Pearson Edexcel

Mark Scheme (Results)

January 2025

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

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

January 2025
Question paper log number P78456RA
Publications Code WCH12_01_2501_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.

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

Question Number	Answer	Mark
1	**The only correct answer is B** (the C–O bond is polar) ***A*** *is incorrect because this is not the reason for nucleophilic attack* ***C*** *is incorrect because this does not lead to nucleophilic substitution* ***D*** *is incorrect because this is not the reason for nucleophilic attack*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is A** (587°C) ***B*** *is incorrect because the graph value is taken from the relative atomic mass* ***C*** *is incorrect because this value has not been converted to °C from Kelvin* ***D*** *is incorrect because the graph value is taken from the relative atomic mass and has not been converted to °C*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** (50.3) ***A*** *is incorrect because this is the mass of crystals precipitated plus the solubility at 20°C* ***B*** *is incorrect because this is the mass of crystals precipitated times four plus the solubility at 20°C* ***C*** *is incorrect because this is the value when the solubility at 20°C has been ignored*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is B** (red) ***A*** *is incorrect because this is the flame colour of barium* ***C*** *is incorrect because this is what is seen when magnesium metal is burned* ***D*** *is incorrect because this is the flame colour of sodium*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is D** (calcium > strontium > barium) ***A*** *is incorrect because barium sulfate is the least soluble / magnesium sulfate is the most soluble* ***B*** *is incorrect because magnesium sulfate is more soluble than calcium and strontium sulfates* ***C*** *is incorrect because calcium sulfate is more soluble than barium sulfate*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** (ethanol) ***B*** *is incorrect because halogenoalkanes are not fully soluble in hexane* ***C*** *is incorrect because halogenoalkanes are not soluble in acid* ***D*** *is incorrect because halogenoalkanes are not soluble in water alone*	**(1)**

Question Number	Answer	Mark
7(a)	**The only correct answer is C** (–67°C) ***A*** *is incorrect because this is higher than the value for HF (and is the boiling temperature for bromine)* ***B*** *is incorrect because this is higher than the value for hydrogen iodide* ***D*** *is incorrect because this is lower than the value for hydrogen chloride*	**(1)**

Question Number	Answer	Mark
7(b)	**The only correct answer is A** (it forms hydrogen bonds) ***B*** *is incorrect because this is not the reason for the higher boiling temperature* ***C*** *is incorrect because this is not the reason for the higher boiling temperature* ***D*** *is incorrect because this is not the reason for the higher boiling temperature*	**(1)**

Question Number	Answer	Mark
8(a)	**The only correct answer is A** (4.5×10^{-5}) ***B*** *is incorrect because this is the rate at 100 seconds* ***C*** *is incorrect because this is the average rate* ***D*** *is incorrect because this is the rate at 385 seconds*	**(1)**

Question Number	Answer	Mark
8(b)	**The only correct answer is B** (mol dm^{-3} s^{-1}) ***A*** *is incorrect because this is not a change in concentration* ***C*** *is incorrect because the power of the volume should be negative* ***D*** *is incorrect because all the powers have the incorrect sign*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is A** (oxidising agent) ***B*** *is incorrect because the acid is an oxidising agent* ***C*** *is incorrect because the acid is not a base* ***D*** *is incorrect because the acid is not a nucleophile*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is D** ($Mg + 2HCl \rightarrow MgCl_2 + H_2$) ***A*** *is incorrect because this reaction is a disproportionation reaction* ***B*** *is incorrect because this reaction is a disproportionation reaction* ***C*** *is incorrect because this reaction is a disproportionation reaction*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is C** ($2NaI + Br_2 \rightarrow 2NaBr + I_2$) ***A*** *is incorrect because astatine cannot displace chlorine from chloride* ***B*** *is incorrect because iodine cannot displace bromine from bromide* ***D*** *is incorrect because chlorine cannot displace fluorine from fluoride*	**(1)**

