Mark Scheme (Results)

October 2018

Pearson Edexcel International
Advanced Subsidiary Level
In Chemistry (WCH02)
Paper 01 Application of Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Answer	Mark
1	**The only correct answer is B** ***A*** *is not correct because ionisation energy does not decrease linearly* ***C*** *is not correct because ionisation energy does not increase down a group* ***D*** *is not correct because ionisation energy does not increase down a group*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** ***A*** *is not correct because calcium oxide is not the final product* ***B*** *is not correct because calcium oxide is not the final product and the equation is not balanced* ***D*** *is not correct because the equation is not balanced*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** ***A*** *is not correct because barium and the bond are incorrect* ***B*** *is not correct because barium is incorrect* ***C*** *is not correct because the bond is incorrect*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is A** ***B*** *is not correct because ionic radius does not determine flame colour* ***C*** *is not correct because numbers of electrons does not determine flame colour* ***D*** *is not correct because ionisation energies do not determine flame colour*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** ***A*** *is not correct because this is the number of moles in 2.12 g and 25.0 cm^3 has not been used* ***B*** *is not correct because this is the moles of solute in 500 cm^3 of solution* ***D*** *is not correct because 83 used as M_r for Na_2CO_3 instead of 106*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is C** ***A*** *is not correct because the burette uncertainty has not been multiplied by 2 for 2 readings* ***B*** *is not correct because the burette uncertainty has not been multiplied by 2 for 2 readings and the pipette uncertainty should not have been multiplied by 2* ***D*** *is not correct because the pipette uncertainty should not have been multiplied by 2*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is D** ***A*** *is not correct because single bonds are longer than multiple bonds* ***B*** *is not correct because single bonds are longer than multiple bonds* ***C*** *is not correct because double bonds are longer than triple bonds*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is C** ***A*** *is not correct because CH_3^+ is not 107°* ***B*** *is not correct because CH_3^+ is not 107° and CH_3^- is not 120°* ***D*** *is not correct because CH_3^- is not 120°*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is D** ***A*** *is not correct because cyclohexane is non-polar* ***B*** *is not correct because hexane is non-polar* ***C*** *is not correct because tetrachloromethane is non-polar*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is D** ***A*** *is not correct because it is unbranched and* ***D*** *has 2 branches* ***B*** *is not correct because it has one branch and* ***D*** *has 2 branches* ***C*** *is not correct because it has one branch and* ***D*** *has 2 branches*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is B** ***A*** *is not correct because the trend is incomplete* ***C*** *is not correct because the trend is incorrect* ***D*** *is not correct because the trend is in reverse*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is B** ***A*** *is not correct because ethanol is polar and has a lower solubility than octane in hexane* ***C*** *is not correct because sodium chloride is ionic and does not dissolve in hexane* ***D*** *is not correct because water is polar and does not dissolve in hexane*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is C** ***A*** *is not correct because bromine changes from 0 to −1 and +1* ***B*** *is not correct because chlorine changes from +1 to −1 and +5* ***D*** *is not correct because iodine changes from 0 to −1 and +5*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is B** ***A*** *is not correct because this is the percentage of carbon in* C_6H_{14} ***C*** *is not correct because this is the percentage of carbon in* C_6H_{10} ***D*** *is not correct because this is the percentage of carbon in* C_6H_6	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is A** ***B*** *is not correct because this is the volume of* $H_2O(g)$ ***C*** *is not correct because this is the volume of* O_2 *needed* ***D*** *is not correct because this is the volume of* CO_2 *formed from 0.2 mol propan-1-ol*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is D** ***A*** *is not correct because both conditions are incorrect* ***B*** *is not correct because particle size is incorrect* ***C*** *is not correct because temperature is incorrect*	**(1)**

Question Number	Answer	Mark
17	**The only correct answer is A** ***B*** *is not correct because reason does not explain the change in equilibrium position* ***C*** *is not correct because change in pressure is incorrect* ***D*** *is not correct because reason does not explain the change in equilibrium position*	**(1)**

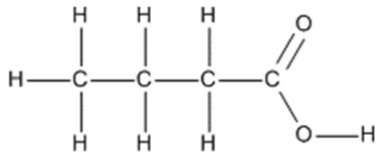
Question Number	Answer	Mark
18	**The only correct answer is A** ***B*** *is not correct because this is a description of a nucleophile* ***C*** *is not correct because this could not be an electrophile* ***D*** *is not correct because this is not true for all electrophiles*	**(1)**

