Pearson Edexcel

Mark Scheme (Results)

Summer 2022

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

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Summer 2022
Question Paper Log Number P70965A
Publications Code WCH12_01_2206_MS

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.

Question number	Answer	Mark
1	**The only correct answer is A** ($2Al(s) + 1½O_2(g) \rightarrow Al_2O_3(s)$) ***B*** *is incorrect because oxygen exists as O_2 in its standard state* ***C*** *is incorrect because standard enthalpy change of formation is for the formation of 1 mol of a compound* ***D*** *is incorrect because standard enthalpy change of formation is for the formation of 1 mol of a compound and oxygen exists as O_2 in its standard state*	**(1)**

Question number	Answer	Mark
2	**The only correct answer is A** (gains electrons and decreases in oxidation number) ***B*** *is incorrect because oxidising agents are reduced during a reaction so there is a decrease in oxidation number* ***C*** *is incorrect because oxidising agents are reduced during a reaction so they gain electrons* ***D*** *is incorrect because oxidising agents are reduced during a reaction so they gain electrons and there is a decrease in oxidation number*	**(1)**

Question number	Answer	Mark
3	**The only correct answer is B** ($CH_3CH_2CH_2CH_2OH$) ***A*** *is incorrect because branching in the carbon chain reduces the boiling temperature of isomeric alcohols* ***C*** *is incorrect because alkanes do not have hydrogen bonding and have lower boiling temperatures than alcohols with a similar number of electrons* ***D*** *is incorrect because alkanes do not have hydrogen bonding and have lower boiling temperatures than alcohols with a similar number of electrons*	**(1)**

Question number	Answer	Mark
4	**The only correct answer is B** (potassium chlorate(III)) ***A*** *is incorrect because the oxidation number of chlorine in $KClO_2$ is +3* ***C*** *is incorrect because the oxidation number of chlorine in $KClO_2$ is +3* ***D*** *is incorrect because the oxidation number of chlorine in $KClO_2$ is +3*	**(1)**

Question number	Answer	Mark
5(a)	**The only correct answer is D** ($Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$) ***A*** *is incorrect because CaO is not a product of the reaction* ***B*** *is incorrect because CaO_2 is an incorrect formula for calcium oxide* ***C*** *is incorrect because CaOH is an incorrect formula for calcium hydroxide*	**(1)**

Question number	Answer	Mark
5(b)	**The only correct answer is A** (calcium oxidised, hydrogen reduced) ***B*** *is incorrect because oxygen is not reduced* ***C*** *is incorrect because hydrogen is not oxidised and calcium is not reduced* ***D*** *is incorrect because hydrogen is not oxidised and oxygen is not reduced*	**(1)**

Question number	Answer	Mark
6	**The only correct answer is A** ($BaCO_3(s) + 2H^+(aq) \rightarrow Ba^{2+}(aq) + CO_2(g) + H_2O(l)$) ***B*** *is incorrect because* Ba_2CO_3 *is not the formula for barium carbonate* ***C*** *is incorrect because solid barium carbonate should not be split up into ions* ***D*** *is incorrect because hydrochloric acid is in solution and should be split up into ions and* Cl^- *are spectator ions*	**(1)**

Question number	Answer	Mark
7	**The only correct answer is D** (Reagent: NaOH(aq), Test for gas: damp red litmus paper turns blue) ***A*** *is incorrect because hydrochloric acid does not react with ammonium ions* ***B*** *is incorrect because hydrochloric acid does not react with ammonium ions* ***C*** *is incorrect because ammonia is produced and it is alkaline so turns damp red litmus paper blue*	**(1)**

Question number	Answer	Mark
8	**The only correct answer is D** (violet) ***A*** *is incorrect because iodine is produced in the reaction and it is brown in aqueous solution but violet in a non-polar organic solvent* ***B*** *is incorrect because chlorine gas is green* ***C*** *is incorrect because bromine is orange in a non-polar organic solvent*	**(1)**