Question Number	Answer	Mark
12(a)	**The only correct answer is D** (0.702 mol dm^{-3}) ***A*** *is incorrect because the stoichiometry has been used incorrectly* ***B*** *is incorrect because volumes have been used the wrong way around* ***C*** *is incorrect because the stoichiometry has not been used*	**(1)**

Question Number	Answer	Mark
12(b)	**The only correct answer is D** (0.68%) ***A*** *is incorrect because this is the error of a burette in* cm^3 *times two* ***B*** *is incorrect because this is the error if only one reading is taken* ***C*** *is incorrect because this is the error using the pipette value*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is B** (56.0%) ***A*** *is incorrect because this is the atom economy for carbon dioxide* ***C*** *is incorrect because this is the value of the mass of carbon dioxide divided by the mass of calcium oxide* ***D*** *is incorrect because the reaction does not have an atom economy of 100%*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is D** (1.012) ***A*** *is incorrect because this is the mass divided by the volume* ***B*** *is incorrect because this is the* M_r *divided by the volume in* cm^3 ***C*** *is incorrect because this is the number of moles*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is C** (0.683 mol dm^{-3}) ***A*** *is incorrect because this is the number of moles in the sample* ***B*** *is incorrect because this is double the number of moles in the sample* ***D*** *is incorrect because this is double the value of the concentration*	**(1)**

Question Number	Answer	Mark
16(a)	**The only correct answer is C** (0.123 m^3) ***A*** *is incorrect because this is the volume of* O_2 *produced* ***B*** *is incorrect because this is the volume of* NO_2 *produced* ***D*** *is incorrect because this is the volume of gas formed from 2 mols of magnesium nitrate*	**(1)**

Question Number	Answer	Mark
16(b)	**The only correct answer is D** (62.0 %) ***A*** *is incorrect because this is 25 divided by the mass of the nitrogen(IV) oxide* ***B*** *is incorrect because this is 25 divided by the mass of one mole of magnesium nitrate* ***C*** *is incorrect because this is 25 divided by the mass of 2MgO*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

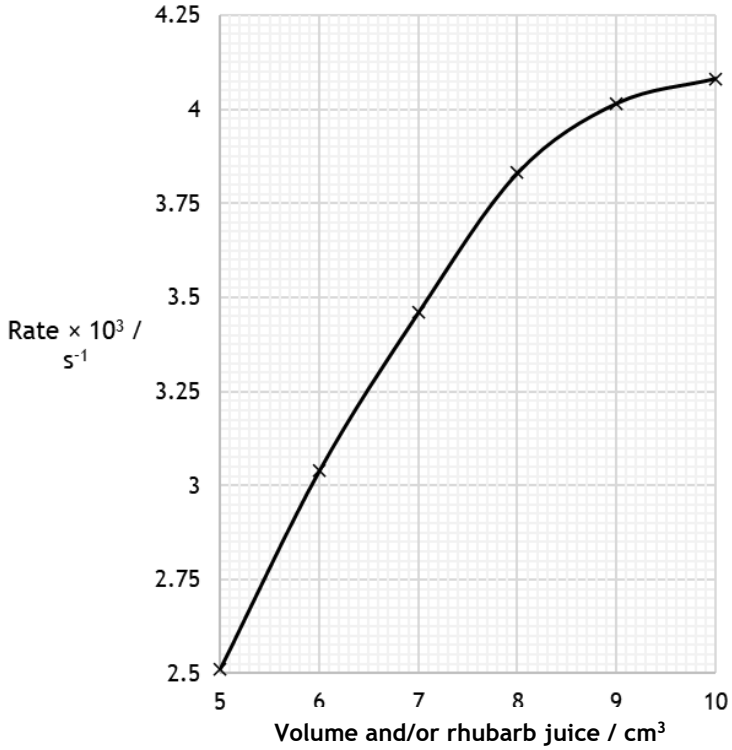
Section B

Question Number	Answer	Additional Guidance	Mark
17(a)(i)	An answer that makes reference to the following points: • oxidation numbers of manganese **(1)** • oxidation numbers of carbon **(1)**	(+)7 to (+)2 (+)3 to (+)4 Allow 2+ etc. Allow roman numerals	**(2)**