Question Number	Answer	Mark
19	**The only correct answer is A** ***B*** *is not correct because the gas molecules do not form free radicals when they absorb ir radiation* ***C*** *is not correct because the gas molecules do not absorb uv radiation* ***D*** *is not correct because the gas molecules do not absorb uv radiation*	**(1)**

Question Number	Answer	Mark
20	**The only correct answer is D** ***A*** *is not correct because non-polar bonds do not absorb ir radiation* ***B*** *is not correct because this is only partly correct* ***C*** *is not correct because this is only partly correct*	**(1)**

(Total for Section A = 20 marks)

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	 ALLOW OH	Skeletal and structural formulae C-H-O as horizontal bond on left or right of structure Incorrect number of carbon atoms Missing hydrogens / C-C bond(s)	**(1)**

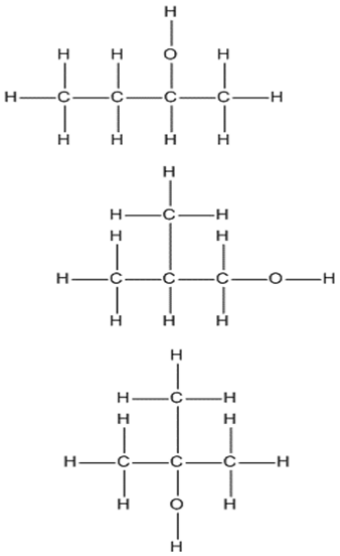
Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Sodium (metal) / Na IGNORE Conditions eg room temperature / solid	Sodium hydroxide / NaOH Sodium carbonate / Na_2CO_3 Sodium hydrogencarbonate / $NaHCO_3$	**(1)**

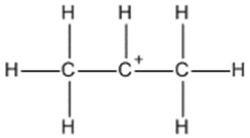
Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	ALLOW names or formulae but if both are given, both must be correct Reagents containing Cl: Phosphorus(V) chloride / phosphorus pentachloride / phosphorus(III) chloride / phosphorus trichloride / thionyl chloride ALLOW Hydrogen chloride / Conc hydrochloric acid **and** zinc chloride / Potassium chloride **and** concentrated / 50% sulfuric acid OR Reagents containing Br: Potassium bromide **and** concentrated / 50% sulfuric acid / (red) phosphorus **and** bromine ALLOW Hydrogen bromide OR Reagents containing I: Red phosphorus **and** iodine Phosphorus(III) iodide ALLOW hydrogen iodide IGNORE Conditions, except those in reject column	Mention of solution Dilute sulfuric acid Dilute sulfuric acid Just 'bromine' Phosphorus(V) iodide	**(1)**

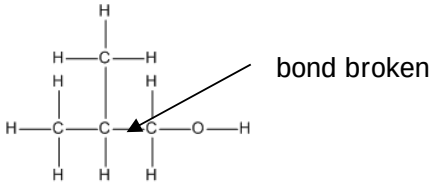
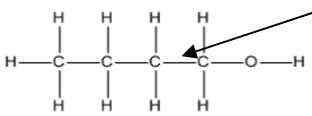
Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	Any one from: $CH_3CH_2CH_2CH_2Cl$ OR $CH_3CH_2CH_2CH_2Br$ OR $CH_3CH_2CH_2CH_2I$ ALLOW Displayed or skeletal formulae IGNORE Names, even if incorrect Molecular formulae		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	ammonia / NH_3 ALLOW $NH_3(g)$ IGNORE Conditions such as heat in a sealed tube / concentrated / in ethanol / in alcohol	Dilute ammonia / ammonia solution / $NH_3(aq)$ NH_3^+ / NH_3^- Ammonium / $NH_4^{(+)}$	**(1)**