Question number	Answer	Mark
9(a)	**The only correct answer is C** (yellow to orange) ***A*** *is incorrect because methyl orange is yellow in alkaline solution* ***B*** *is incorrect because methyl orange is yellow in alkaline solution and turns red when excess acid has been added* ***D*** *is incorrect because methyl orange turns red when excess acid is added*	**(1)**

Question number	Answer	Mark
9(b)	**The only correct answer is C** (22.80, 22.35, 22.40 (cm^3)) ***A*** *is incorrect because the first titre should be higher than the other two titres* ***B*** *is incorrect because the second and third titres should be concordant and lower than the first titre* ***D*** *is incorrect because the second and third titres should be lower than the first titre*	**(1)**

Question number	Answer	Mark
9(c)	**The only correct answer is B** (0.0668 (mol dm^{-3})) ***A*** *is incorrect because the volumes have been used the wrong way round* ***C*** *is incorrect because the mole ratio of 2 : 1 has not been used* ***D*** *is incorrect because the mole ratio has been used as 2 H_2SO_4 : 1 NaOH*	**(1)**

Question number	Answer	Mark
10(a)	**The only correct answer is D** (decreasing the activation energy of the reaction) ***A*** *is incorrect because only an increase in temperature causes the average kinetic energy of the molecules to increase* ***B*** *is incorrect because only a decrease in temperature causes the average kinetic energy of the molecules to decrease* ***C*** *is incorrect because if the activation energy increased, the rate of decomposition would decrease*	**(1)**

Question number	Answer	Mark
10(b)	**The only correct answer is D** (0.833 (mol dm^{-3})) ***A*** *is incorrect because the volume of oxygen has not been converted into moles* ***B*** *is incorrect because the 2 : 1 mole ratio has been used the wrong way around* ***C*** *is incorrect because the 2 : 1 mole ratio has not been used*	**(1)**

Question number	Answer	Mark
11	**The only correct answer is A** (change in equilibrium position: left, enthalpy change: endothermic) ***B*** *is incorrect because an exothermic reaction would decrease the concentration of iodine* ***C*** *is incorrect because the equilibrium position would shift to the left* ***D*** *is incorrect because the equilibrium position would shift to the left*	**(1)**

Question number	Answer	Mark
12	**The only correct answer is C** (nucleophile) ***A*** *is incorrect because electrophiles attack atoms with a slight negative charge* ***B*** *is incorrect because free radicals attack neutral atoms* ***D*** *is incorrect because oxidising agents remove electrons from a species*	**(1)**

Question number	Answer	Mark
13	**The only correct answer is B** (**P** and **Q** only) ***A*** *is incorrect because **Q** is also primary alcohol and will be oxidised to a carboxylic acid* ***C*** *is incorrect because **R** is a secondary alcohol and will be oxidised to a ketone* ***D*** *is incorrect because **R** is a secondary alcohol and will be oxidised to a ketone and **S** is a tertiary alcohol so is not easily oxidised*	**(1)**

Question number	Answer	Mark
14(a)	**The only correct answer is C** (concentrated phosphoric(V) acid) ***A*** *is incorrect because acidified potassium manganate(VII) converts an alkene into a diol* ***B*** *is incorrect because aqueous bromine reacts with an alkene to form a bromoalcohol* ***D*** *is incorrect because phosphorus(V) chloride reacts with an alcohol to form a chloroalkane*	**(1)**

