Section A (70 marks)

1		Suggested solution	accept	reject
(a)		$ZnCl_2$ [1]		
(b)		PbO [1]		
(c)		V_2O_5 [1]		
(d)	**(i)**	NH_4Cl [1]		
	(ii)	$NaOH + NH_4Cl \rightarrow NaCl + H_2O + NH_3$ [1]		

2		Suggested solution	accept
(a)		Isotopes are **atoms of the same element** with the **same number of protons but different number of neutrons**. [1]	
(b)	**(i)**	<table><tr><th>particle</th><th>number of protons</th><th>number of electrons</th><th>number of neutrons</th></tr><tr><td>G_1</td><td>16</td><td>16</td><td>16</td></tr><tr><td>G_2</td><td>16</td><td>18</td><td>18</td></tr><tr><td>G_3</td><td>16</td><td>16</td><td>20</td></tr></table> [2]: 5 correct [1]: 1 to 4 correct	
	(ii)	Nuclide notation of atom G_2: $^{34}_{16}S$ [1]: chemical symbol, proton number and mass number.	

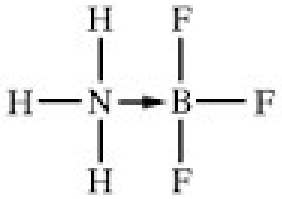
3		Suggested solution
(a)	**(i)**	<table><tr><th>gases</th><th>time/s</th><th>relative molecular mass</th></tr><tr><td>carbon monoxide, CO</td><td>119</td><td>28</td></tr><tr><td>chlorine, Cl_2</td><td>190</td><td>71</td></tr><tr><td>methane, CH_4</td><td>90</td><td>16</td></tr><tr><td>oxygen, O_2</td><td>127</td><td>32</td></tr></table> [1] All correct
	(ii)	Time taken = k x M_r For CO, k = 119 / 28 = 4.25

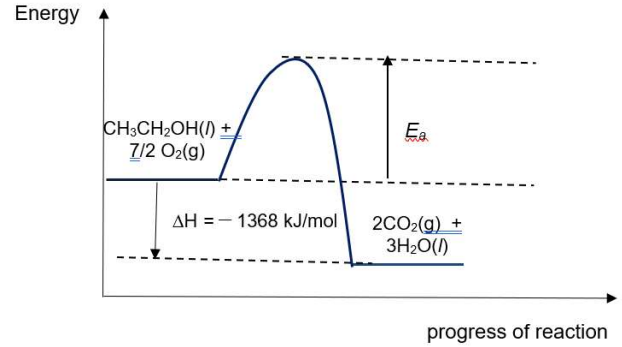
		For Cl_2, k = 190 / 71 = 2.68 For CH_4, k = 90 / 16 = 5.63 For O_2, k = 127 / 32 = 3.97 The measurements do not support the conclusion. [1] The constant, k, is not the same for the gases. [1] Award 2nd mark if student compares at least two k values.
(b)		Accept any time between 127 seconds and 190 seconds. [1] Sulfur dioxide is **soluble in water** so the water level rises faster than predicted. [1]

4		**Suggested solution**
(a)		Cu_2O is oxidised to $CuSO_4$ because the oxidation state of copper increases from +1 in Cu_2O to +2 in $CuSO_4$. [1] Cu_2O is reduced to Cu because the oxidation state of copper decreases from +1 in Cu_2O to 0 in Cu. [1] This is disproportionation as Cu_2O is oxidised and reduced simultaneously. [1]
(b)	**(i)**	<table><tr><td>Element</td><td>Cu</td><td>O</td></tr><tr><td>% by Mass</td><td>84.1</td><td>15.9</td></tr><tr><td>Number of moles/ mol</td><td>$\frac{84.1}{64}$ = 1.3141</td><td>$\frac{15.9}{16}$ = 0.99375</td></tr><tr><td>Mole ratio (divide by the smallest number)</td><td>$\frac{1.3141}{0.99375}$ = 1.3224</td><td>$\frac{0.99375}{0.99375}$ = 1</td></tr><tr><td></td><td>X3</td><td>X3</td></tr><tr><td>Simplest ratio</td><td>4</td><td>3</td></tr></table> Empirical formula is Cu_4O_3 [1] Working + Empirical formula Let the molecular formula of paramelaconite be $(Cu_4O_3)_n$. (4 x 64 + 3 x 16)n = 304 n = 1 Working to prove that the molecular formula of paramelaconite is Cu_4O_3. [1]
	(ii)	$Cu_4O_3 + 2H_2SO_4 \rightarrow Cu_2O + 2CuSO_4 + 2H_2O$ [1]

