



Mark Scheme (Results)

January 2020

Pearson International Advanced Level
In Chemistry (WCH12)
Paper 01 Energetics, Group Chemistry,
Halogenoalkanes and Alcohols

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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:
 - ensure that text is legible, and that spelling, punctuation and grammar are accurate so that meaning is 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

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	<p>The only correct answer is D $\frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{I}_2(\text{s}) \longrightarrow \text{HI}(\text{g})$</p> <p><i>A is incorrect because neither element is in its molecular form</i></p> <p><i>B is incorrect because 2 mol of hydrogen iodide is formed</i></p> <p><i>C is incorrect because iodine is not in its standard state</i></p>	1

Question Number	Answer	Mark
2	<p>The only correct answer is C (8.7 °C)</p> <p><i>A is incorrect because the ratio of 3:4 rather than 4:3 has been used</i></p> <p><i>B is incorrect because the change in volume of the final solution has been ignored</i></p> <p><i>D is incorrect because the change in moles and the change in volume of HCl has been ignored</i></p>	1

Question Number	Answer	Mark
3	<p>The only correct answer is D (391 kJ mol⁻¹)</p> <p><i>A is incorrect because only 1 mol of hydrogen has been used</i></p> <p><i>B is incorrect because the enthalpy of the reaction has been subtracted in the calculation</i></p> <p><i>C is incorrect because the enthalpy of the reaction has been ignored in the calculation</i></p>	1

Question Number	Answer	Mark
4	<p>The only correct answer is C (6.0)</p> <p><i>A is incorrect because a 1:1 ratio has been used</i></p> <p><i>B is incorrect because that is the moles produced in the stoichiometric equation</i></p> <p><i>D is incorrect because oxygen is in excess and has not been taken into account</i></p>	1

Question Number	Answer	Mark
5	<p>The only correct answer is B ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3 > (\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{CH}_3 > (\text{CH}_3)_3\text{CCH}_2\text{CH}_3$)</p> <p><i>A is incorrect because as the chain length of alkanes increases the boiling temperature increases</i></p> <p><i>C is incorrect because as the number of hydroxyl groups increases so the amount of hydrogen bonding will increase and the boiling temperature will increase</i></p> <p><i>D is incorrect because as the number of electrons increases so the boiling temperature increases</i></p>	1

Question Number	Answer	Mark
6(a)	<p>The only correct answer is B (iodide ions reduce chlorine)</p> <p><i>A is incorrect because the chlorine is reduced</i></p> <p><i>C is incorrect because the iodide ions are oxidised</i></p> <p><i>D is incorrect because iodide ions are oxidised and chlorine is reduced</i></p>	1

Question Number	Answer	Mark
6(b)	<p>The only correct answer is A (the upper layer is purple)</p> <p><i>B is incorrect because cyclohexane is less dense than water</i></p> <p><i>C is incorrect because iodine forms a purple (molecular)solution in cyclohexane</i></p> <p><i>D is incorrect because iodine is considerably more soluble in cyclohexane than in water</i></p>	1

Question Number	Answer	Mark
7	<p>The only correct answer is B (first ionisation energy decreases)</p> <p><i>A is incorrect because ionic radius increases with increasing atomic number</i></p> <p><i>C is incorrect because metallic bonding becomes weaker with increasing atomic number</i></p> <p><i>D is incorrect because the reactivity with water increases as the atomic number increases</i></p>	1

Question Number	Answer	Mark
8	<p>The only correct answer is C (thermal stability of Group 2 nitrates increases)</p> <p><i>A is incorrect because solubility of sulfates decreases going down Group 2</i></p> <p><i>B is incorrect because solubility of hydroxides increases going down Group 2</i></p> <p><i>D is incorrect because the thermal stability of carbonates increases going down Group 2</i></p>	1

Question Number	Answer	Mark
9	<p>The only correct answer is D (6, 3, 5, 1, 3)</p> <p><i>A is incorrect as the oxygen atoms do not balance</i></p> <p><i>B is incorrect as the oxygen atoms do not balance</i></p> <p><i>C is incorrect as the iodine atoms do not balance</i></p>	1