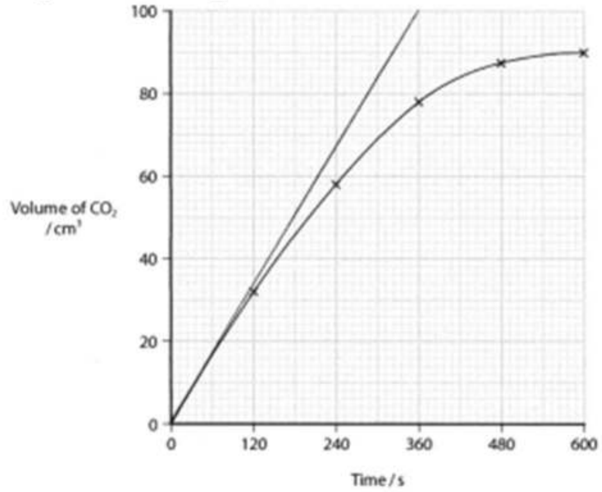
Question number	Answer	Mark
14(b)	**The only correct answer is C** ($C_6H_{11}OH$ + [O] → $C_6H_{10}O$ + H_2O) ***A*** *is incorrect because [O] is needed from the oxidising agent and hydrogen gas would not be produced* ***B*** *is incorrect because [O] is needed from the oxidising agent and hydrogen atoms would not be produced* ***D*** *is incorrect because the oxidising agent is not oxygen gas*	**(1)**

Question number	Answer	Mark
14(c)	**The only correct answer is C** (3750-3200, 1669-1645) ***A*** *is incorrect because there is a C-H bond in both compounds* ***B*** *is incorrect because there is a C-H bond in both compounds and there is no C=O in cyclohexene* ***D*** *is incorrect because there is no C=O in cyclohexene*	**(1)**

(Total for Section A = 20 marks)

Question Number	Answer	Additional Guidance	Mark
15(a)	An explanation that makes reference to the following points: • **Size (and charge)** calcium ion / Ca^{2+} has a larger (ionic) radius than a magnesium ion (but the same charge) **or** magnesium ion / Mg^{2+} has a smaller (ionic) radius / is smaller than a calcium ion (but the same charge) **(1)** • **Polarising power** so calcium ion / Ca^{2+} causes less polarisation / distortion **or** magnesium ion / Mg^{2+} causes more polarisation / distortion **(1)** • **What is polarised** of the carbonate ion / CO_3^{2-} / anion / negative ion / C−O bonds / C=O bonds /CO bonds **(1)**	Penalise omission of 'ion' or just magnesium / Mg / calcium / Ca without charge once only in M1 and M2 Allow reverse argument for magnesium ions in M1 and M2 Allow size for radius or just 'bigger / smaller' Allow ionic radius / size of cation increases down the group / decreases up the group Allow calcium carbonate has a larger **cation** Allow calcium ions have a lower charge density Allow calcium ions have more shells of electrons Ignore effective nuclear charge / mass : charge ratio Ignore atomic radius Ignore omission of same charge Do not award M1 if mention of different / incorrect charges on magnesium and calcium ions Allow polarising power of cation decreases down the group Allow Ca^{2+} causes less weakening of bonds for polarisation Do not award just 'the carbonate ion is less polarisable' for M2, although this can score M3 Allow electron cloud for ion Do not award reference to nitrate / N-O bonds Do not award reference to breaking unspecified bonds / (ionic) bond between cation and anion Do not award references to intermolecular forces	**(3)**

Question Number	Answer	Additional Guidance	Mark
15(b)(i)	• calculation of mol of CO_2 **(1)** • calculation of mol of HCl **(1)** • calculation of volume of HCl **and** corresponding volume unit **(1)**	Example of calculation: mol $CO_2 = \frac{100}{24\,000} = 0.0041667 / 4.1667 \times 10^{-3}$ (mol) mol HCl = 2 x 0.0041667 = 0.0083333 / 8.3333×10^{-3} (mol) TE on M1 vol HCl = $\frac{0.0083333}{0.500}$ x 1000 = (16.667) = 16.6 cm^3 / 0.0166 dm^3 Do not award incorrect units e.g. cm^{-3} / dm^{-3} Allow 16.67 / 16.7 cm^3 as the theoretical volume of CO_2 is 100.02 / 100.2 cm^3 Do not award 17 cm^3 as the theoretical volume of CO_2 is 102 cm^3 so would exceed the measurable volume of the syringe Allow any number between 16 and 16.7 cm^3 / 0.016 and 0.0167 dm^3 inclusive TE on M2 Ignore SF except 1 SF Correct answer with units and no working scores (3) Accept fractions / correct working not evaluated for M1 and M2 e.g. 1/240, 1/120	**(3)**