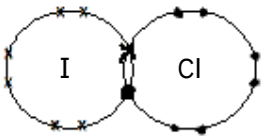
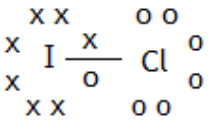
Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	To prevent the escape of ammonia (gas) / NH_3 (when heated under reflux) ALLOW Ammonia would escape if heated under reflux OR To prevent the escape of HCl / HBr / HI IGNORE To increase the rate of reaction Reaction reaches completion Just 'to prevent (toxic) gas / vapour escaping' Just 'to prevent reactants / products escaping' Reference to low melting point of ammonia	To prevent the escape of 1-aminobutane	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)	 All 3 correct **(2)** Any 2 correct **(1)** ALLOW OH / CH_3 If no other mark is given, allow (1) for 3 correct skeletal / structural formulae IGNORE Connectivity of vertical OH groups, unless O I H I C Names, even if incorrect	O-H-C- / -C-H-O at end of molecule once only Missing H / C-C once only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	 ALLOW $CH_3CH^+CH_3$ **First mark** Structure **(1)** **Second mark** Charge ALLOW Charge shown anywhere on structure or outside of brackets **(1)** ALLOW (1) for $C_3H_7^+$ / $CH_3CH_2CH_2^+$ / CH_3CO^+ / CH_2OH^+ / $C_2H_3O^+$ / CH_3O^+	Penalise non-displayed formulae once only in (d)(i) and(d)(ii) Any species with C=O scores (0)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(ii)	 **First mark** Correct alcohol **(1)** **Second mark** Correct bond ALLOW Any type of identification of bond broken TE on correct bond shown on butan-1-ol  **(1)**	Butan-2-ol / 2-methylpropan-2-ol score (0)	**(2)**

(Total for Question 21 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	 ALLOW All dots, all crosses or other symbols The shared pair of electrons anywhere in the overlap region, on or inside the lines Diagram without circles The shared pair shown horizontally The shared pair anywhere between I and Cl Cl and I reversed Diagram with additional straight line as covalent bond between I and Cl e.g.  IGNORE Any attempt at ICl_3 diagram Inner shell electrons, even if incorrect	Ions / double bond	**(1)**

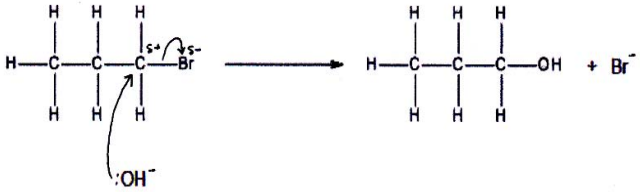
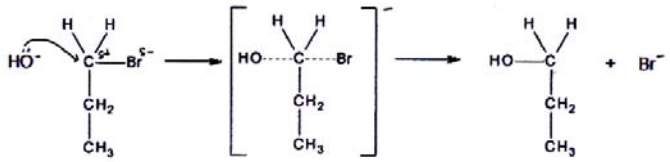
Question Number	Acceptable Answers	Reject	Mark
***22(a)(ii)**	Any **two** points from: **First point** One of the (5)p electrons is promoted **(1)** **Second point** From a (5)p orbital to an empty (5)d orbital **(1)** IGNORE Just 'iodine has an empty d orbital' **Third point** Iodine can form 3 (covalent) bonds / has 3 bonding pairs (of electrons) **and** 2 lone pairs ALLOW 3 bond pairs and 2 lone pairs shown on a dot-and-cross diagram **(1)** IGNORE Just '3 bond pairs' **Fourth point** Iodine expands its octet (to 10) OR Iodine has 10/more than 8 electrons (in its outer shell) **(1)** IGNORE Electron pairs arranged to minimise repulsion / maximum separation for all points	Dative covalent bonds / ions for Third point only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	ICl bonds are polar / ICl is polar **and** because chlorine is more electronegative than iodine / $I^{\delta+}$-$Cl^{\delta-}$ ALLOW Iodine and chlorine / they have different electronegativities OR There is a difference in electronegativities for the reason **(1)** ICl_3 is (a) polar (molecule) **and** because it is not symmetrical / is asymmetrical / asymmetric distribution of electron pairs / density the bond polarities / dipole (moments) do not cancel out **(1)** IGNORE Just 'because it is T-shaped' IGNORE Explanation of electronegativity	Iodine is more electronegative than chlorine	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	(From pale) yellow / straw (to) colourless IGNORE Clear	Any other colour with yellow	**(1)**

Question Number	Acceptable Answers	Reject	Mark
***22(b)(ii)**	Moles Tl^{3+} used = $\frac{25.0 \times 0.0464}{1000}$ = 0.00116 /1.16 x 10^{-3} **(1)** Moles $S_2O_3^{2-}$ used / moles I^- formed = $\frac{23.20 \times 0.100}{1000}$ = 0.00232 / 2.32 x 10^{-3} **(1)** (1 mol $S_2O_3^{2-}$ ≡ ½mol I_2 ≡ 1 mol I^- Moles I^- reacted with Tl^{3+} = 2.32 x 10^{-3}) So ratio I^- : Tl^{3+} = 2 : 1 TE on mol $S_2O_3^{2-}$ **(1)** Final oxidation number of thallium is (+)1 / I ALLOW Tl^+ ALLOW TE (+)2 / II / Tl^{2+} from a 1:1 ratio of I^-or I_2 : Tl^{3+} **(1)** **Note** M3 and/or M4 may be awarded from an equation e.g. $Tl^{3+} + 2I^- \rightarrow Tl^+ + I_2$ Scores M3 and M4 Correct oxidation state with no working scores M4 only		**(4)**

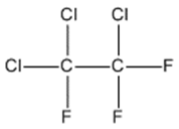
(Total for Question 22 = 10 marks)

Question Number	Acceptable Answers	Reject	Mark
23 (a)(i)	**Mechanism 1** – no intermediate drawn  Dipole on C-Br **(1)** Curly arrow from (or close to) lone pair on O of OH^- to C (of C-Br) **(1)** Curly arrow from C-Br bond to (or just beyond) Br **(1)** Propan-1-ol **and** Br^-/ KBr as products **(1)** **Mechanism 2** – S_N2 mechanism  Dipole on C-Br **(1)** Curly arrow from lone pair on OH^- to C (of C-Br) **(1)** IGNORE curly arrow from C-Br to Br Intermediate including dotted bonds and negative charge ALLOW Negative charge anywhere on intermediate **(1)** Propan-1-ol **and** Br^-/ KBr as products **(1)**	full charges on C and Br KOH / $OH^{\delta-}$ as nucleophile loses M2 only full charges on C and Br KOH / $OH^{\delta-}$ as nucleophile loses M2 only 5 full bonds for M3	**(4)**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	Nucleophilic ALLOW Nucleophile **(1)** Substitution **(1)** IGNORE Heterolytic / S_N2 / S_N1 / unimolecular / bimolecular / hydrolysis	Homolytic Any other type of reaction e.g. elimination / addition	**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(b)	Mol 1-bromopropane used $= \frac{0.50}{122.9} = 0.004068 / 4.068 \times 10^{-3}$ ALLOW 4.065×10^{-3} if 80 used as A_r for Br **(1)** **EITHER** Mol propene formed = $\frac{18}{24000}$ $= 0.00075 / 7.5 \times 10^{-4}$ **(1)** Percentage yield = $\frac{7.5 \times 10^{-4}}{4.068 \times 10^{-3}} \times 100$ $= 18.435\%$ ALLOW 18.45% if 80 used as A_r for Br Or 18.293 / 18.428 / 18.437 from correct rounding of mol 1-bromopropane TE on mol 1-bromopropane / propene used provided answer <100% **(1)** **OR** Theoretical volume propene $= 4.068 \times 10^{-3} \times 24\,000$ $= 97.64 / 97.632\ cm^3$ ALLOW $97.56\ cm^3$ if 80 used as A_r for Br TE on mol 1-bromopropane / propene used provided answer <100% **(1)** Percentage yield = $\frac{18}{97.632} \times 100$ $= 18.435 / 18.437\%$ ALLOW 18.45% if 80 used as A_r for Br TE on theoretical volume propene **(1)** IGNORE SF except 1SF Correct answer with no working scores (3) ALLOW Alternative methods		**(3)**

Question Number	Acceptable Answers	Reject	Mark
23(c)	**Fastest:** 1-iodopropane **(1)** **Reason –** conditional on correct halogenoalkane **Answer must refer to the carbon-halogen bond** **C-I** is the weakest (bond) OR **C-I** has the lowest bond enthalpy OR bond enthalpy **C-Cl** > **C-Br** > **C-I** OR Bond enthalpy decreases from **C-Cl** to **C-I** OR **C-Halogen** bond strength decreases down the group (of halogens) ALLOW **C-I** bond requires the least amount of energy to break **(1)** IGNORE Just 'it has the weakest bond' References to bond length / intermolecular forces / electronegativity	1-chloropropane / 1-bromopropane score (0) Any reference to ion(s) for M2 only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	 ALLOW The structure reversed Skeletal / structural formulae	Fl as symbol for fluorine	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	The C-F bond is strong /has a high bond enthalpy OR The C-F bond is stronger than the C-Cl bond) ALLOW The C-F bond is difficult to break / requires a lot of energy to break / is too strong to break UV radiation does not have enough energy to break C-F bonds ALLOW Reverse argument e.g. C-Cl is weaker (than C-F) IGNORE Any reference to electronegativity	$F^{\bullet}$ is less stable than $Cl^{\bullet}$ Reference to F^- ions	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(iii)	$Cl^{\bullet} + O_3 \rightarrow ClO^{\bullet} + O_2$ **(1)** $ClO^{\bullet} + O_3 \rightarrow Cl^{\bullet} + 2O_2$ **(1)** ALLOW Equations in either order / multiples / • anywhere on the chlorine species IGNORE Curly arrows / state symbols / initiation and termination steps, even if incorrect Equations added together to give overall equation No TE on incorrect species	Missing • once only **or** • on an oxygen species once only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(iv)	Butane / it is flammable / ignites easily ALLOW It is non-renewable OR It is a greenhouse gas OR It produces greenhouse gases / CO_2 **and** when it burns OR It produces gases when it burns **and** that cause global warming OR It produces CO during incomplete combustion **and** this is toxic IGNORE More waste is produced / Difficult to transport / References to cost / Causes pollution / Just ' produces CO / CO_2' / Just 'produces greenhouse gases' / Explosive	Toxic	**(1)**

(Total for Question 23 = 16 marks)
(Total for Section B = 38 marks)

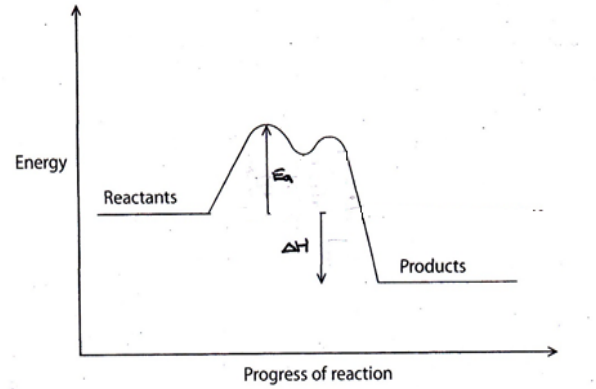
Section C

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	The oxidation numbers may be written above or below the species in the equation ALLOW Oxidation numbers written as 3−, 1+, 1− IGNORE Oxidation numbers of other elements, even if incorrect **First mark** – O.N. of nitrogen Nitrogen changes from −3(in NH_3) to 0 (in N_2) **(1)** **Second mark** – O.N of chlorine Chlorine changes from +1 (in NaClO) to −1 (in NaCl) **(1)** **Third mark** – redox Nitrogen is oxidised (as its oxidation number has increased) **and** Chlorine has been reduced (as its oxidation number has decreased) ALLOW M3 even if incorrect / missing oxidation numbers in M1 and M2 **(1)** IGNORE Redox explained in terms of electron gain or loss Reference to oxidising or reducing agent Ammonia is oxidised / sodium chlorate(I) is reduced	Sodium / hydrogen / oxygen is oxidised / reduced for M3 only	**(3)**

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	Moles NH_3 = $\frac{120}{24000}$ = 0.0050 / 5 x 10^{-3} **(1)** Moles NaClO needed = $\frac{0.0050 \times 3}{2}$ **(1)** = 0.0075 / 7.5 x 10^{-3} TE on moles NH_3 Volume NaClO needed = $\frac{0.0075 \times 1000}{0.20}$ = 37.5 cm^3 OR $\frac{0.0075}{0.20}$ = 0.0375 / 3.75 x 10^{-2} dm^3 TE on moles NaClO Value **and** correct unit required **(1)** Correct answer with units but no other working scores (3) IGNORE SF except 1 SF	cm^{-3} dm^{-3}	**(3)**

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	**First mark** Equilibrium position shifts to the left / towards the reactants ALLOW Less ammonia / NH_3 is formed **(1)** **Second mark** Because the **forward** / **right** reaction is exothermic / releases heat (energy) ALLOW Because the **reverse** / **backward** / **left** reaction is endothermic / absorbs heat (energy) OR Higher temperature favours the endothermic reaction **(1)** IGNORE Reference to rate of reaction / pressure	Equilibrium shifts to the right for M1 only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	**First mark** – activation energies Labelled activation energy with catalyst shown on diagram at a lower value than activation energy without a catalyst If these are not shown: ALLOW Catalyst provides an alternative route with a lower activation energy **(1)** IGNORE Just 'catalyst lowers the activation energy' / Just ' catalyst moves E_a to the left' if not shown on diagram **Second mark** – energy of molecules A higher fraction of the molecules have energy (equal to or) greater than the activation energy ALLOW More molecules have energy (equal to or) greater than the activation energy More molecules have enough energy to react More molecules have the activation energy **(1)** IGNORE References to collisions Just 'so more molecules can react'	Another curve added to the diagram for M1 only Activation energy with catalyst drawn to the left of the peak	**(2)**

Question Number	Acceptable Answers	Reject	Mark
24(b)(iii)	 **First mark** – complete curve (PTO for examples) Curve completed as shown with 'double hump' ALLOW 'single hump' **(1)** IGNORE Additional curve for uncatalysed reaction Depth of trough, even if below the product level **Second mark** – products and Δ*H* Products to the right of reactants **and** at lower energy level than reactants **and** downwards arrow labelled Δ*H* ALLOW Balanced or unbalanced formulae instead of products Products line slightly overlapping reactants line e.g. Reactants Products −92 (kJ mol^{-1}) as label for Δ*H* Labelled double-headed arrow / labelled line that starts and ends at the correct energy levels **(1)** **Third mark –** activation energy Arrow labelled E_a / activation energy ALLOW Labelled double-headed arrow / labelled line that starts and ends at the correct energy levels / Activation energy labelled on a curve with 'one hump' **(1)** IGNORE Second E_a on a 'double hump' diagram **Note**: endothermic diagram can score M1 and M3	Labelled catalysed reaction with higher activation energy Arrow in wrong direction Arrow in wrong direction	**(3)**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	$NH_4Cl(s) + 3Cl_2(g) \rightarrow NCl_3(l) + 4HCl(g)$ Balanced equation ALLOW Multiples **(1)** State symbols Conditional on correct species or 'near miss' e.g use of NH_3Cl **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	**First mark** -shape (trigonal) pyramid(al) ALLOW **3-dimensional** shape drawn with or without lone pair e.g.  **(1)** IGNORE Bond angle, even if incorrect **Second mark** – electron pairs 4 pairs of electrons / 3 bond pairs and 1 lone pair / 4 regions of electron density ALLOW 1 lone pair and 3 (covalent) bonds/ Diagram showing electron pairs / lone pair and 3 bond pairs **(1)** **Third mark** – repulsion / separation Electron pairs arranged to minimise repulsion ALLOW Electron pairs arranged for maximum separation **(1)** IGNORE Lone pairs repel more than bond pairs	Any mention of ions loses M2 and M3. Just 'bonds repel'	**(3)**

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	IGNORE any reference to permanent dipole forces In M2 and M4, allow comparison of energy needed to break a bond as equivalent to strength of bond **First mark** – Nitrogen trichloride and ethanol / both have London forces / dispersion forces / van der Waals' forces / forces between an instantaneous dipole and an induced dipole **(1)** **Second mark** The London forces / dispersion forces / van der Waals' forces / forces between an instantaneous dipole and an induced dipole are strong**er** in nitrogen trichloride **and** because it has 58 electrons whereas ethanol has 26 ALLOW Nitrogen trichloride has more electrons (than ethanol) for the second part of M2 **(1)** **Third mark** Ethanol (also) has hydrogen bonding **(1)** **Fourth mark** The total intermolecular forces in nitrogen trichloride and ethanol must be similar OR Similar amount of heat / energy needed to break the intermolecular forces OR Hydrogen bonds in ethanol are stronger than / similar strength to London forces in nitrogen trichloride (so compensate for the weaker London forces in ethanol) ALLOW Hydrogen bonds are stronger than / have similar strength to London forces OR Hydrogen bonding is the strongest intermolecular force **(1)**	Any mention of nitrogen forming hydrogen bonds or **breaking** covalent bonds or ions loses M1 only Incorrect number(s) of electrons Ethanol forms hydrogen bonds with water	**(4)**

(Total for Question 24 = 22 marks)
(Total for Section C = 22 marks)
Total for Paper = 80 marks

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