Question Number	Answer	Mark
10(a)	<p>The only correct answer is A (is yellow in colour and is insoluble in concentrated aqueous ammonia)</p> <p><i>B is incorrect because silver iodide is insoluble in concentrated aqueous ammonia</i></p> <p><i>C is incorrect because silver iodide is not cream</i></p> <p><i>D is incorrect because silver iodide is not cream and is insoluble in concentrated aqueous ammonia</i></p>	1

Question Number	Answer	Mark
10(b)	<p>The only correct answer is D (73%)</p> <p><i>A is incorrect because only the numbers of atoms are used in the calculation</i></p> <p><i>B is incorrect because the sum of the reactants and products are used in the calculation</i></p> <p><i>C is incorrect because only the numbers of products are used in the calculation</i></p>	1

Question Number	Answer	Mark
11 (a)	<p>The only correct answer is D (substitution)</p> <p><i>A is incorrect because a chlorine atom has been replaced</i></p> <p><i>B is incorrect because a hydroxyl group has been added to the reactant molecule</i></p> <p><i>C is incorrect because the reaction is not redox</i></p>	1

Question Number	Answer	Mark
11(b)	<p>The only correct answer is A (higher because ethanol molecules can hydrogen bond)</p> <p><i>B is incorrect because the number of atoms is irrelevant</i></p> <p><i>C is incorrect because the boiling temperature of ethanol is higher</i></p> <p><i>D is incorrect because the boiling temperature of ethanol is higher</i></p>	1

Question Number	Answer	Mark
11(c)	<p>The only correct answer is B (faster because the C-Br bond is weaker than the C-Cl bond)</p> <p><i>A is incorrect because the rate of the reaction depends on the bond strength rather than polarity</i></p> <p><i>C is incorrect because the rate is faster</i></p> <p><i>D is incorrect because the rate is faster</i></p>	1

Question Number	Answer	Mark
12 (a)	<p>The only correct answer is B (11.2)</p> <p><i>A is incorrect because the volume of unreacted oxygen has been ignored</i></p> <p><i>C is incorrect because the volume of unreacted oxygen has been ignored and the water produced has been treated as steam</i></p> <p><i>D is incorrect because the water produced has been treated as steam</i></p>	1

Question Number	Answer	Mark
12(b)	<p>The only correct answer is B (1600)</p> <p><i>A is incorrect because the volume of unreacted oxygen has been ignored</i></p> <p><i>C is incorrect because the reaction of carbon dioxide with sodium hydroxide has been ignored and the volume of unreacted oxygen has also been ignored</i></p> <p><i>D is incorrect because the volume of unreacted oxygen has been ignored and the water produced has been treated as steam</i></p>	1

Question Number	Answer	Mark
13	<p>The only correct answer is D (2-chloro-2-methylpropane)</p> <p><i>A is incorrect because because 1-chlorobutane is a primary halogenoalkane and would not react immediately</i></p> <p><i>B is incorrect because 2-chlorobutane is a secondary halogenoalkane and would not react immediately</i></p> <p><i>C is incorrect because 1-chloro-2-methylpropane is a primary halogenoalkane and would not react immediately</i></p>	1

Question Number	Answer	Mark
14(a)	<p>The only correct answer is B (29)</p> <p><i>A is incorrect because propanone would be expected to have a fragment peak at m/z 15</i></p> <p><i>C is incorrect because propanone would be expected to have a fragment peak at m/z 43</i></p> <p><i>D is incorrect because propanone would be expected to have a molecular ion peak at m/z 58</i></p>	1

Question Number	Answer	Mark
14(b)	<p data-bbox="342 277 1646 310">The only correct answer is C (warm with acidified potassium dichromate(VI), turns green, no change)</p> <p data-bbox="342 370 1402 402"><i>A is incorrect because propanone does not give a positive result with Fehling's solution</i></p> <p data-bbox="342 462 1297 495"><i>B is incorrect because neither propanal nor propanone contains an OH group</i></p> <p data-bbox="342 555 1329 587"><i>D is incorrect because neither propanal nor propanone contains a -COOH group</i></p>	1