Question Number	Answer	Additional Guidance	Mark
15(b)(ii)		Example of working: 	**(3)**
	• tangent drawn at t = 0	Tangent must touch the curve for at least 24 s (2 small squares horizontally) and extend to at least 20 cm^3	
	• gradient	Gradient = $\frac{100}{360}$ = 0.27778 (expected value 0.25 to 0.33 for tangent at t = 0) TE on tangent drawn at any time value If no tangent drawn, allow a selected point and y/x value e.g. 32/120 = 0.27	
	• units	Stand alone mark $cm^3\ s^{-1}$ or cm^3 / s or $\frac{cm^3}{s}$ Allow $cm^3\ s^{-}$	

Question Number	Answer	Additional Guidance	Mark
15(b)(iii)	An answer that makes reference to the following point: • initial rate halves **and** final volume of CO_2 halves / is 45 (cm^3)	Allow initial rate decreases **and** final volume of CO_2 decreases Do not award any specific decrease (e.g. decrease by a factor of 4) except for half	**(1)**

(Total for Question 15 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
16(a)	An explanation that makes reference to the following points: • atomic radius increases **or** distance between the nucleus and outer electrons increases **or** there are more shells / energy levels of inner electrons between the nucleus and the outer shell electrons **(1)** • so there is less attraction (by the nucleus with a higher charge) for the bonding electrons / shared pair of electrons **(1)**	Allow size of atoms increases / gets bigger Allow just 'more shells of electrons' Allow effective nuclear charge decreases Do not award nuclear charge decreases Do not award reference to ions / ionic radius for M1 only Allow greater shielding between the nucleus and the bonding electrons / shared pair of electrons **Note** – bonding / shared pair can be mentioned anywhere in the answer	**(2)**

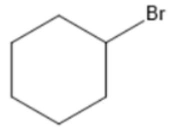
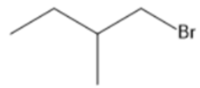
Question Number	Answer	Additional Guidance	Mark
16(b)	An answer that makes reference to the following points: • three oxidation numbers of I: IO_3^- = (+)5 I^- = −1 I_2 = 0 **(1)** • two different species / ions / compounds (of iodine) are oxidised and reduced (to form the same species) **or** there is not one species / ion / compound that is being oxidised and reduced **or** 2 different oxidation states are not produced from one oxidation state (of iodine) **or** only one species / oxidation state of iodine is formed **(1)**	Allow oxidation numbers written near species in the equation Ignore oxidation numbers of H and O Do not award O.N. I_2 is neutral / I^- is −5 Allow I_2 / iodine is oxidised and reduced in the reverse reaction Allow (iodine in) IO_3^- is only being reduced **or** (iodine in) I^- is only being oxidised Ignore just 'the reaction is only oxidation / reduction' Ignore just 'comproportionation' Ignore just 'I / iodine is not simultaneously oxidised and reduced'	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(c)	• sulfur dioxide / sulfur (IV) oxide / SO_2 produced from HBr **and** hydrogen sulfide / H_2S produced from HI	Example of table: <table><tr><th>Hydrogen halide</th><th>Compound produced with the lowest oxidation number of sulfur</th></tr><tr><td>(HBr)</td><td>sulfur dioxide / SO_2</td></tr><tr><td>(HI)</td><td>hydrogen sulfide / H_2S</td></tr></table>Ignore Br_2 and I_2 **Note** - If name and formula are given, both must be correct	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(d)	An explanation that makes reference to the following points: • all hydrogen halides have London forces (and dipole-dipole forces between molecules) **(1)** • the strength of the London forces increases as the number of electrons increases (so the boiling temperature increases from HCl to HI) **or** the strength of the London forces increases as the polarisability of the molecules increases from HCl to HI **(1)** • (only) HF has hydrogen bonding (between molecules) **(1)** • hydrogen bonding is (much) stronger than London forces / dipole-dipole forces (so HF has the highest boiling temperature) **(1)**	Allow van der Waals' forces / dispersion forces / attractions between instantaneous dipoles and induced dipoles for London forces or a description of London forces Ignore London forces omitted from HF Do not award this mark if ions mentioned in answer Do not award this mark if breaking H-Cl, H-Br or H-I bonds Ignore the strength of the London forces increases as the size of the molecule / M_r increases Do not award M3 if hydrogen bonding in any other hydrogen halide Allow more heat energy is needed to overcome hydrogen bonding than London forces Allow hydrogen bonding is the strongest intermolecular force / bond	**(4)**