Question Number	Answer	Additional Guidance	Mark
17 (a)(ii)	An answer that makes reference to the following points: • manganate(VII) reduction	$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ Allow multiples Ignore state symbols	**(1)**

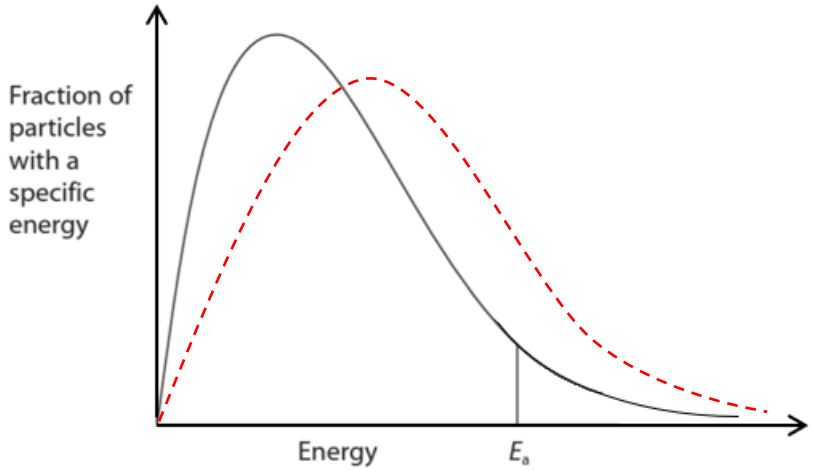
Question Number	Answer	Additional Guidance	Mark
17 (a)(iii)	An answer that makes reference to the following points: • ethanedioic acid oxidation	$C_2H_2O_4 \rightarrow 2CO_2 + 2H^+ + 2e^-$ Allow multiples Ignore state symbols	**(1)**

Question Number	Answer	Additional Guidance	Mark
17 (b)(i)	• boxes completed to 3SF	261 | 0.00383 | 3.83	(1)

Question Number	Answer	Additional Guidance	Mark
17 (b)(ii)	• suitable choice of scale so that the points cover at least 3 large squares **(1)** • correct choice of axes suitably labelled including units **(1)** **(1)** • all points plotted correctly (within half a small square) **(1)** • curved line of best fit	An example of a graph:  TE on 17(b)(i) Allow $(1\div t)\times 10^3$ on the y-axis with units Ignore spurious 0,0 labels where the curve does not join the origin	(4)

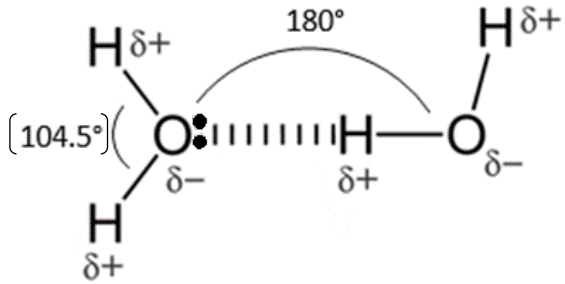
Question Number	Answer	Additional Guidance	Mark
17(b)(iii)	An explanation that makes reference to the following points: • more particles will be in the same volume **(1)** • increasing the number of (successful) collisions per unit time **(1)**	Allow references to particles being closer together Allow molecules/ions for particles Allow space for volume Allow references to frequency of collisions Ignore chance/probability of collisions More particles so more successful collisions scores 1	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(c)	An explanation that makes reference to two of the following points: • titrate • a known volume of (undiluted) rhubarb juice • with a known concentration of manganate(VII) • until a colour change is seen	Apply the list principle Allow sample of ethanedioic acid for rhubarb juice Allow specific volume quoted Allow fixed/set volume Do not award reference to "known concentration of ethanedioic acid" Allow fixed/set concentration Allow specific colour changes even if incorrect Ignore references to indicators Ignore references to calculations Ignore references to mass Ignore references to time Allow use of a fixed volume and concentration of manganate(VII) and adding the rhubarb juice dropwise for 2 marks Allow use of known volume of rhubarb juice and excess manganate(VII) and recording the volume of CO_2 gas for 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(d)(i)	• a line that has a similar shape with peak that is lower and to the right	Example of a drawing  Ignore shading Do not award if the line cut the curve more once Do not award if the line plateaus above the height of the E_a line Do not award if line does not start at the origin Ignore changes to the E_a line	(1)