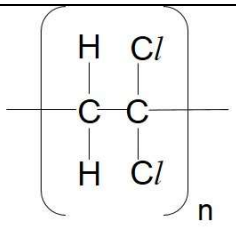
5		**Suggested solution**
(a)		Atoms of the different metals have **different sizes**. The **regular layers of atoms are disrupted**. [1] The **layers of atoms cannot slide over each other** easily when a force is applied. [1]

(b)	**(i)**	Insert a lighted splint into the gas. Lighted splint extinguishes with a 'pop' sound. [1]
	(ii)	Chromium sulfate is insoluble in water. [1] A layer of insoluble chromium sulfate will form over the surface of chromium metal and prevent the reactants from reacting further. [1]
	(iii)	Add aqueous chromium nitrate to sulfuric acid. Filter to collect chromium sulfate precipitate. Wash the precipitate with a small amount of cold water and dry between filter paper. [1] Two soluble reactants that form chromium sulfate [1] Filter + Wash + Dry
(c)		Layer of chromium(III) oxide **prevents oxygen and water from coming into contact with iron** in stainless steel. [1]
(d)	**(i)**	Chromium reacts faster with acid than iron. [1] Chromium is more reactive than iron. [1]
	(ii)	**Iron will not rust** as chromium is more reactive than iron, **chromium will corrode instead of iron**. [1]

6		**Suggested solution**
(a)	**(i)**	Iron(III) chloride is used up in step 1 and regenerated in step 2. [1]
	(ii)	Iron(III) chloride provides **an alternative pathway with a lower activation energy**. [1] As a result, there are more particles with **energy equal to or greater than the activation energy.** The **frequency of effective collisions increases**. Thus, the rate of the reaction increases. [1]
(b)	**(i)**	**Both electrons come from nitrogen atom** instead of one electron from each of the bonded atom. [1]
	(ii)	Simple molecular structure [1]
	(i)	 [1]

7		Suggested solution
(a)		The **energy absorbed to break 10 C-H, 2 C-C, 2 C-O and 7 O=O bonds** is **smaller** than the **energy released to form 8 C=O and 12 O-H bonds**. [1] List the bonds correctly [1] List the magnitude of energy correctly (e.g. smaller)
(b)	**(i)**	enthalpy change for the reaction for one mole of ethanol = − (2736 /2) = − 1368 kJ/mol [1]
	(ii)	 [1] Shape of curve + Label ΔH and Ea correctly [1] Label reactants and products correctly
(c)	**(i)**	Sugarcane absorbs carbon dioxide during photosynthesis which offsets the carbon dioxide produced when bioethanol is burnt. [1]
	(ii)	Ethene is obtained from crude oil and **is finite**. Ethene **cannot be replaced quickly enough** to keep up with our rate of use. [1] Sugarcane can be **replaced relatively quickly after use**. [1]
	(iii)	**Large areas of land are needed** to grow sugarcane for the extraction of bioethanol. This may **compete with the use of land for growing other food crops**. [1] **Or** Some processes used in growing sugarcane such as use of **machinery may require use of fossil fuels**. **More carbon dioxide may also be produced** in these processes. Accept other reasonable answer.

8		Suggested solution
(a)	**(i)**	**X**: Respiration **Y**: Photosynthesis [1] Both **X** and **Y** are correct
	(ii)	The **balance** between the processes that **produce carbon dioxide such as respiration** and the **processes that remove carbon dioxide such as photosynthesis** **regulates the amount of carbon dioxide in the atmosphere**. [1] Process such as respiration add carbon dioxide into the atmosphere and process such as photosynthesis removes carbon dioxide from the atmosphere [1] Idea of a balance between respiration with photosynthesis
(b)		Carbon dioxide contributes to **global warming**, which causes **melting of polar ice cap** which leads to rising sea levels which leads to flooding of low land. [1]

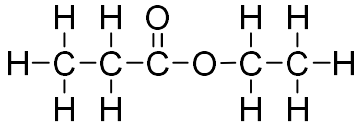
9		Suggested solution
(a)	**(i)**	This minimises wastage and **reduces operating costs**. [1] Must state one reason for recycling to award the mark.
	(ii)	Fractional distillation [1]
(b)	**(i)**	$CH_2=CH_2$ (g) + H_2O (g) → CH_3CH_2OH(l) Number of moles of C_2H_4 = (10 x 1000) / (2 x 12 + 1 x 4) = 357.14 mol [1] Number of moles of CH_3CH_2OH = 357.14 mol Theoretical yield of CH_3CH_2OH = 357.14 x (12 x 2 + 1 x 6 + 16) = 16428.6 g = 16.4286 kg % yield = (8.4 / 16.4286) x 100 = 51.1% [1]
	(ii)	There are impurities present in ethene used to produce ethanol. [1]
(c)	**(i)**	Substitution [1]
	(ii)	 [1]
	(iii)	Both polymers have macromolecular structure with intermolecular forces of attraction between the polymer chains. [1] The size of poly(dichloroethene) is bigger than poly(ethene) and more energy is needed to overcome the stronger intermolecular forces of attraction between the polymer chains. [1]
	(iv)	Cracking forms shorter chain alkanes which can be used as fuel. Fuels are more useful and in higher demand. [1]