Section B

Question Number	Answer	Additional Guidance	Mark
15(a)(i)	<ul style="list-style-type: none">the hydrated crystals already have a certain amount/ 4.5 g / 5 moles of / (more) water or 4.5 g is the difference in mass between the hydrated and anhydrous salt (1)so that the total amount/mass/ volume of water is kept the same/ 50 cm³/ 58 g (1)	Allow: anhydrous crystals have no water Do not award: less water Ignore references to differences in solubility Do not award: 58 cm ³	2

Question Number	Answer	Additional Guidance	Mark
15 a(ii)	<ul style="list-style-type: none"> <li data-bbox="405 342 982 412">• calculation of energy transferred = mass x 4.2 x ΔT (1) <li data-bbox="405 464 982 534">• calculation of moles = mass ÷ M_r (1) <li data-bbox="405 586 982 656">• calculation of $\Delta_{soln}H$ = - Energy in kJ ÷ moles (1) 	<p data-bbox="1031 261 1360 293"><u>Example of calculation:</u></p> <p data-bbox="1031 337 1503 370">50 x 4.2 x 16.0 = 3360 (J) / 3.360kJ</p> <p data-bbox="1121 451 1413 483">8 / 159.6 = 0.050125</p> <p data-bbox="1031 492 1402 524">Allow 8 / 159.5 = 0.050157</p> <p data-bbox="1052 561 1241 594">3.36 ÷ 0.0501</p> <p data-bbox="1157 597 1625 630">= -67.03242 / -66.98965 (kJ mol⁻¹)</p> <p data-bbox="1031 638 1612 670">(-67.066 / -66.932/ from rounded values)</p> <p data-bbox="1031 711 1304 743">Ignore SF except 1 SF</p> <p data-bbox="1031 751 1667 784">Do not award M3 for a positive answer or no sign</p> <p data-bbox="1031 824 1220 857">TE throughout</p> <p data-bbox="1031 889 1167 922">Comment:</p> <p data-bbox="1031 922 1654 954">If mass of salt has been added i.e. 58 g then</p> <p data-bbox="1031 954 1675 987">M1 is lost but value for heat energy produced</p> <p data-bbox="1031 987 1262 1019">will be 3.8976 kJ</p> <p data-bbox="1031 1019 1514 1052">M2 can be scored and also M3 for</p> <p data-bbox="1031 1052 1251 1084">=77.758 kJ mol⁻¹</p> <p data-bbox="1031 1141 1661 1174">If value of moles has been rounded to 0.05 value</p> <p data-bbox="1031 1174 1318 1206">for M3 is -67.2 kJ mol⁻¹</p> <p data-bbox="1031 1206 1507 1239">Accept answer in J mol⁻¹ if units given</p> <p data-bbox="1031 1239 1297 1271">Do not penalise mol⁻¹</p>	3

Question Number	Answer	Additional Guidance	Mark
15(a)(iii)	<ul style="list-style-type: none"> two arrowheads both pointing down 	Ignore: additional arrows(working)	1

Question Number	Answer	Additional Guidance	Mark
15 a (iv)	<ul style="list-style-type: none"> use of correct Hess cycle $\Delta_r H = \Delta_{soln} H(\text{anhydrous}) - \Delta_{soln} H(\text{hydrated})$ i.e. correct application of Hess cycle correct evaluation including sign 	<p><u>Example of calculation:</u></p> <p>(1) -67.0 -12.6 = (1) -79.6(kJ mol⁻¹)</p> <p>TE from (a)(ii) but not from (a)(iii)</p> <p>Ignore SF</p>	2

Question Number	Answer	Additional Guidance	Mark
15(b)	<p>An answer that make reference to one reason for each direction.</p> <p>Forward</p> <ul style="list-style-type: none"> • adding water to the anhydrous salt will produce a solution and does not form a solid • some of the water may turn to steam/be lost (because the forward reaction is exothermic) • difficult to determine when exactly 5 mol water to 1 mol CuSO₄ has been added to form a solid • the temperature of a solid is difficult to measure <p style="text-align: right;">(1)</p> <p>Reverse</p> <ul style="list-style-type: none"> • the hydrated salt has to be heated/ the energy from the Bunsen burner is difficult to take into account/ hard to measure the temperature when heating • the temperature of a solid is difficult to measure • the salt may decompose further <p style="text-align: right;">(1)</p>	<p>Ignore references to ΔH measurements in both forward and reverse</p> <p>Ignore "heat loss (to the surroundings)"</p> <p>Do not award if same reason given for "forward"</p>	2

Question Number	Answer	Additional Guidance	Mark
15(c)	<p>An description that makes reference to the following points:</p> <ul style="list-style-type: none"> (water molecules) break the (ionic) lattice/solid (1) (water molecules) can hydrate/surround the ions / ion-dipole interactions form (1) 	<p>Accept Dissociate the ions</p> <p>Do not award references to atoms/molecules of coppersulfate</p> <p>Do not award references to hydrogen bonding of Cu^{2+} / reactions between copper sulfate and water</p>	2

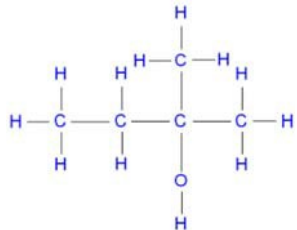
Question Number	Answer	Additional Guidance	Mark
15(d)(i)	<ul style="list-style-type: none"> calculation of moles HCl in mean titre (1) calculation of moles sodium carbonate in 25 cm³ and 250 cm³ (1) 	<p>Example of calculation:</p> $25.60 \times 0.0900 \div 1000 = 0.002304 / 2.304 \times 10^{-3} \text{ (mol)}$ $0.002304 \div 2 = 0.001152 / 1.152 \times 10^{-3} \text{ (mol)}$ $0.001152 \times 250/25 = 0.01152 / 1.152 \times 10^{-2} \text{ (mol)}$ <p>Ignore SF except 1 SF/ units</p> <p>TE at each stage</p>	2

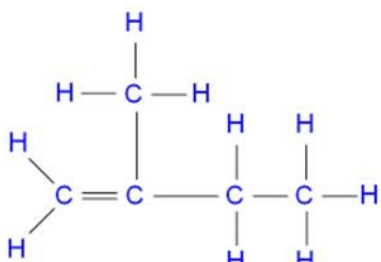
Question Number	Answer	Additional Guidance	Mark
15 d(ii)	<p>Method 1</p> <p>M1 calculation of mass sodium carbonate in solution (1)</p> <p>M2 calculation of mass of water of crystallisation (1)</p> <p>M3 calculations of moles of water (1)</p> <p>M4 calculation of water : Na₂CO₃ mole ratio and value of x to a whole number (1)</p> <p>Method 2</p> <p>M1 calculation of mass of 1 mole (1)</p> <p>M2 calculation of mass of water in sample (1)</p> <p>M3 calculation of moles of water (1)</p> <p>M4 value of x to a whole number (1)</p>	<p>Examples of calculation:</p> <p>0.01152 × 106 = 1.22112</p> <p>3.29 – 1.22112 = 2.06888</p> <p>2.06888 ÷ 18 = 0.114938</p> <p>0.114938 ÷ 0.01152 = 9.98 = 10</p> <p>3.29 ÷ 0.01152 = 285.59</p> <p>285.59 – 106 = 179.59</p> <p>179.59 ÷ 18 = 9.977</p> <p>= 10</p> <p>TE at each step and from (i) Correct answer scores M4 only Comment: if candidate has used 25 cm³ answer in (i) might be 1.125 × 10⁻² and TE in (ii) could give 10.35 rounded to 10 4 marks</p>	4

Question Number	Answer	Additional Guidance	Mark																				
*16 (a)	<p>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.</p> <p>Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.</p> <p>The following table shows how the marks should be awarded for indicative content.</p> <table border="1" data-bbox="352 630 833 885"> <thead> <tr> <th>Number of indicative marking points seen in answer</th> <th>Number of marks awarded for indicative marking points</th> </tr> </thead> <tbody> <tr> <td>6</td> <td>4</td> </tr> <tr> <td>5-4</td> <td>3</td> </tr> <tr> <td>3-2</td> <td>2</td> </tr> <tr> <td>1</td> <td>1</td> </tr> <tr> <td>0</td> <td>0</td> </tr> </tbody> </table> <table border="1" data-bbox="352 938 1192 1247"> <thead> <tr> <th></th> <th>Number of marks awarded for structure of answer and sustained line of reasoning</th> </tr> </thead> <tbody> <tr> <td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td> <td>2</td> </tr> <tr> <td>Answer is partially structured with some linkages and lines of reasoning.</td> <td>1</td> </tr> <tr> <td>Answer has no linkages between points and is unstructured.</td> <td>0</td> </tr> </tbody> </table> <p>The following table shows how the marks should be awarded for structure and lines of reasoning.</p>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained line of reasoning	Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.	2	Answer is partially structured with some linkages and lines of reasoning.	1	Answer has no linkages between points and is unstructured.	0	<p>Guidance on how the mark scheme should be applied:</p> <p>The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages). In general, it would be expected that 5 or 6 indicative points would get 2 reasoning marks and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).</p>	6
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
3-2	2																						
1	1																						
0	0																						
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	<p>Indicative content</p> <ul style="list-style-type: none"> • IP1 methane has (only) London forces / dispersion forces / instantaneous dipole - induced dipole forces • IP2 London forces are weaker than hydrogen bonds • IP3 NH₃/ H₂O / HF have hydrogen bonds • IP4 the hydrogen bond is stronger in HF than H₂O / NH₃ or London forces are same/similar as they have the same number of electrons • IP5 Fluorine has higher electronegativity than N or O / is the most electronegative element/ H-F bond is the most polar • IP6 Water has more hydrogen bonds (than ammonia/ HF) 	<p>Any mention of breaking covalent bonds or a different number of electrons negates 1 reasoning mark</p> <p>Allow van der Waals' forces</p> <p>Allow reverse</p> <p>Do not award ammonia having dipole-dipole bonds rather than hydrogen bonds</p> <p>Allow ratio of 2:1 in H₂O with NH₃/HF</p>	
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Question Number	Answer	Additional Guidance	Mark
16b	<p>An answer that makes reference to the following points:</p> <p>Similarities</p> <ul style="list-style-type: none"> • both produce hydrogen halides (1) • formation of hydrogen halides protonation (1) • both give off misty/steamy fumes (1) <p>Differences</p> <ul style="list-style-type: none"> • only the reaction of potassium bromide is redox/bromide ions are stronger reducing agents than chloride ions (1) • (red)-brown fumes/liquid produced with potassium bromide (1) • sulfur dioxide/bromine given off with potassium bromide (1) 	<p>Both similarities and differences can be shown in equations or with observations</p> <p>Accept $KX + H_2SO_4 \rightarrow HX + KHSO_4$ Allow $2KX + H_2SO_4 \rightarrow 2HX + K_2SO_4$</p> <p>Do not award white smoke/fumes</p> <p>Accept $2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$ Do not award rotten egg smell/references to yellow solid Comment: This can be awarded from an incorrect/unbalanced equation</p>	4

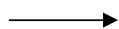
Question Number	Answer	Additional Guidance	Mark
17(a)		<p>Allow -OH</p> <p>Ignore connectivity of OH unless horizontal</p> <p>Ignore skeletal and structural formulae</p> <p>Ignore length of bonds</p> <p>Do not award CH₃/C₂H₅ or missing H</p>	1
17(b)(i)	<ul style="list-style-type: none"> (concentrated) phosphoric(V) acid / H₃PO₄ 	<p>Accept (concentrated) sulfuric acid / H₂SO₄</p> <p>Do not award dilute sulfuric acid If formula and name are given, both must be correct</p> <p>Allow aluminium oxide / Al₂O₃</p>	1

Question Number	Answer	Additional Guidance	Mark
17 b (ii)		Allow skeletal or structural formulae, CH ₂ C(CH ₃)C ₂ H ₅ , or any combination	1

Question Number	Answer	Additional Guidance	Mark
17(b)(iii)	<p>An explanation that makes reference to the following points:</p> <ul style="list-style-type: none"> (in both cases) there are two identical (functional) groups/atoms on one carbon (of the double bond) (1) neither display geometric isomerism (1) 	<p>Comment</p> <p>Allow "on ends/ sides of the double bond"</p> <p>Ignore reference to restricted rotation about the double bond</p> <p>Do not award molecules for groups/atoms</p> <p>M2 dependent on M1</p> <p>Comment: M2 can be awarded for e.g. "both have two methyl groups on one carbon (of the double bond)"</p> <p>Allow Max (1) for correct description of 2-methylbut-2-ene</p>	2

Question Number	Answer	Additional Guidance	Mark
17(c)	<ul style="list-style-type: none"> • $\text{CH}_3\text{CH}_2\text{CCl}(\text{CH}_3)_2$ (1) • tertiary carbocations are more stable (than secondary carbocations)/have more electron donating groups (1) 	<p>Allow displayed or skeletal formulae Do not award $\text{C}_5\text{H}_{11}\text{Cl}$ or bromoalkane</p> <p>Ignore references to product stability Do not award just a comparison with primary carbocation stability</p>	2

Question Number	Answer	Additional Guidance	Mark
17(d)(i)	<ul style="list-style-type: none"> • $(\text{C}_5\text{H}_{11}\text{OH} + \text{PCl}_5) \quad \text{C}_5\text{H}_{11}\text{Cl} + \text{POCl}_3 + \text{HCl}$ 	<p>Ignore state symbols even if incorrect Accept PCl_3O</p>	1



Question Number	Answer	Additional Guidance	Mark
17(d)(ii)	<ul style="list-style-type: none"> • this reaction is one step / the other method is a two-step process (1) • yield is higher because in the 2 step process both steps give 2 isomers/this reaction has no isomers /no organic by-products /no minor product (1) 	<p>Ignore higher atom economy,(non)reversible References to temperature and pressure</p>	2

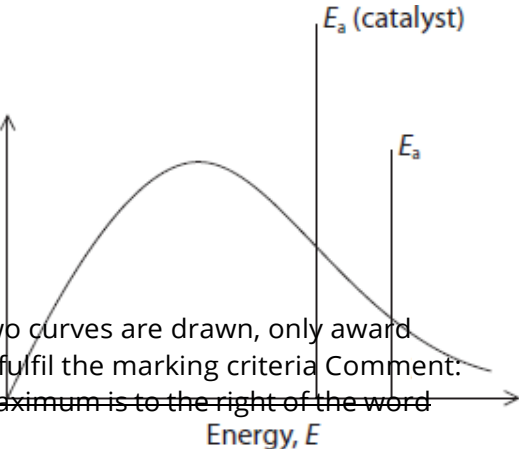
Question Number	Answer	Additional Guidance	Mark
17(d)(iii)	O-H (stretch) and 3750-3200 (cm ⁻¹)	Allow OH Do not award —OH	1

Question Number	Answer	Additional Guidance	Mark
17(e)	<ul style="list-style-type: none"> 2-methylbutan-2-ol is a tertiary alcohol cannot be oxidised (in the liver so is excreted unchanged) (1) 2-methylbutan-1-ol (is a primary alcohol and) would be oxidised to a aldehyde (which is toxic) (1) 	Ignore any reference to further oxidation	2

Section C

Question Number	Answer	Additional Guidance	Mark
18 (a)	<ul style="list-style-type: none"> • calculation of M_r (1) • calculation of % nitrogen (1) 	<p>Example of calculation:</p> <p>$(14 \times 2) + (1 \times 2) + 12 + 16$ $(=60)$</p> <p>$\% = (28/60) \times 100 =$ 46.667%</p> <p>TE on incorrect M_r Ignore SF except 1SF</p> <p>Correct answer with no working scores (2)</p>	2

Question Number	Answer	Additional Guidance	Mark
18(b)	<p>Suggestions that make reference to the following points:</p> <ul style="list-style-type: none"> • (It is used for crops such as rice because) the ammonia produced will dissolve/react in the water/form ammonium ions (and not be lost) (1) • (In areas of unpredictable rainfall the urea will breakdown/decompose and) ammonia will escape/vapourise or farmers don't know when to apply the urea as it may be wasted (1) 	<p>Ignore references to eutrophication, global warming</p> <p>Do not award references to acid rain ammonia is absorbed by crops</p>	2

Question Number	Answer	Additional Guidance	Mark
18(c)(i)	<ul style="list-style-type: none"> • the curve should be asymmetric and should start at the origin (1) • and be asymptotic to the x axis and must not end horizontally (1) • the Activation Energies should both lie to the right of the maximum and should be in the order shown i.e. E_a no catalyst should lie at higher energy (1) 	<p>Example of graph</p>  <p>Do not award M3 if two curves are drawn, only award M1, M2 if both curves fulfil the marking criteria Comment: Penalise M1 if peak maximum is to the right of the word "Energy" on the x axis</p>	3

Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	<ul style="list-style-type: none"> larger proportion / larger number / more molecules have energy greater than or equal to E_a so there are more successful collisions / rate increases. (1) (because) the area (under the curve) to the right of/at a greater energy than E_a is larger (1) 	May be shown on labelled diagram	2

Question Number	Answer	Additional Guidance	Mark
18(c)(iii)	<ul style="list-style-type: none"> Higher pressure moves position of equilibrium forward/ to the right/ increases yield/ makes more ammonia (1) 4 (gaseous) moles/molecules on LHS and 2 (gaseous) moles / molecules on RHS (1) 	<p>If position of equilibrium moves to the left score (0)</p> <p>Allow more (gaseous) moles/molecules on LHS</p>	2

Question Number	Answer	Additional Guidance	Mark
18(d)(i)	No changes in oxidation number	<p>If oxidation numbers are given they must be correct</p> <p>May be shown on the equation</p> <p>Ignore no element is oxidised or reduced</p>	1

Question Number	Answer	Additional Guidance	Mark
18(d)(ii)	<ul style="list-style-type: none"> • a high temperature increases the rate of the reaction (1) • so the ammonia formed reacts quickly with the exhaust gases (1) 	<p>Comment</p> <p>Allow alternative approach</p> <ul style="list-style-type: none"> • the forward reaction / formation of ammonia is endothermic (1) • (so) a high temperature increases yield of ammonia/moves position of equilibrium to the right/cooling would move position of equilibrium to the left/cooling would reduce the yield of ammonia (1) 	2

Question Number	Answer	Additional Guidance	Mark
18(d)(iii)	<ul style="list-style-type: none"> • N in NH₃ is oxidised from -3 to 0 (1) • N in NO is reduced from (+)2 to 0 / O in O₂ is reduced from 0 to -2 (1) • no (element in a) single compound / molecule/species is (simultaneously) oxidised and reduced (1) 	May be shown in the equation Max 1 from M1 and M2 if "oxidised/reduced" are missing or reversed	3

Question Number	Answer	Additional Guidance	Mark
18(d)(iv)	<p>Any two from</p> <ul style="list-style-type: none"> • oxides of nitrogen dissolve in water to form acid rain/nitric acid • oxides of nitrogen cause breathing problems / asthma • depletion of the ozone layer • formation of (photochemical) smog 	<p>IGNORE: NO is a pollutant/is toxic</p> <p>Do not award global warming/greenhouse gas</p>	2