Question Number	Answer		Additional Guidance	Mark
17(d)(ii)	An answer that makes reference to the following points:			(3)
	• the molecules/particles have more kinetic energy	(1)	Allow increases the mean energy of the particles	
	• so more molecules/particles have energy ≥ E_a	(1)	Allow reference to correct part of the graph for M2 Allow collisions have more energy than E_a	
	• so more successful collisions occur per unit time	(1)	Allow more frequent successful collisions	

(Total for Question 17 = 17 marks)

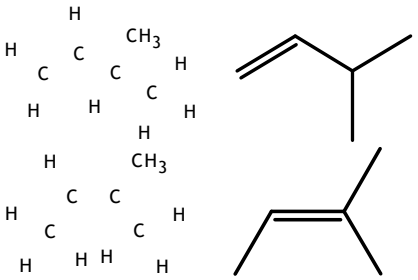
Question Number	Answer	Additional Guidance	Mark
18(a)	An answer that makes reference to the following points: • hydrogen bond shown from lone pair on the oxygen on one molecule to the hydrogen on the other **(1)** • linear O–H–O bond and labelled 180° **(1)** • δ+ on the hydrogen atom, δ– on the oxygen atom (in the hydrogen bond) **(1)**	Example of a diagram  Ignore other lone pairs Ignore H−O−H bond angles even if incorrect Allow dipole moments (+⟶) on bonds Penalise O_2H once only	**(3)**

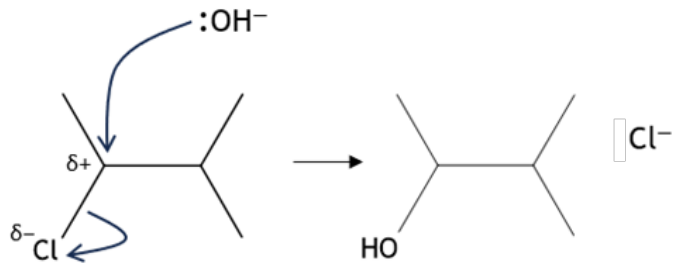
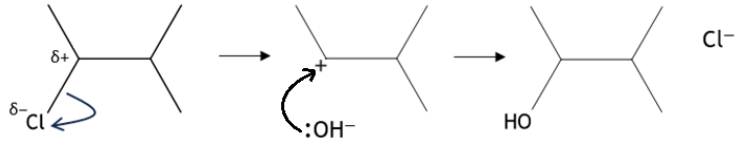
Question Number	Answer	Additional Guidance	Mark
18(b)	An explanation that makes reference to the following points: • molecules are a similar size / same number of electrons so the London forces are similar (and cannot account for big difference in boiling temperature) **(1)** • there are more **hydrogen bonds** between water molecules (than hydrogen bonds between ammonia molecules, resulting in water having a higher boiling temperature than ammonia) **(1)** • density of ammonia decreases between the two temperatures as it turns (from a liquid) to a gas **or** density of water increases between the two temperatures as it turns (from a solid) to a liquid **(1)**	Ignore comments on permanent dipole-dipole forces Accept for London forces instantaneous dipole-induced dipole/ dispersion forces Allow van der Waals' forces Allow M_r for size Accept converse Allow the hydrogen bonds in water are stronger than the hydrogen bonds in ammonia because oxygen is more electronegative than nitrogen Allow reference to two lone pairs on oxygen compared to one on nitrogen so more hydrogen bonds Allow reference to numbers of hydrogen bonds even if incorrect Allow M3 for a description of the expanded hydrogen bond structure of ice	**(3)**