Question Number	Answer	Additional Guidance	Mark
16(e)	An answer that makes reference to the following point: • calculation of mol of AgCl **(1)** • calculation of mass of Cl^- **(1)** • calculation of percentage of Cl^- **(1)** **OR** • calculation of % by mass of Cl in AgCl **(1)** • calculation of mass of Cl in residue **(1)** • calculation of percentage of Cl^- **(1)**	Example of calculation: **Method 1** mol AgCl = $\frac{0.226}{143.4}$ = 0.0015760 / 1.5760 x 10^{-3} mass Cl^- = 1.5760 x 10^{-3} x 35.5 = 0.055948 (g) % Cl^- = $\frac{0.055948}{0.098}$ x 100 = 57.09 / 57.1 / 57 (%) **Method 2** % by mass of Cl in AgCl = $\frac{35.5}{143.4}$ x 100 = 24.756 (%) mass of Cl = 24.756 x 0.226 = 0.055948 (g) % by mass of Cl^- in residue = $\frac{0.055948}{0.098}$ x 100 = 57.09 / 57.1 / 57 (%) Correct answer with no working scores (3) Allow TE at each stage Allow alternative methods Ignore SF except 1 SF Accept fractions / correct working not evaluated for M1 and M2	**(3)**

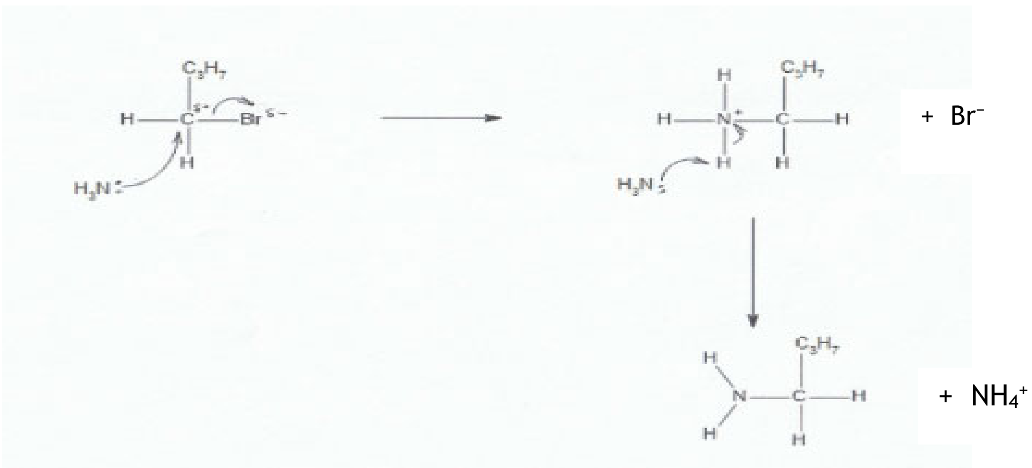
(Total for Question 16 = 12 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>17(a)</td><td>• both classifications correct</td><td>Example of table:
<table>
<tr><th>Halogenoalkane</th><th>Classification</th></tr>
<tr><td>
</td><td>secondary</td></tr>
<tr><td>
</td><td>primary</td></tr>
</table>
Allow 2^{o} for secondary
Allow 1^{o} for primary
Ignore halogenoalkane</td><td>(1)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
17(b)	An explanation that makes reference to the following points: • 2-chloro-2-methylpropane should react faster than 1-iodobutane because it is tertiary **(1)** • 1-iodobutane should react faster than 2-chloro-2-methylpropane because the C−I bond enthalpy is lower than C−Cl **(1)** • it is not possible to predict the relative effects of these two opposing factors / structure and bond enthalpies **(1)**	Stand alone mark Allow tertiary / branched chain / more branched halogenoalkanes have a higher rate of hydrolysis than primary halogenoalkanes Do not award secondary for 2-chlor-2-methylpropane Do not award tertiary carbocation Stand alone mark Allow just 'the C−I bond is weaker / has a lower bond enthalpy than C−Cl' Ignore just 'bonds in 1-iodobutane are weaker' Do not award H−I / H−Cl bonds Conditional on two opposing factors If M1 and M2 scored, allow 'so it is not possible to predict the relative rate of hydrolysis'	**(3)**

Question Number	Answer	Additional Guidance	Mark
17(c)(i)	• **ammonia** (gas) would escape (from the condenser when heated under reflux) **or** to prevent **ammonia** (gas) escaping (from the condenser when heated under reflux)	Ignore just 'ammonia will evaporate' Ignore concentrated alcoholic Ignore references to safety Ignore just 'gas / reactant escapes' Do not award any other substance escaping	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(c)(ii)	• lone pair on N of NH_3 **and** curly arrow from lone pair on N to, or towards C **(1)** • dipole on C-Br **and** curly arrow from C-Br bond to, or just beyond, Br **(1)** • lone pair on N of NH_3 **and** curly arrow from lone pair on N to, or towards H **(1)** • curly arrow from N-H bond to, or towards N **(1)**	Penalise missing lone pair on N once only Penalise negative charge on NH_3 once only Penalise half-arrow heads once only Do not award any charge / dipole on H Ignore any changes to final products	**(4)**
Example of mechanism:			



Question Number	Answer	Additional Guidance	Mark
17(d)	• calculation of amounts of KBr and H_2SO_4 **(1)** • calculation of amount of C_2H_5OH **and** statement or implication that this is the limiting quantity **(1)** • calculation of maximum mass of C_2H_5Br formed **(1)**	Example of calculation: amount KBr = $\frac{14.90}{119}$ = 0.12521 (mol) amount H_2SO_4 = $\frac{16.35}{98.1}$ = 0.16667 (mol) Allow use of 98 for M_r of H_2SO_4 giving 0.16684 (mol) amount C_2H_5OH = $\frac{4.65}{46}$ = 0.10109 / 0.10 / 0.1 (mol) **and** any indication that the limiting reagent is C_2H_5OH e.g. by use of mol of ethanol in M3 (maximum amount C_2H_5Br formed = 0.10109 (mol) maximum mass C_2H_5Br formed = 0.10109 x 108.9 = 11.008 / 11.01 / 11.0 / 11 (g) Allow use of 109 for M_r of C_2H_5Br giving 11.018 (g) Ignore SF except 1 SF, but allow 0.1 for mol C_2H_5OH	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
17(e)*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. <table><tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></tr><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></table> The following table shows how the marks should be awarded for structure and lines of reasoning.	Guidance on how the mark scheme should be applied: 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).	**(6)**

	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

Comment:
Look for the indicative marking points first, then consider the mark for structure of answer and sustained line of reasoning

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.

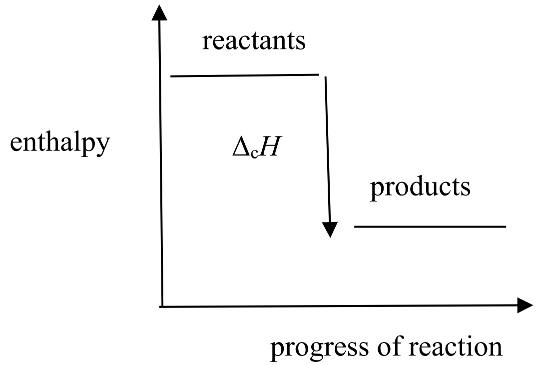
General points to note
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

	Indicative content • **IP1 –Similarity** Both reactions involve hydroxide ions / OH^- • **IP2 – Type of reaction** Reaction with aqueous solution is substitution **and** reaction with ethanolic solution is elimination • **IP3 – Type of reagent** (OH^- is a) nucleophile in aqueous solution **and** a base in ethanolic solution • **IP4 – Products** In aqueous solution propan-2-ol / an alcohol forms **and** in ethanolic solution propene / an alkene forms • **IP5 – Equation in aqueous solution** $CH_3CHBrCH_3 + OH^- \rightarrow CH_3CHOHCH_3 + Br^-$ • **IP6 – Equation in ethanolic solution** $CH_3CHBrCH_3 + OH^- \rightarrow CH_3CH{=}CH_2 + H_2O + Br^-$	Penalise use of incorrect halogenoalkane once only Allow OH^- shown with both reactions anywhere in the answer e.g. in the equations Allow both reactions need heat (under reflux) Ignore displacement for substitution Ignore dehydration for elimination Do not award dehydrogenation for elimination If IP2 and IP3 not awarded, allow 1 IP for just 'nucleophilic substitution' or 'elimination by a base' This can be scored from the equations In IP5 and IP6, allow displayed formulae / any combination of displayed and structural formulae / skeletal formula Allow KOH / KBr / $K^+ + OH^-$ / $K^+ + Br^-$ The equations must be balanced Ignore state symbols even if incorrect Ignore mechanisms even if incorrect	

(Total for Question 17 = 18 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	• (temperature) 298 K / 25°C **and** (pressure) 1 atm / 100 kPa / 101 kPa / 1 x 10^5 Pa / 1.01 x 10^5 Pa	Allow 'a specified / stated temperature' Ignore just 'room temperature' Do not award 298°K Do not award incorrect pressure units e.g. 101 Pa	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	• molecular formula for 2,2,4-trimethylpentane **(1)** • rest of equation correct **conditional** on use of C_8H_{18} **or** use of structural / displayed / skeletal formula for 2,2,4-trimethylpentane **(1)**	Example of equation: $C_8H_{18} + 12½O_2 \rightarrow 8CO_2 + 9H_2O$ Accept 25/2 for 12½ Allow multiples e.g. $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ Ignore state symbols even if incorrect	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(a)(iii)	• y axis labelled enthalpy **and** products line drawn at a lower level than reactants line **(1)** • downwards arrow labelled with $\Delta_c H$ **(1)**	Example of diagram;  Allow energy / *H* / enthalpy level as label for y axis Do not award ΔH / enthalpy change / energy change as label for y axis Allow names / formulae of reactants and products but both must be there e.g. $C_8H_{18} + O_2$ for reactants and $CO_2 + H_2O$ for products Ignore missing / incorrect balancing numbers if formulae given Ignore label / missing label on x axis Ignore activation energy hump(s) M2 Conditional on reactants higher than products Allow label as ΔH / −5461 / other label that indicates enthalpy change of combustion / reaction Do not award double headed arrow / or just a line with no arrow / arrow labelled $-\Delta H$	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(a)(iv)	• calculation of energy given out by 1 g **(1)** • calculation of energy given out by 1 cm^3 **(1)** • calculation of energy given out by 1 dm^3 **(1)**	Example of calculation: **Method 1** enthalpy change / g = $\frac{5461}{114}$ = 47.904 (kJ) enthalpy change / cm^3 = 47.904 x 0.692 = 33.149 (kJ) TE on M1 enthalpy change / dm^3 = 33.149 x 1000 = 33 149 / 33.149 x 10^3 (kJ) TE on M2 **Method 2** mass of 2,2,4-trimethylpentane in 1 dm^3 = 0.692 x 1000 = 692 (g) (1) mol in 1 dm^3 = $\frac{692}{114}$ = 6.0702 (mol) (1) TE on M1 enthalpy change / dm^3 = 6.0702 x 5461 = 33 149 / 33.149 x 10^3 (kJ) (1) TE on M2 Allow alternative methods Correct answer with some working scores (3) Ignore SF except 1 SF Ignore minus sign Ignore units, even if incorrect	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	• calculation of heat evolved **(1)** • calculation of moles of ethanol used **(1)** • working for heat evolved per mole **(1)** • value of $\Delta_c H$ to 2 / 3 SF **and** negative sign **and** units **(1)**	Example of calculation: heat evolved = 100.0 x 4.18 x 13.2 = 5517.6 (J) / 5.5176 kJ Do not award 100.305 x 4.18 x 13.2 = 5534.4 (J) amount of ethanol = $\frac{0.305}{46}$ = 0.0066304 / 6.6304 x 10^{-3} (mol) heat evolved per mole = $\frac{5.5176}{6.6304 \times 10^{-3}}$ (= 832.17) TE on M1 and M2 $\Delta_c H$ = − 830 / − 832 kJ mol^{-1} Allow units kJ/mol or $\frac{kJ}{mol}$ or kJ mol^{-} Ignore letter case in units e.g. k or K, J or j Accept – 830 000 / − 832 000 J mol^{-1} TE on M3 Ignore SF except 1 SF in M1, M2 and M3 Correct answer with some working to 2/3 SF with sign and units scores (4)	**(4)**

Question Number	Answer	Additional Guidance	Mark
18(b)(ii)	• calculation of percentage error	Example of calculation: $\frac{2 \times 0.05}{13.2} \times 100$ = 0.75758 (%) Allow 0.7576 / 0.758 / 0.76 / 0.8 Correct answer with no working scores (1) Ignore signs Do not award 0.75 / 0.757 / 0.80	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(b)(iii)	An answer that makes reference to any **two** of the following points: • heat loss (to the surroundings) **(1)** • incomplete combustion (of ethanol) **(1)** • some ethanol evaporates **(1)** • calculation does not take into account the heat capacity of the beaker **(1)**	 Allow insufficient oxygen for combustion Ignore not all of the ethanol was burned Ignore product(s) / water evaporates Allow some heat is used to heat up the beaker Ignore thermometer Ignore ethanol was impure Ignore water was not stirred Ignore no lid on beaker	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)	• calculation of bond energies of O−H **and** C−H **(1)** • calculation of bond energy of C−O **(1)** • calculation of bond energy of C−C **(1)**	Example of calculation: **Method 1** bond energy O−H = 928/2 = (+)464 (kJ mol^{-1}) **and** bond energy C−H = 1740/4 = (+)435 (kJ mol^{-1}) bond energy C−O = 2105 – (3 x 435) – 464 = (+)336 (kJ mol^{-1}) TE on M1 bond energy C−C = 3322 – (5 x 435) – 464 −336 = (+)347 (kJ mol^{-1}) **Method 2** 3322 – 2105 = 1217 = C−C + 2 x C−H (1) bond energy 2 x C−H = 1740/2 = (+)870 (kJ mol^{-1}) (1) C−C = 1217 – 870 = (+)347 (kJ mol^{-1}) (1) M3 TE on M1 and M2 in both methods Correct answer with some working scores (3)	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(d)	An answer that makes reference to the following points: • there are fewer (gas) molecules on the right hand side / more (gas) molecules on the left hand side **(1)** • so the equilibrium position will shift to the right / product side **and** the equilibrium yield of ethanol will increase **(1)**	Ignore effect of temperature Ignore effect on rate of reaction Allow moles for molecules Allow 2 (gas) molecules on the left and 1 (gas) molecule on the right Allow higher pressure favours the side with fewer (gas) molecules Allow forward reaction is favoured **and** the equilibrium yield of ethanol will increase	**(2)**

(Total for Question 18 = 20 marks)

Total for Section C = 20 marks
Total for paper = 80 marks

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