	2
	Reasoning: Based on the radii of atoms and ions with <u>4 electron shells</u> , atoms or ions with 4 electron shells should have a <u>range of 115 pm to 196 pm</u> [1]. Hence, the ionic radii of strontium ion could be 115 pm.	

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Suggested Answers

Paper 2

Section A [50 marks]

A1	(a)	A	1
	(b)	D	1
	(c)	E	1
		SiO ₂ is acidic and CaO is basic.	
	(d)	В	1
		CO_2 is NOT a toxic gas. It is not considered to be an air pollutant.	
	(e)	B and C	1
	(f)	High carbon steel is stronger and harder than low carbon steel. [1] High carbon steel is less malleable/more brittle than low carbon steel [1] TWO properties are expected as the question reads "How are the properties."	el. 2
A2	(a)	S X C X S • electron of C x S X S • electron of S A linear molecule is predicted as sulfur belongs to the same group in the Periodic Table as oxygen. The molecule is similar to CO2. Electrons involved in bonding (2 C=S bonds) – [1] Other valence electrons of sulfur – [1]	2 he
	(D)	truefalseCarbon disulfide has a low boiling point. \checkmark Carbon disulfide has a good electrical conductivity when molten \checkmark Carbon disulfide is very soluble in water. \checkmark Carbon disulfide is a crystalline solid at room temperature \checkmark 4 correct answers – [2] 2-3 correct answers – [1] 1 correct answer – [0]	

	(c)		2
		2+ Legend: x electron of S • electron of S x x	
		magnesium ion sulfide ion	
		Valence electrons correct – [1]	
A3	(a)	As the reaction progresses, more <u>sulfur</u> [1] is produced which appears as a pale yellow precipitate. Formation of the <u>thick precipitate does</u> <u>not allow the cross to be seen / covers the cross</u> . [1] <i>Must be able to identify the substance as sulfur.</i>	2
	(b) (i)	With a lower concentration (from 1.0 to 0.2 mol/dm ³), there are <u>lesser</u> reactant particles per unit volume of solution. [1] There are <u>less frequent</u> <u>collisions</u> between reactant particles, resulting in a <u>lower frequency of</u> <u>effective collision decreases</u> . [1] This <u>slows down</u> the speed of the reaction and a <u>longer time is taken</u> for enough sulfur to form so that the cross cannot be seen. [1]	3
	(b) (ii)	0.6 mol/dm^3 Any value between $0.5 - 0.6 \text{ mol/dm}^3$ is acceptable.	1
	(c) (i)	He could repeat the experiment using the <u>same volume</u> and <u>concentration</u> of dilute hydrochloric acid to add to the <u>same volume</u> of sodium thiosulfate of <u>concentration of 0.2 mol/dm³</u> (or 0.4 mol/dm ³ , 0.8 mol/dm ³ , 1.0 mol/dm ³), but with a little <u>chromium(III)</u> oxide (0.1 g) added. <i>Must mention what should be done, with the variables that need to be controlled.</i> [1] He could <u>measure the time</u> from when the acid was added until the cross could no longer be seen. <i>Mention what results need to be collected.</i> [1] If he is right, the time measured should be <u>less than 39 s</u> (or 20 s, 10 s, 8 s). <i>Mention what results to expect.</i> [1]	3
	(c) (ii)	They do so by providing an <u>alternative pathway</u> of lower activation energy for the reaction to occur.	1
		energy of the reaction".	
A4	(a)	The reaction produces <u>aqueous iodine</u> that gives the brown colour. Must mention the correct product that gives the brown colour. Iron(II) sulfate solution is light green and NOT brown.	1

	(b)	K ₂ SO ₄ [1]	2
	(-)	potassium sulfate [1]	0
	(C)	IFON: +3; +2 [1] iodino: 1:0 [1]	2
	(1)		
		The entire row must be correct in order to score.	
	(c)	Iron is reduced in the reaction. This is because Fe^{3+} in $Fe_2(SO_4)_3$ gained	1
	(ii)	electrons to form Fe^{2+} in $FeSO_4$.	
		Mention the element. Explanation should be based on electron transfer	
		as required by the question.	
	(d)	Iron(II) sulfate will produce a <u>green precipitate</u> [1] while iron(III) sulfate	2
		will produce a <u>reddish-brown precipitate</u> . [1]	
	(e)	Test a solution of iron(II) sulfate with a piece of blue litmus paper.	1
		Describe the test, don't just mention "blue litmus paper".	
		The litmus paper will turn red to show that the solution is eside	
		Describe the expected result	
		Another acceptable answer is the use of a pH probe/sensor with	
		datalogger in which the pH measured is below 7. Students are advised	
		to avoid the use of Universal indicator because the pH of the solution is	
		not specified. Thus, the colour change may not be accurate.	
A5	(a)	oxygen; water	1
	(b)	Vehicles with petrol engines emit air pollutants such as carbon	3
		with the beemoglobin in the blood to form carboxybeemoglobin, thereby	
		preventing the blood from transporting oxygen efficiently [1] Nitrogen	
		dioxide and sulfur dioxide are acidic gases that cause breathing	
		difficulties. [1] On the other hand, vehicles with fuel cells produce only	
		water as a harmless waste product. [1]	
		Students should read the question carefully to pick out the requirement	
		of the question to describe the narmout effects of all pollutants on numan	
		acceptable Students are expected to mention as a comparison the	
		emissions from vehicles with fuel cells.	
	(C)		2
		energy ↑	
		$2H_2 + O_2$	
		enthalpy change of	
		2H ₂ O reaction	
		$ \qquad \qquad \longrightarrow \qquad $	
		progress of reaction	
		Electrolysis of water requires electrical energy	
		\Rightarrow endothermic reaction NOT exothermic	
		Formulae of the products – [1]	
•	1	Upright arrow showing only ONE direction (UP) – [1]	

	(d)	Hydrogen may be obtained from water by electrolysis, a process that <u>requires electrical energy</u> . This energy is obtained through the <u>burning of fossil fuels [1]</u> which emits <u>air pollutants such as nitrogen</u> <u>dioxide and sulfur dioxide. [1]</u> Thus, hydrogen may not be a completely non-polluting fuel. Reference should be made to the information provided in (c) which states that hydrogen for fuel cells can be obtained from water by electrolysis and that electricity is used to provide the energy for	2
A6	(a) (i)	If the sample of aspirin melts over a <u>range of temperatures</u> , it shows that the sample of aspirin is <u>impure</u> . [1] However, if the sample of aspirin melts at a <u>fixed temperature</u> , the sample is <u>pure</u> . [1] <i>"A range of temperatures" is NOT the same as "having variable melting</i>	2
	(-)	point". The latter suggests that the melting point changes.	0
	(a) (ii)	other unknown substance [1] as impurities.	2
	(b)	A weak acid <u>ionises/dissociates partially in water</u> to form a <u>low</u> <u>concentration of H⁺ ions</u> .	1
	(c)	No. of mol of NaOH = $\frac{0.10 \times 16.70}{1000}$ = 0.00167 mol [1]	3
		1 mol of NaOH \equiv 1 mol of aspirin	
		No. of mol of aspirin = 0.00167 mol	
		Mass of aspirin in one tablet = 0.00167×180 = 0.3006 g = 300.6 mg $\approx 301 \text{ mg}$ [1]	
		The student's results do not agree with the value as it is slightly more than 300 mg. [1]	
	(d)	working must be clearly snown and answer expressed in 3 s.f.	2
	(u)	sodium hydroxide. [1] Thus, the mass of aspirin calculated is <u>more than</u> the actual. [1]	2
		Students should mention how the calculated value is affected.	

Section B [30 marks]

B7	(a)	Across Period 3, the ratio of the number of chlorine atoms to the number of atoms of the other element <u>increases</u> from 1:1 for sodium to 4:1 for silicon. [1] After silicon, the ratio <u>decreases</u> to 1:3 for phosphorus and 1:1 for sulfur and chlorine. [1] <i>It may be easier to describe the ratio as that of the number of chlorine atoms to the number of atoms of other elements.</i>	2
	(b)	silicon chloride or SiCl ₄	1
	(i)	This is because the product formed. SiO ₂ , is insoluble in water.	
	(b)	$PCl_3 + 3H_2O \rightarrow H_3PO_3 + 3HCl$	1
	(c)	The oxidation state of chlorine increases from 0 in Cl_2 to +1 in the formation of HC <i>l</i> O. [1] The oxidation state of chlorine decreases from 0 in Cl_2 to -1 in the formation of HC <i>l</i> . [1] Since the oxidation state of chlorine increases and decreases in the	2
		same reaction, a disproportionation reaction is said to have occurred. Must mention how the oxidation state of chlorine changes. The meaning of disproportionation is given in the passage.	
	(d)	The information in the table supported only the idea of <u>student 2</u> . [1] <i>Must mention which student.</i> As can be seen from the table, <u>all covalent chlorides hydrolyse but not</u> <u>the ionic chlorides</u> . Thus, whether or not a chloride hydrolyses, depends on the bonding of the chloride. [1] <i>Describe the evidence that supports the idea.</i> However, <u>some metal chlorides hydrolyse (A/Cl₃) and not others (NaCl and MgCl₂). Thus, whether or not a chloride hydrolyses, is not linked to the metal or non-metal character of the element. [1] <i>Explain why the idea of student 1 is not supported.</i></u>	3
	(e)	In all cases, if a chloride hydrolyses, <u>hydrochloric acid</u> is produced. [1] Thus, if a chloride hydrolyses, the pH of the solution will be <u>below 7</u> (due to the <u>H⁺ ions from hydrochloric acid</u>), otherwise the pH of the solution should be 7. [1] <i>Must make reference to hydrochloric acid that is produced.</i>	2
	(f)	Argon is a noble gas with <u>all the electron shells completely filled with</u> <u>electrons</u> . Hence, argon is <u>unreactive</u> and so, <u>does not form a compound</u> <u>with chlorine</u> .	1
Do		Experiment 1	2
Dð	(a)	Anode: $4OH^{-}(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^{-}[1]$ Cathode: $Ag^{+}(aq) + e^{-} \rightarrow Ag(s)^{*}$	3

		Experiment 2 Anode: Ag(s) \rightarrow Ag ⁺ (aq) + e ⁻ [1]	
		Cathode: Ag ⁺ (aq) + $e^- \rightarrow Ag(s)^{-1}$	
		Both reactions * correct – [1] Students are advised to present their answers clearly, specifying which	
		experiment and electrode they are referring to, when writing the	
	(b)	equations. A white precipitate will be observed due to the formation of insoluble	2
	(i)	silver chloride. [1]	2
		$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3 [1]$	
		An explanation is expected in the question. Ionic equation is also acceptable, $Ag^+ + Cl^- \rightarrow AgCl$	
	(b)	After some time, all the silver ions are discharged in	2
	(ii)	Experiment 1. Thus, no more silver is being deposited on the object.	
		However, in Experiment 2, silver ions are <u>continuously being</u> <u>produced</u> as the silver rod (anode) <u>dissolves</u> into the electrolyte. Thus, silver ions are still being discharged and silver is being deposited on the object.	
		He could add a few drops of <u>aqueous sodium chloride</u> to a sample of each electrolyte from <u>Experiment 1 and Experiment 2</u> . A white precipitate will form in the electrolyte taken from Experiment 2 but not from Experiment 1, indicating the presence of silver ions. This shows that his reasoning is correct. [1]	
		Explanation for observation, especially where the silver ions came from – [1] Description of test and expected results – [1]	
	(c)	Iron is more reactive than silver. Thus, iron will displace silver from its salt solution and a coating of silver forms on the iron. However, gold is less reactive than silver and so, is not able to displace silver from its salt solution.	1
		Must compare the reactivities of the 3 metals, iron, silver and gold.	
B 9	(a)	The reddish-brown bromine water turns colourless.	1
(E)	(i)		
	(a)	Must mention the original colour of bromine water	1
	(ü) (ii)		
	(b)	Margarine 3. [1] It contains 40% by mass of water compared to margarine 1 and margarine 2 which have 10% each. [1]	2
		Must state the comparative water content.	
	(c)	% by mass of unsaturated fat in this margarine = 20% Thus, number of drops of bromine water required = 3	1
		The % by mass of unsaturated fat is the same as for margarine 3.	

	(d) (i)	No, I do not agree with the student. Iodine <u>only reacts with unsaturated fats</u> and not saturated fats. The mass of iodine that reacts can only <u>compare the amount of</u> <u>unsaturated fats</u> in each cooking oil. It does not compare the total amount of saturated and unsaturated fats. [1] It is correct to say that oil C contains a larger amount of <u>unsaturated fats</u> than oil D. [1] <i>Must mention that iodine does not react with saturated fats. Students</i> <i>must be able to identify the term 'fats' refer to both saturated and</i> <i>unsaturated fats. It is advisable for students to give their own conclusion</i> <i>of the results.</i>	2
	(d) (ii)	No. of mol of iodine = $\frac{127}{2(127)}$ = 0.500 mol [1]	3
		No. of mol of fat = $\frac{100}{400}$ = 0.250 mol [1]	
		Mole ratio of fat : iodine = 0.250 : 0.500 = 1 : 2	
		Thus, there are 2 double bonds in each molecule.	
		For every one C=C double bond, 2 atoms of iodine are required for complete saturation.	
		2 atoms of iodine \equiv 1 molecule of iodine	
		Solution of $C=C$ double bond requires 1 mol of lodine (1 ₂) for complete saturation.	
B9	(a)	This is to ensure that <u>all the oxygen</u> in the air has reacted with copper.	1
0	(i)		
	(a)	$2Cu + O_2 \rightarrow 2CuO$	3
	(a) (ii)	$2Cu + O_2 \rightarrow 2CuO$ No. of mol of $Cu = \frac{1}{64} = 0.01563 \text{ mol } [1]$	3
	(a) (ii)	$2Cu + O_2 \rightarrow 2CuO$ No. of mol of Cu = $\frac{1}{64} = 0.01563 \text{ mol } [1]$ Mole ratio of Cu : CuO = 1 : 1 No. of mol CuO produced = 0.01563 mol [1] Mass of CuO produced = 0.01563 x (64 + 16) = 1.25 g	3
	(a) (ii)	$2Cu + O_2 \rightarrow 2CuO$ No. of mol of $Cu = \frac{1}{64} = 0.01563 \text{ mol } [1]$ Mole ratio of $Cu : CuO = 1 : 1$ No. of mol CuO produced = 0.01563 mol $[1]$ Mass of CuO produced = 0.01563 x (64 + 16) = 1.25 g Since the mass of solid left behind is less than 1.25 g (1.07g), this means that not all of the copper has reacted. Some copper must have been left behind at the end of the experiment. [1]	3
	(a) (ii)	$2Cu + O_2 \rightarrow 2CuO$ No. of mol of $Cu = \frac{1}{64} = 0.01563 \text{ mol } [1]$ Mole ratio of Cu : $CuO = 1$: 1 No. of mol CuO produced = 0.01563 mol [1] Mass of CuO produced = 0.01563 x (64 + 16) = 1.25 g Since the mass of solid left behind is less than 1.25 g $(1.07g)$, this means that not all of the copper has reacted. Some copper must have been left behind at the end of the experiment. [1] Or	3
	(a) (ii)	$2Cu + O_2 \rightarrow 2CuO$ No. of mol of $Cu = \frac{1}{64} = 0.01563 \text{ mol } [1]$ Mole ratio of $Cu : CuO = 1 : 1$ No. of mol CuO produced = 0.01563 mol $[1]$ Mass of CuO produced = 0.01563 x (64 + 16) = 1.25 g Since the mass of solid left behind is less than 1.25 g $(1.07g)$, this means that not all of the copper has reacted. Some copper must have been left behind at the end of the experiment. Or No. of mol of $CuO = \frac{1.07}{64 + 16} = 0.01338 \text{ mol } [1]$	3
	(a) (ii)	$2Cu + O_2 \rightarrow 2CuO$ No. of mol of $Cu = \frac{1}{64} = 0.01563 \text{ mol } [1]$ Mole ratio of Cu : $CuO = 1 : 1$ No. of mol CuO produced = 0.01563 mol $[1]$ Mass of CuO produced = 0.01563 x (64 + 16) = 1.25 g Since the mass of solid left behind is less than 1.25 g (1.07g), this means that not all of the copper has reacted. Some copper must have been left behind at the end of the experiment. Or No. of mol of $CuO = \frac{1.07}{64 + 16} = 0.01338 \text{ mol } [1]$ Mole ratio of $Cu : CuO = 1 : 1$ No. of mol of $Cu = 1 : 1$ No. of mol of $Cu = 1 : 1$ No. of mol of $Cu = 0.01338 \text{ mol } [1]$ Mass of Cu that reacted = 0.01338 mol $[1]$ Mass of Cu that reacted = 0.01338 mol $[1]$	3

(b) (i)	nitrogen	1
(b) (ii)	The air contains 21% of oxygen. During the reaction, <u>oxygen is used up</u> . (Copper is the reactant in excess.) [1]	2
	Total volume of gas left in the gas syringes = $\frac{79}{100} \times 200 = 158 \text{ cm}^3$ [1]	
(c)	Question: "describe and explain how the results of the tests would <u>differ</u> for each jar…"	3
	Describe the expected observations when gas in Jar A is tested. *When the gas from Jar A was tested, there would be <u>no change in the</u> <u>volume</u> after the experiment was carried out. The total volume of the gas would still read 200 cm ³ .	
	<i>Or</i> *When the gas from Jar A was tested, there would be <u>no change in the</u> <u>mass</u> of the solid the end of the experiment.	
	<i>Explain the observations expected for Jar A.</i> This is because the candle <u>used up the oxygen</u> in Jar A during <u>combustion</u> . There was <u>no more oxygen</u> available to react with the copper.	
	Describe the expected observations when gas in Jar B is tested. *When the gas from Jar B was tested, the total volume of gas that remained in the gas syringes at the end of the experiment would be 158 cm^3 .	
	Or	
	*When the gas from Jar B was tested, the mass of the solid at the end of the experiment would read 1.07 g.	
	<i>Explain the observations expected for Jar B.</i> This is because even after the candle <u>used up the oxygen in Jar B</u> , the plant in the jar can still undergo <u>photosynthesis</u> to replenish the oxygen in the jar. Thus, there is still oxygen available for the reaction with copper.	
	Hence, the mass of solid formed would be higher in the experiment that obtained the gas from Jar B than the gas obtained from Jar A.	
	Students must read and understand the question. Most students were not clear about what the question was asking. Students need to make reference to the processes that occurred, combustion and photosynthesis and to relate their answer to the results of the tests (using the same procedure as in Experiment 1).	
	Results of test with gas from Jar A Results of test with gas from jar B Explanation of how oxygen is used up with reference to combustion [1] Explanation of how oxygen is replenished with reference to photosynthesis [1]	

GCE 'O' Level Examinations 2012

Chemistry 6092

Suggested Answers

Paper 2

Section A

1	Tot	al = 6
This	question involves the reaction of acids and bases and QA	
ai	E	1
aii	В	1
	Acids react with carbonates to give salt, carbon dioxide and water	
aiii	C	1
	Acids react with reactive metals to give salt and hydrogen	
aiv	Α	1
	Note that metal carbonates/metal hydrogencarbonates will liberate carbon	
	dioxide gas when reacting with acids.	
b	copper(II) oxide	1
	Note that the hint given is a <u>blue</u> solution. Based on the colour, the metal ion present is conper(II) ion	
		1
C	aqueous sodium nydroxide / aqueous potassium nydroxide	1

	Note that the keyword is <u>titrated</u> and the products formed are salt and water. This implies that D must be an <u>alkali</u> . Any insoluble metal hydroxide / metal carbonate is not acceptable.	
2	Tota	d = 4
This ques	question involves the topic on atomic structure and formation of ions. Note that is stion insists on giving the ' names' , hence chemical symbol is <u>not acceptable</u> .	the
а	carbon-12 and carbon-14	1
b	fluorine-19 and neon-20	1
с	fluorine-19 and iodine-131	1
d	magnesium-24 and strontium-90	1
3	Tota	l = 9
This	question involves the topic on air pollution	
ai	Nitrogen oxides are formed when <u>nitrogen and oxygen in the air</u> [1] react under <u>high temperatures</u> [1] in the engine of the aircraft. Note that nitrogen comes from the air and <u>not from the fuel</u> . The reaction will require a high temperature for bond breaking and bond forming to occur.	2
aii	Lightning activity	1
bi	element: nitrogen [1]	2
	change in oxidation state: <u>+2 in NO to +4 in NO</u> ₂ [1]	
bii	Every one nitrogen monoxide molecule is able to break down two ozone molecules and <u>regenerate</u> another nitrogen monoxide molecule in the two step reaction [1]. The newly generated nitrogen monoxide molecule is able to take part in the reaction again. Hence, a <u>continuous cycle</u> of nitrogen monoxide molecules is being regenerated and this can destroy thousands of ozone molecules [1]. Students must be able to explain the regeneration of NO molecules for the cycle to repeat itself many times over.	2
ci	$2CO + 2NO \rightarrow 2CO_2 + N_2$	1
	Note that state symbols are not required as the question did not specify.	

cii	Carbon dioxide gas.	1	
	Carbon dioxide is a greenhouse gas that is able to trap heat energy in the atmosphere causing global warming .		
	Note that this question requires the identification of carbon dioxide gas and the problem it causes.		
	Sulfur dioxide is not accepted because the question asks for an environmentally harmful gas produced in <u>large amounts</u> .		
4	Tota	l = 8	
This	is question involves the topic on organic acids, esters and general trends.		
ai	но н 	1	
aii	product of reaction with ethanoic acid: <u>H₂O</u>	1	
	product of reaction with ethanoyl chloride: HCI		
	Note that the question insists on the ' formula' of both substances.		
aiii	Esters are used in the manufacture of perfume.	1	
	Esters are used as solvents for varnishes and paints.		
	Esters are used as artificial food flavouring.		
	Any 2 of the above is acceptable		
	Note that both uses must be given to be awarded full credit. The most		
	common incorrect answer given was sweeteners.		
bi	Name: propanoyl chloride [1]	2	
	Structure: [1]		
	н—с́—с́—с <i>і</i> І І		
	н н		
bii	C _n H _{2n+1} COC/	1	



cii	M_r of ammonium nitrate = 14 + 4 + 14 + 48 = 80 [1]	3
	% of nitrogen in ammonium nitrate = $[(14 \times 2) \div 80] \times 100\%$	
	= 35.0% [1]	
	Mass of nitrogen = [(35 ÷ 100] × 50 kg = 17.5 kg [1]	
ciii	Calcium hydroxide will react with ammonium nitrate to form calcium nitrate,	2
	water and <u>ammonia gas</u> [1]. This results in a loss of nitrogen in the form of ammonia to the atmosphere [1].	
6	Total	= 12
This	question involves the tonic on Periodic Table and chemical bonding	
ai	Melting and boiling points decrease down Group I from lithium to potassium [1].	2
	Melting and boiling points increases down Group VII from chlorine to jodine	
	[1].	
aii	Sodium consists of a giant metallic structure while chlorine consists of a	3
	simple molecular structure (exists as simple, discrete molecules) [1].	
	In sodium, a large amount of energy is required to overcome the strong	
	<u>cations</u> and the <u>'sea of delocalised electrons</u> ' [1].	
	However, in chlorine, a small amount of energy is required to overcome the	
	weak intermolecular forces of attraction between the molecules [1].	
	Hence, sodium has higher melting and boiling points as compared to chlorine.	
bi	The molecular mass of bromine is about twice that of chlorine [1]. However,	2
	the density of bromine is almost a hundred times that of chlorine [1].	
	Students have to compare the molecular masses and densities of both substances.	



Section B

B7	Tota	l = 12	
This	This question involves the topic on basic electrolysis and data-based analysis. Students should		
read	the question and extract relevant answers from the text.		
ai	If negative ions are able to pass through the membrane, the <u>hydroxide ions</u> will be able to migrate to the left compartment of the cell and <u>react with the chlorine</u> <u>gas</u> [1 mk pt]. This will <u>reduce the yield of chlorine</u> [1 mk pt] produced by the cell. If chloride ions are able to migrate to the right compartment of the cell and mix	3	
	with the sodium hydroxide solution [1 mk pt]. The sodium hydroxide solution produced is thus not pure and contains chloride ions as the impurities [1 mk pt].		
	4 mk pts – [3]		
	2-3 mk pts – [2]		
	1 mk pt – [1]		
aii	The membrane cell uses lesser energy [1] to electrolyse brine compared to the mercury cell.	2	
	The membrane cell does not produce <u>toxic wastes like mercury</u> . In the mercury cell, the <u>toxic mercury must be removed</u> from used brine [1] which may be dangerous and costly.		
	Note that merely stating the advantages would not be given full credit. Comparison words should be used to highlight advantages. The question requires more than one advantage.		
	'Low maintenance cost' is not considered in the answer as there is not direct comparison with the mercury cell.		
aiii	The <u>concentration</u> of sodium hydroxide produced using the membrane cell (35%) is <u>lower</u> than the mercury cell (50%) [1].	1	
b	No. of moles of chlorine = $1000000 \div 71$	2	
	= 1.4085 × 10 ⁴ mol <i>[1]</i>		
	Energy comsumption per mole = 2750 kWh \div 1.4085 × 10 ⁴ mol		

	= 0.195 kWh/mol [1]	
	Note that the common mistakes include using $A_r = 35.5$ instead of $M_r = 71$ and units were given wrongly.	
ci	$2NaC/ + 2H_2O \rightarrow 2NaOH + H_2 + C/_2$	1
	The overall reaction would combine the two half-reactions.	
CÌÌ	Mass of NaC/ in brine = $(25 \div 100) \times 1000000$	3
	$= 2.50 \times 10^5 \text{ g}$ [1]	
	Brine is a saturated solution of sodium chloride containing about 25% by mass of	
	sodium chloride' – this is given at the beginning of the question.	
	No. of moles of NaC/ = 2.50×10^5 g ÷ (23 + 35.5)	
	$= 4.2735 \times 10^{3} \text{ mol} [1]$	
	Comparing molar ratio:	
	$2 \text{ mol NaCl} \equiv 2 \text{ mol NaOH}$	
	$4.2735 \times 10^{\circ}$ mol mol NaC/ = $4.2735 \times 10^{\circ}$ mol mol NaOH	
	Mass of NaOH = $4.2735 \times 10^3 \times (23 + 16 + 1)$	
	1.71 + 105 = [1]	
	$= 1.71 \times 10^{\circ} \text{g}$ [7]	
B 8	Tot	al = 8
This	uestion involves the tonic on speed of reaction and using metallic compounds as	
catal	vsts	
	, oto:	
а	A higher temperature would lead to a faster rate of reaction. It is important to	1
	take note of the temperature to ensure that the initial temperature is constant .	
	This is so that the results of the experiment will show the effects of different	

	Note that the common mistakes include imprecise answers that 'make it a fair test / to act as a better control.'	
b	The time taken for the reaction to complete using Group I and Group II metal	2
	compounds as catalysts are 45 seconds (based on experiments 1 and 5) and	
	46 seconds (based on experiments 4 and 9) respectively [1].	
	However, the time taken for the reaction to complete using transition metal compounds as catalysts are <u>faster</u> , ranging from <u>15 seconds in experiment 7 to</u> <u>26 seconds in experiments 3 and 8</u> [1]. Hence, Group I and Group II metal compounds are less effective catalysts than transition metal compounds.	
	Note that the question insists the use of information and data form the table given. Thus, reference must be made to which experiements are compared or by quoting reaction times.	
ci	Fe ²⁺ and Fe ³⁺ ions	1
cii	<u>Fe³⁺ ion</u> is a more effective catalyst. Comparing <u>experiments 6 and 7</u> , the time taken for the reaction to complete using <u>Fe³⁺ ions (15 seconds)</u> is faster than using <u>Fe²⁺ ions (22 seconds)</u> [1].	1
di	Yes, the type of anion does not affect the rate of reaction.	2
	Comparing experiments <u>1 and 5</u> , where the type of anion is different, the time taken for the reaction remains the same as 45 seconds. Similar results for the time taken for the reaction to complete are observed in experiments <u>3 and 8</u> (26 seconds), <u>4 and 9</u> (46 seconds), and <u>2 and 6</u> (22 seconds) [2].	
	Note that no marks will be awarded if students just gave a yes or no answer without explanation. Students are advised to give at least two examples from the table to support their answers.	
dii	15 seconds	1

B9	Either Tota	= 10	
This	This question involves the topic on reactivity series of metals.		
а	W, Z, Y, X	2	
	The entire sequence must be correct.		
	Note that the most common mistake is to arrange the metals in reverse order.		
b	<u>Effervescence</u> would be observed [1]. The effervescence observed is a <u>result of</u> <u>the hydrogen gas</u> evolved from the reaction of metal Z with hydrochloric acid [1].	2	
С	To a <u>fixed mass (1.00 g)</u> of metal M , add a <u>fixed volume (25.0 cm³)</u> and <u>concentration (0.100 mol/dm³)</u> of dilute hydrochloric acid into the conical flask[1].	3	
	Start the stopwatch immediately when hydrochloric acid is added to metal ${f M}.$		
	Collect and measure the <u>volume of hydrogen gas evolved</u> using a gas syringe. <u>Record</u> the volume of hydrogen gas produced <u>after 1 minute</u> [1].		
	A similar procedure is carried out with metals W , X , Y and Z . The metal that produces the most hydrogen gas after 1 minute has the fastest rate of reaction. The volume of gas collected after 1 minute using metal M <u>falls between Y and X</u> , making M the fourth most reactive metal [1].		
	Note that the <u>common mistakes</u> include using <u>displacement reactions</u> to determine the reactivity of metals, as well as deducing the reactivity of metals based on the <u>total volume of gas collected</u> at the end of reaction.		
	Other valid measurements/alternative answers include time taken for the metal to dissolve completely in excess dilute hydrochloric acid.		
di	Metal Y [1 mk pt]. The two most reactive metals, <u>W and Z are extracted by</u> <u>electrolysis</u> , [1 mk pt] while the least reactive <u>metal X occurs uncombined</u> [1 mk pt]. Since the <u>reactivity of metal M falls between metals Y and X</u> , [1 mk pt] and metal M is extracted by heating its ores with carbon, metal Y must be extracted in the same manner too.	2	
	4 mk pts – [2] 2-3 mk pts – [1] 1 mk pt – [0]		

dii	Metal Y could be <u>iron / zinc</u> .	1
	Lead is not acceptable because lead reacts with dilute hydrochloric acid to form insoluble salt (reaction will stop).	

B9	Or Tota	= 10
This	question involves the topic on organic chemistry – mainly alkanes and alkenes.	
ai	$ \underbrace{\begin{array}{cccccccccc} H & H & H & H & H \\ H & H & H & H & H & H \\ H & -C & -C & -C & -C & -C & -H \\ H & -C & -C & -C & -C & -H \\ H & H & H & H & H & H \end{array} $ $ \underbrace{\begin{array}{cccccccccccccccccccccccccccccccc$	2
aii	Add aqueous bromine to each product. The reddish-brown solution decolourises	2
	<u><i>I</i> turns to form a colourless solution</u> [1] when added to butene. The solution remains <u>reddish-brown</u> when added to hexane [1].	
	not accepted.)	
bi	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1
	There are two other isomers not shown here.	
bii	$2C_6H_{14}$ + $19O_2 \rightarrow 12CO_2$ + $14H_2O$	1
biii	Incomplete combustion in car engines causes the production of toxic <u>carbon</u> <u>monoxide</u> , which <u>reacts with haemoglobin</u> in blood to prevent blood from <u>transporting oxygen</u> around the body.	1
	Note that the most common mistake is the identification of nitrogen oxides from the incomplete combustion of carbon-containing fuels.	
biv	The use of a powdered catalyst increases the total surface area available to allow more reactant particles to come close together to collide effectively. This increases the rate of the reaction.	1
	Students must be careful not to give the idea that the reactants react with the catalyst.	
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C	Long chain alkane molecules are in low demand . Thus, heavy fractions like lubricating oils which contain long chain alkane molecules are usually <u>cracked</u> . Short chain alkane molecules that are <u>more useful</u> are produced. Thus, the demand for petrol, which is made up of shorter chain alkane molecules, is met.	2
	Two points must be addressed: - discuss the relative demand of differently sized molecules from crude oil - identify the change in the size of molecules that occurs during cracking	