(Total for Question 18 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)	• 2-chloro-3-methylbutane	Allow 2-chloromethyl-3-butane Ignore additional/omitted brackets, hyphens and commas Ignore 3-methyl-2-chlorobutane	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)(i)	• elimination	Do not award addition-elimination	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)(ii)	An answer that makes reference to the following points: **(1)** • structure of 3-methylbut-1-ene **(1)** • structure of 2-methylbut-2-ene	Allow any type of structure, including mixed  If multiple structures are given both must be correct Allow isomers in any order Ignore connectivity of CH_3 Ignore names even if incorrect Penalise missing hydrogen atoms once only	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An answer that makes reference to the following points: • lone pair on oxygen of OH^- • dipole on C–Cl • curly arrow from oxygen (lone pair) to carbon in C−Cl bond • curly arrow from C–Cl bond to Cl or just beyond • 3-methylbutan-2-ol and Cl^-	 Allow KCl as a product if K^+ is a reactant Ignore OH–C connectivity for P5 All 5 points score 3 marks, 3 or 4 points scores 2 marks, 2 points scores 1 mark Allow S_N1 mechanism for full marks  Penalise single headed arrows once only Ignore transition state	**(3)**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)	An explanation that makes reference to the following points: • (the rate will be) faster **(1)** • the C–I bond is weaker **(1)**	Accept converse answers M1 dependent on some attempt at M2 (even if incorrect) Allow bond enthalpy is lower for C–I Allow C−I bond needs less energy to break Ignore C – I bond breaks more easily Ignore breaks faster Ignore the C – I bond is longer Ignore reasoning for bond weakness even if incorrect Ignore comments on polarisation	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)	An answer that makes reference to the following points: • role in (b) : base **(1)** • role in (c) : nucleophile **(1)**	 Allow proton acceptor Ignore alkali Ignore prefixes/suffixes Allow nucleophilic	**(2)**

(Total for Question 19 = 11 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*20</td>
<td>
This question assesses the 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><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></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
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent 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>
</table>
</td>
<td>
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, a response 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 were no linkages between the points, then the same 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
3 or 4 indicative points would get 1 reasoning mark
0, 1 or 2 indicative points would get zero reasoning marks

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).
</td>
<td>(6)</td>
</tr>
</table>

	Indicative content **IP1** O−H bond (broad) absorption at ~3400 (cm^{-1}) **IP2** C=O absorption at 1740-1700(cm^{-1}) so cannot be butan-1-ol **IP3** M^+ has an m/z value of 74 so could be 1-hydroxypropanone **or** butan-1-ol **(**propenoic acid has a M^+ value of 72) **IP4** base / most abundant peak has an m/z value of 43 so could be $CH_3CO^{(+)}$ / $C_3H_7^{(+)}$ **IP5** no C=C absorption on IR spectra at 1669-1645(cm^{-1}) **or** O–H peak absorbance too high for acid (so not propenoic acid) **IP6** so the substance is 1-hydroxypropanone, (not propenoic acid or butan-1-ol)	**Comment**: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning Allow use of molecular formulae throughout Ignore C−H absorptions Allow ranges between 3800-3000(cm^{-1}) Allow due to hydroxyl/alcohol Accept so can only be 1-hydroxypropanone or propenoic acid Ignore references to aldehydes Allow $CCH_2OH^{(+)}$ Ignore other proposed base peaks Do not award negatively charged fragments Allow propenoic acid would have a(n additional) peak at 1669-1645(cm^{-1}) Allow a range from 3300-2500(cm^{-1}) Allow a correct structure	