10		Suggested solution
(a)		Concentration of Ca^{2+} ions in mol/dm^3 = 62.1 / 40 = 1.55 mol/dm^3 The hardness classification is soft and is not ideal for aquarium water. [1] working and conclusion
(b)	**(i)**	$Cl_2 + 2S_2O_3^{2-} \rightarrow 2Cl^- + S_4O_6^{2-}$ [1]
	(ii)	Volume of water = 360 / 2 = 180 dm^3 Mol of Cl_2 = (0.023 / 71) x 180 = 0.058310 mol Cl_2 : $S_2O_3^{2-}$ 1 : 2 Mol of $S_2O_3^{2-}$ needed to react with Cl_2 = 2 x 0.058310 = 0.11662 mol [1] Mol of NH_2Cl = (0.020 / (14 + 2 + 35.5)) x 180 = 0.069903 mol NH_2Cl : $S_2O_3^{2-}$ 1 : 2 Mol of $S_2O_3^{2-}$ needed to react with NH_2Cl = 2 x 0.069903 = 0.13981 mol [1] Total number of mol of $S_2O_3^{2-}$ = 0.11662 + 0.13981 = 0.25643 mol Total volume of $S_2O_3^{2-}$needed = 0.25643 / 0.010 = 25.6 dm^3 [1]
(c)		Concentration of CO_3^{2-} in mol/dm^3 = 31.1 / (12 + 16 x 3) = 0.51833 mol/dm^3 Mol of CO_3^{2-} = 0.51833 x 360 = 186.6 mol [1] Mol of CO_3^{2-} left after reacting with 186 mol of H^+ = 186.6 – 186 = 0.6 mol

		Concentration of CO_3^{2-} in g/dm^3 = 0.6 x (12 + 16 x 3) = 36 g/dm^3 dKH = 36 / 10.7 = 3.36 [1]
(d)	**(i)**	Chlorine is more reactive than bromine. [1] Chlorine can displace bromine from bromide in seawater. [1]
	(ii)	To provide heat to vapourise bromine. [1]

11		**Suggested solution**
(a)		Graphite electrodes are unreactive and do not participate in the reaction. [1] either unreactive or do not participate in the reaction.
(b)		The anode of beaker A decreases in size. Copper anode is oxidised to form copper(II) ions Cu (s) → Cu^{2+} (aq) + 2e^- [1] anode decreases in size + correct half equation Effervescence is observed at anode of beaker B. Since OH^- ions are below SO_4^{2-} ions in the anion electrochemical series, OH^- ions will be preferentially discharged. 4OH^- (aq) → 2H_2O (*l*) + O_2 (g) + 4e^- [1] effervescence + correct half equation
(c)	**(i)**	Number of moles of electrons = 193000 / 96500 = 2 mol [1]
	(ii)	Cu^{2+} (aq) + 2e^- → Cu (s) Number of moles of Cu = 0.5 x 2 = 1 mol [1] Mass of copper formed = 1 x 64 = 64 g [1]

	(iii)	$C(s) + O_2(g) \rightarrow CO_2(g)$ [1] Carbon undergoes combustion with the oxygen gas. [1]
(d)		Hydroxide ions will be discharged and decrease in concentration. [1] Universal indicator will change from green to red/orange/yellow. [1]

12		**Suggested solution**
(a)	**(i)**	Oxalic acid [1]
	(ii)	Oxalic acid is a dibasic acid and the other three acids are monobasic acid. [1] Oxalic acid will produce a higher concentration of H^+ ions. [1]
	(iii)	Accept value lower than 1.34×10^{-5}
(b)		Agree: oxalic acid contains carboxyl functional group –COOH. [1] Disagree: oxalic acid does not have the general formula $C_nH_{2n+1}COOH$ [1]
(c)	**(i)**	Reagent is Ethanol [1] Condition is warm in the presence of a few drops of concentrated sulfuric acid (H_2SO_4) [1] Full structural formula of ethyl propanoate is  [1]
	(ii)	Dilute sulfuric acid, heat [1]