(Total for Question 20 = 6 marks)

TOTAL FOR SECTION B = 40 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
21(a)	• calculation of the enthalpy of the broken bonds **(1)** • calculation of enthalpy of the formed bonds **(1)** • calculation of the enthalpy change per mole **(1)**	<u>Example of a calculation:</u> (8 × 413) + 498 = 3802 (6 × 413) + (2 × 336) + (2 × 464) = 4078 (3802-4078) ÷ 2 = –276 ÷ 2 = –138(kJ mol^{-1}) TE on M1 and M2 if used correctly Ignore incorrect units Correct answer with some working scores 3 marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
21(b)	An answer that makes reference to the following points: • (it is an) element in its standard state	Allow no change to element in state or bonding e.g. $O_2(g) \rightarrow O_2(g)$ Ignore references to ground/natural state	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(c)	An explanation that makes reference to the following points: • part (a) uses mean bond enthalpies (rather than for specific compounds) **(1)** • bond enthalpies refer to the gaseous state **(1)**	Allow average for mean Allow methanol is not a gas / methanol is a liquid Do not award incorrect states	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(d)(i)	An answer that makes reference to the following points: • oxidation		**(1)**

Question Number	Answer	Additional Guidance	Mark
21(d)(ii)	An answer that makes reference to the following points: • sulfuric acid / H_2SO_4 **(1)** • potassium dichromate(VI) / $K_2Cr_2O_7$ **(1)** • distillation **(1)** • orange → green **(1)**	If name and formula are given both must be correct Ignore concentration Ignore acidified / H^+ Do not award HCl acid Accept sodium dichromate(VI) / $Na_2Cr_2O_7$ Allow dichromate with no oxidation number Ignore methanol as an extra reagent Ignore heat Do not award reflux Allow orange → blue Do not penalise order of responses	**(4)**

Question Number	Answer	Additional Guidance	Mark
21(e)(i)	An answer that makes reference to two of the following points: • (a catalyst) may reduce the operating temperature • a lower pressure may be used which is safer / requires less expensive/specialised equipment • the reaction may not proceed via toxic gas / greenhouse gases • the reaction may go to completion (rather than being in equilibrium) • only one reaction vessel required • may produce fewer by-products produced • may take less time • may require less energy if a lower pressure is used	Allow definitive answers i.e. "it will" rather than "it may" for all marking points Ignore cost/transport Allow equipment may have thinner walls etc. Ignore pollutants Ignore use less resources Allow less separation steps may be required Allow may increase atom economy Allow reference to faster rate	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(e)(ii)	An explanation that makes reference to two of the following points: • (all contain) d-block elements • (all are) heterogeneous (catalysts) • (all) are solids	Accept (all contain) transition metals Allow in a different phase/state to reactants If no other mark is scored: Allow reduce activation energy by providing an alternate reaction path scores 1	**(2)**

Question Number	Answer	Additional Guidance	Mark
21(e)(iii)	An answer that makes reference to the following points: • the reaction is exothermic **(1)** • so (by Le Chatelier) the temperature could be decreased (to increase the yield) **(1)** • but this would decrease the rate **(1)** • pressure could be increased as fewer moles of gas on the right-hand side **(1)** • (increasing the pressure would be more expensive because either) increasing the pressure uses more energy **or** equipment walls need to be thicker/stronger **(1)**	All marks are independent Ignore references to removing methanol, increasing concentration and catalysts Allow the catalyst may not work at a lower temperature Allow molecules for moles Allow products side for RHS Do not award incorrect numbers stated for either side Allow fuel for energy	**(5)**

(Total for Question 17 = 20 marks)
TOTAL FOR SECTION C = 20 MARKS

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom