Pearson Edexcel

Mark Scheme (Final)

Summer 2023

Pearson Edexcel International Advanced Subsidiary Level In Chemistry (WCH14)
Paper 01
Unit 4: Rates, Equilibria and Further Organic 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

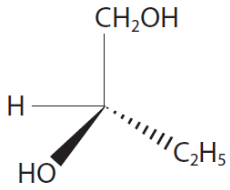
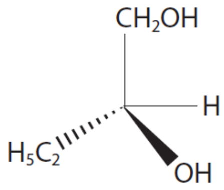
Question Number	Answer	Mark
1	**The only correct answer is B** ($K_c = \frac{[Y]^2[Z]}{[W][X]}$) ***A*** *is incorrect because Y has been multiplied by 2 instead of raised to the power of its coefficient* ***C*** *is incorrect because the expression has been inverted and because Y has been multiplied by 2 instead of raised to the power of its coefficient* ***D*** *is incorrect because the expression has been inverted*	**(1)**

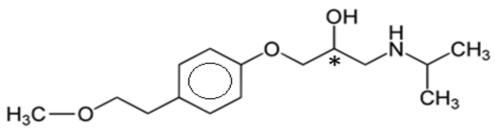
Question Number	Answer	Mark
2	**The only correct answer is B** (homogeneous, decreases) ***A*** *is incorrect because the system is homogenous at 360 °C* ***C*** *is incorrect because the system is homogenous at 360 °C and* K_c *decreases* ***D*** *is incorrect because* K_c *decreases*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is C** (atm^{-2}) ***A*** *is incorrect because coefficients have not been taken into account* ***B*** *is incorrect because coefficients have not been taken into account and the expression has been inverted* ***D*** *is incorrect because these are the units for the inverted expression*	**(1)**

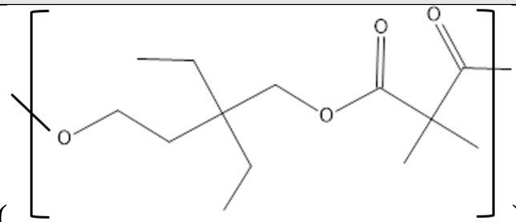
Question Number	Answer	Mark
4(a)	**The only correct answer is D** (time, absorption) ***A*** *is incorrect because the labels are the wrong way round* ***B*** *is incorrect because* R_f *is not used in HPLC* ***C*** *is incorrect because* R_f *is not used in HPLC*	**(1)**

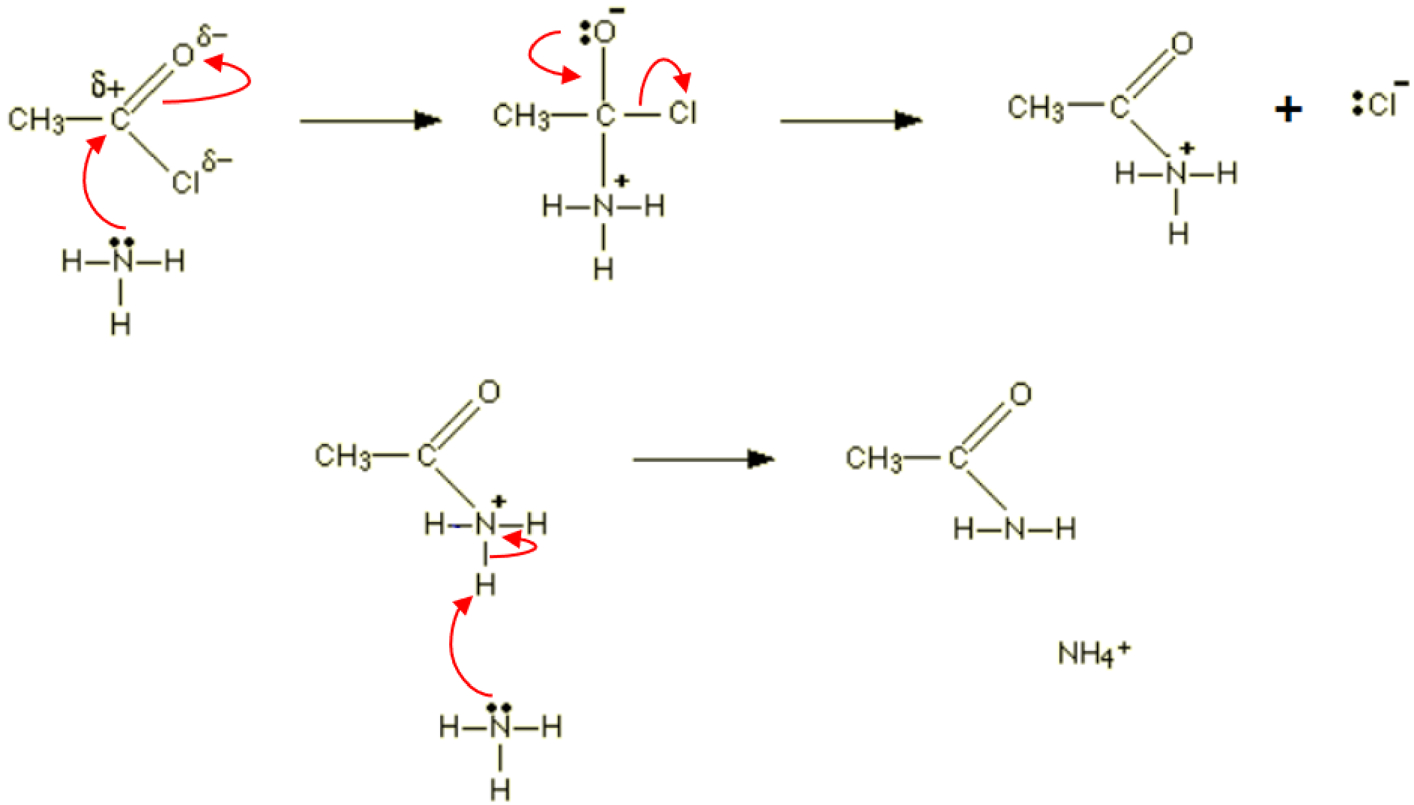
Question Number	Answer	Mark
4(b)	**The only correct answer is D** (G is most attracted to the stationary phase, F is the most abundant) ***A*** *is incorrect because E is the least attracted to the solid phase and F is the most abundant* ***B*** *is incorrect because F is the most abundant* ***C*** *is incorrect because E is the least attracted to the solid phase*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is D** ( ) ***A*** *is incorrect because the molecules are not enantiomers (the molecule on the right is not chiral)* ***B*** *is incorrect because the same enantiomer is shown twice* ***C*** *is incorrect because the molecules are not enantiomers (the molecule on the right is not chiral)*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is B** (1, ) ***A*** *is incorrect because there is only 1 chiral centre* ***C*** *is incorrect because there is only 1 chiral centre* ***D*** *is incorrect because there is only 1 chiral centre*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is A** (rate = $k[H_2O_2]^2[I^-]$) ***B*** *is incorrect because the concentration of hydrogen peroxide should be squared* ***C*** *is incorrect because this includes an intermediate* ***D*** *is incorrect because the concentration of hydrogen peroxide should be squared and includes an intermediate*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is A** () ***B*** *is incorrect because there is an extra –OH group on the alcohol* ***C*** *is incorrect because a C=O on the acid has been replaced by a methyl group forming an ether linkage* ***D*** *is incorrect because an ester link has been replaced by an ether*	**(1)**

Question Number	Answer	Mark
9(a)	**The only correct answer is C** (6) ***A*** *is incorrect because the mechanism requires 6 curly arrows* ***B*** *is incorrect because the mechanism requires 6 curly arrows* ***D*** *is incorrect because the mechanism requires 6 curly arrows* 	**(1)**

Question Number	Answer	Mark
9(b)	**The only correct answer is B** (ethanamide) ***A*** *is incorrect because it is not a ketone* ***C*** *is incorrect because it is not an IUPAC name* *D is incorrect because there are two carbon atoms in the formula*	**(1)**

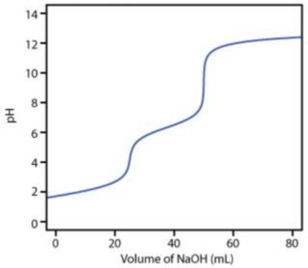
Question Number	Answer	Mark
10	**The only correct answer is D** (higher, higher) ***A*** *is incorrect because hydrogen bonding in butanoic acid results in higher boiling temperature and solubility in water* ***B*** *is incorrect because hydrogen bonding in butanoic acid results in higher boiling temperature* ***C*** *is incorrect because hydrogen bonding in butanoic acid results in higher solubility in water*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is B** (3-hydroxy-2-methylbutanoic acid) ***A*** *is incorrect because the numbering of the groups is incorrect* ***C*** *is incorrect because the acid does not have an additional methyl branch on the third carbon* ***D*** *is incorrect because the acid is not a straight chain*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is B** (ethane-1,2-diol) ***A*** *is incorrect because the disodium salt of the acid would be produced* ***C*** *is incorrect because ethanedioic acid is not a monomer of the polyester* ***D*** *is incorrect because water is used in the hydrolysis and is not a product*	**(1)**

Question Number	Answer	Mark
13(a)	**The only correct answer is B** (bromothymol blue, phenol red and phenolphthalein) ***A*** *is incorrect because bromocresol green and methyl red do not change within the vertical portion* ***C*** *is incorrect because methyl red does not change within the vertical portion* ***D*** *is incorrect because the indicators do not change within the vertical portion*	**(1)**

Question Number	Answer	Mark
13(b)	**The only correct answer is A** (CH_3COOH and NaOH) ***B*** *is incorrect because ammonia is not a strong base* ***C*** *is incorrect because HCl is a strong acid* ***D*** *is incorrect because HCl is a strong acid*	**(1)**

Question Number	Answer	Mark
14(a)	 **The only correct answer is A** ( ) ***B*** *is incorrect because the curve is inverted* ***C*** *is incorrect because this is a titration curve for a monoprotic acid* ***D*** *is incorrect because this is a titration curve for a triprotic acid*	**(1)**

Question Number	Answer	Mark
14(b)	**The only correct answer is B** ((*Z*)-but-2-enedioic acid) ***A*** *is incorrect because maleic acid is the Z isomer* ***C*** *is incorrect because the carbon chain of maleic acid has four carbon atoms and maleic acid is the Z isomer* ***D*** *is incorrect because the carbon chain of maleic acid has four carbon atoms*	**(1)**

Question Number	Answer	Mark
15	**The only correct answer is C** (H_2CO_3, CO_3^{2-}) ***A*** *is incorrect because these species are interconverted by protonation/deprotonation* ***B*** *is incorrect because these species are interconverted by protonation/deprotonation* ***D*** *is incorrect because these species are interconverted by protonation/deprotonation*	**(1)**

Question Number	Answer	Mark
16	**The only correct answer is D** (13.1) ***A*** *is incorrect because the molarity was divided by 200 instead of 0.2* ***B*** *is incorrect because the moles of barium hydroxide were used instead of the concentration of hydroxide ions* ***C*** *is incorrect because the concentration of barium hydroxide is used instead of the concentration of hydroxide ions*	**(1)**

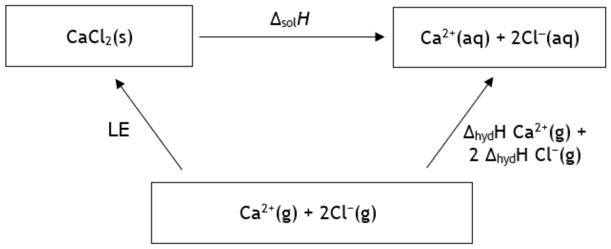
TOTAL FOR SECTION A =20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
17(a)	• (+)178 (kJ mol^{-1})	Do not award –178 (kJ mol^{-1}) Ignore units even if incorrect	**(1)**

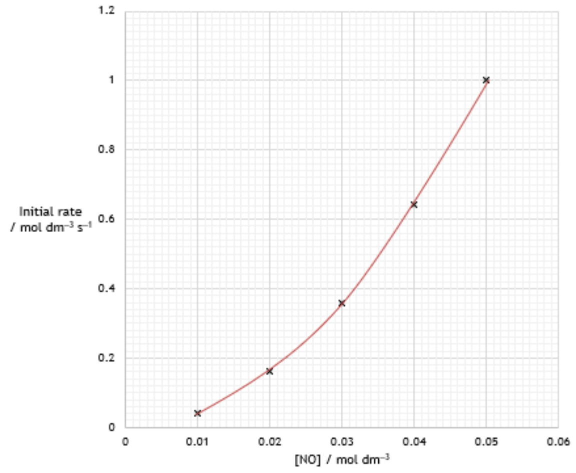
Question Number	Answer	Additional Guidance	Mark
17(b)	• equation or workings **(1)** • answer to 3SF with negative sign **(1)**	Example of calculation: $\Delta_f H = \Sigma$(all other terms) $\Delta_f H = 178 + 590 + 1145 + (2 \times 122) + (2 \times -349) + (-2258)$ –799 (kJ mol^{-1}) Correct answer scores (2) TE on incorrectly transferred values e.g. –394 Penalise omission of ×2 once only (–572 scores 1 mark) TE on one incorrect sign No TE on incorrect expression Penalise M2 for incorrect units +799 scores 1 mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(c)	An explanation that makes reference to the following points: • calcium chloride is almost completely ionic **(1)** • calcium iodide has partially covalent character **(1)** • iodide (ion) is larger (than chloride (ion)) **(1)** • (so) more (easily) polarised **(1)**	Allow reverse arguments Accept $CaCl_2$ is 100% ionic Allow LE is calculated assuming a pure ionic structure Allow shows more covalent character Allow $CaCl_2$ has less covalent character than CaI_2 Ignore polar Do not award M2 for CaI_2 is covalent Do not award M2 for Intermolecular forces Accept iodide has a lower charge density Allow iodine ion Ignore iodine is larger Do not award molecules, Cl_2 or I_2 loses M3 Accept more (easily) distorted Allow (more) polarisable Do not award CaI_2 is more polarised If no comparison for M3 and M4 allow 1 mark, e.g., “iodide is large and is polarised” Penalise iodine/chlorine or incorrect ions once only.	**(4)**

Question Number	Answer	Additional Guidance	Mark
17(d)(i)	An answer that makes reference to the following points: • two labelled arrows in the correct direction **(1)** • formulae including state symbols **(1)**	An example of a completed cycle:  Accept two arrows on right-hand side Allow $\Delta_{latt}H$/ ΔH_{latt} Allow $\Delta_{hyd}H$ alone on right-hand arrow Allow ΔH_{hyd} Allow numerical values rather than the symbols Allow missing 2 for the $\Delta_{hyd}H\ Cl^-$ Allow left arrow going down if labelled as lattice dissociation energy or –LE	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(d)(ii)	• calculation **(1)** • enthalpy change of solution **(1)**	Example of a calculation: –(–2258) – 1579 – (2 × 378) = –77 (kJ mol^{-1}) No TE on an incorrect cycle, but (+)77 scores 1 mark Allow TE on transcription errors from M1, and award M2 Allow ×2 omitted, answer = (+)301 (kJ mol^{-1}) scores (1)	**(2)**

(Total for Question 17 = 11 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	• smooth line of best-fit through all the points	An example of a graph:  Ignore extrapolation at either end of the best-fit line Allow non-smooth lines, within 1 square of each point Do not award use of a ruler	**(1)** **Expert**

Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	• graph is not a straight line (through the origin)	Accept reverse argument Accept 1st order would be a straight line Accept the relationship is not linear / directly proportional Allow 2^{nd} order with justification e.g., as it's a curve or rate quadruples when concentration doubles Ignore half lives Allow rate not doubling when concentration is doubled Ignore gradient not constant. Ignore exponential No TE 18(a)(i)	**(1)**

Question Number	Answer		Additional Guidance	Mark
18(a)(iii)	An answer that makes reference to the following points: • order of reaction for NO • order of reaction for O_2	 **(1)** **(1)**	 2 / 2nd / second 1 / 1st / first	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(a)(iv)	• rate = $k[NO]^2[O_2]$	Allow TE on incorrect orders in a(iii) Allow r on LHS Do not award round brackets Must be a rate equation to gain the mark Correct answer scores 1	**(1)**

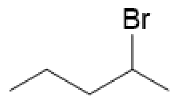
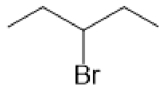
Question Number	Answer		Additional Guidance	Mark
18(a)(v)	• substitution **or** rearrangement • answer **and** units	**(1)** **(1)**	Example of a calculation: $0.040 = k\,(0.010)^2(0.05)$ $k = \frac{0.040}{(0.010)^2(0.05)}$ $= 8000\ dm^6\ mol^{-2}\ s^{-1}$ Allow units in any order Allow s^- Allow $dm^6/mol^2\,s$ but not $dm^6/mol^2/s$ Allow TE on a(iv) for both marks, units must match order for M2 Correct answer with units scores 2, even if expression in Q18(a)(iv) is incorrect	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)	An answer that makes reference to the following points: • the equilibrium constant is (very) large **(1)** • the equilibrium position is (far) to the right / (heavily) favours the products **(1)**	Allow K_p >>1 Allow synonyms e.g., huge, massive, etc. Allow high Ignore quite large Ignore K_p >1, positive Ignore numerator is larger than the denominator Ignore references to partial pressures Allow goes to completion Do not award “shifts to the right” Ignore favours the forward reaction Do not award M2 for comments on rate For two marks there must be a comment on extent/magnitude	**(2)**

(Total for Question 18 = 9 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>19(a)(i)</td><td>

- one mark per correct row **(3)**

</td><td>An example of a completed table:
<table>
<tr><th>Isomer</th><th>Skeletal structure</th><th>Number of peaks on 13C NMR spectrum</th></tr>
<tr><td>1</td><td></td><td>5</td></tr>
<tr><td>2</td><td></td><td>5</td></tr>
<tr><td>3</td><td></td><td>3</td></tr>
</table>

If no other mark is scored three correct structures score 1 mark

Accept displayed or structural formulae</td><td>(3)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>19(a)(ii)*</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).

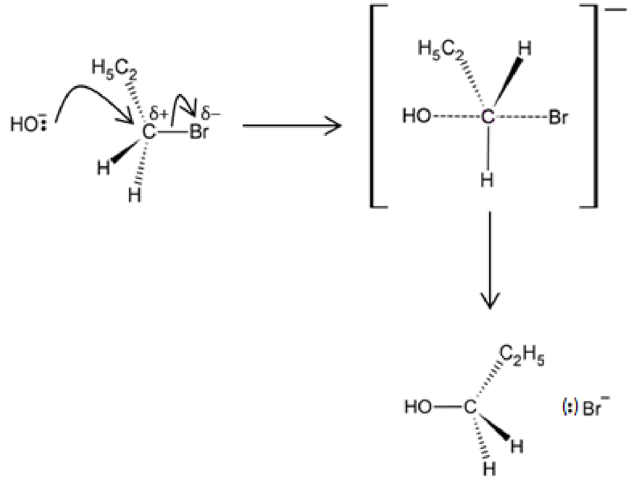
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general, it would be expected that 5 or 6 indicative points would get 2 reasoning marks, 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).

Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning.</td>
<td>(6)</td>
</tr>
</table>

	Indicative content: • IP1: 3 peaks so 3 (proton/hydrogen/H) environments • IP2: the peak in the range 3.7– 4.2 (δ/ppm) is the H attached to the same carbon as the bromine • IP3: split into 5 peaks as next to 4 hydrogens • IP4: the peak at 0.8 – 1.3 (δ/ppm) is the Hs in the methyl groups **and** the peak at 1.6 – 2.2 (δ/ppm) is the two -CH_2-hydrogen groups • IP5: peak areas 1:4:6 • IP6: identification of 3-bromopentane by name or structural formula	Allow “3 chemical shifts” in place of peaks Accept -CHBr- has the highest chemical shift Allow IP2 if peak is correctly labelled on the spectrum IP2 can be awarded for any of the three formulae Allow any word that implies 5 peaks e.g., pentet, quintuplet, quintet or multiplet IP3 can be awarded for any correct explanation of splitting patterns – reference to (n+1) rule IP4 can be awarded for an explanation of the symmetry of the molecule leading to equivalent methyl and CH_2 groups, if the peaks are correctly identified (including on the diagram) Allow IP4 if peaks are correctly labelled on the spectrum Allow IP4 to be awarded if the correct splitting patterns are described for δ-values of both peaks. Allow numbers in any order Allow ratio alone Allow single values for chemical shifts throughout (within each range) I1, I2, I4, I5 and I6 can be shown on a labelled diagram with labelled spectrum	

Question Number	Answer	Additional Guidance	Mark
19(b)	An answer that makes reference to the following points • lone pair on oxygen of OH^- • dipole on C–Br • curly arrow from lone pair to delta positive carbon • curly arrow from C–Br bond to Br or just beyond (allow shown on transition state) • transition state (including partial bonding) • negative charge anywhere on transition state • propan-1-ol **and** Br^-	Example of a mechanism:  Ignore charges for P5 Do not award OH–C connectivity for P5 TE on incorrect reactant molecule TE on incorrect connectivity from transition state for P7 but otherwise do not award OH–C Allow 2D representations S_N1 mechanisms could score points 1, 2, 4 and 7 (2 marks max) All 7 points score 4 marks, 5 or 6 points scores 3 marks, 3 or 4 points scores 2 marks, 2 points scores 1 mark	**(4)**

(Total for Question 19 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
20(a)(i)	• expression or suitable working **(1)** • correct answer **(1)**	Example of a calculation: (192 + 0.5 × 205) – (220) (+)74.5 (J K^{-1} mol^{-1}) Correct answer scores 2 –74.5 scores 0 TE on small errors in M1 e.g., miss out 0.5, as long as the answer is positive Penalise incorrect units once only for ai-aiii Allow J K^{-} mol^{-} Allow J/K mol but not J/K/mol	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	• balanced equation or suitable working **(1)** • correct answer **(1)**	Example of a calculation: ΔS surroundings = $-\Delta H/T$ = – (–82000) ÷ (2048) = 82000 ÷ 2048 (+) 40.039 (J K^{-1} mol^{-1}) Correct answer scores 2 Ignore SF – 40 scores 1 mark 0.04 scores 1 mark with correct units or without units, 2 marks with kJ K^{-1} mol^{-1}	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iii)	• total entropy change	Example of a calculation: $74.5 + 40.0 = (+)114.5$ (J K^{-1} mol^{-1}) TE on ai and aii, but both must be in the correct units Ignore SF except 1SF	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)	• gradient **(1)** • activation energy **(1)**	Example of a calculation: $\frac{(-197) - (-190)}{(0.00673) - (0.00649)} = \frac{-7}{0.00024}$ gradient = –29 167 (K) (allow any negative value between 28 300-30 000) $(-8.31 \times -29\,167) \div 1000 = (+)242.4$ (kJ mol^{-1}) (allow values between 235.1 to 249.3 for 2 marks) Ignore SF except 1 SF Allow TE from M1 Answers in J mol^{-1} score both marks if in the allowed range (235100-249300)	**(2)**

Question Number	Answer		Additional Guidance	Mark
20(c)	An explanation that makes reference to the following points: • (thermodynamically) feasible because ΔS_{total} is positive • activation energy high so the reaction is very slow (at low temperatures)	 **(1)** **(1)**	 Ignore thermodynamically stable/unstable Allow high temperature will provide E_a so reaction will proceed Allow reaction may not happen as E_a is (very) high Allow high E_a so kinetically stable Allow high E_a so kinetically non-feasible TE on 20(a)(iii) but not on 20(b)	**(2)**

(Total for Question 20 = 9 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>21(a)</td><td>An answer that makes reference to the following points:

• row for oxidation correct (1)

• row for reduction correct (1)</td><td>Example of an answer:
<table>
<tr><th>Reagent and conditions</th><th>Reaction (✓/✗)</th><th>Name of organic product (if formed)</th></tr>
<tr><td>refluxed with excess acidified potassium dichromate(VI)</td><td>✗</td><td>(N/A)</td></tr>
<tr><td>excess lithium tetrahydrioaluminate(III) in dry ether</td><td>✓</td><td>hexane-2,5-diol</td></tr>
</table>
Accept no product or blank in first row
Accept 2,5-hexanediol in second row
Ignore errors with spaces, commas and missing ne or e in hexane
Do not award hex-2,3-diol</td><td>(2)</td></tr>
</table>

Question Number	Answer	Additional Guidance	Mark
21(b)	An answer that makes reference to the following point: • (pale) **yellow** crystals	Allow precipitate / ppt / ppte / solid Allow antiseptic smell Ignore formulae even if incorrect Do not award yellow-orange Use the list principle: if two answers and one correct and one wrong, no credit.	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(c)(i)	An answer that makes reference to the following point: • nucleophilic addition	Do not award S_N1 or S_N2	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(c)(ii)	An answer that makes reference to the following point: • $CH_3C(OH)(CN)CH_2CH_2C(OH)(CN)CH_3$	Allow displayed / skeletal / any combination Do not award missing hydrogens or single bonds shown between C and N. If two structures are given both must be correct.	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(d)(i)	An answer that makes reference to the following point: • orange precipitate	Allow yellow / red Allow crystals / solid / ppt / ppte Ignore modifiers e.g., dark/light/brick Do not award reddish-brown	**(1)**

Question Number	Answer	Additional Guidance	Mark
21(d)(ii)	A description that makes reference to the following points: • (re)crystallise **(1)** • measure the **melting** temperature and compare with known values **(1)**	Ignore purify the product Allow refer to database, etc. Ignore NMR / mass spec. etc.	**(2)**

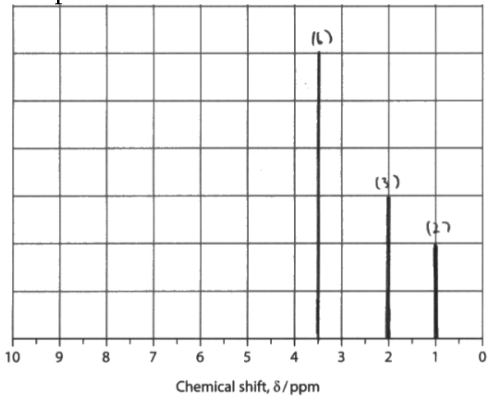
(Total for Question 21 = 8 marks)
TOTAL FOR SECTION B = 50 MARKS

Section C

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>22(a)</td>
<td>An answer that makes reference to the following points:

• three peaks (1)

• peaks shown in approximately the correct height ratio (peak area 6:3:2), highest peak can’t be on the right (1)

• appropriate δ values for 2 or 3 peaks (1)</td>
<td>An example of a sketch:


Allow vertical lines for peaks
Do not award split peaks for M1

M2 is dependent on M1

<table>
<tr><td>group</td><td>allowable δ values</td><td>(ratio)</td></tr>
<tr><td>amine</td><td>0.5-2.5</td><td>2</td></tr>
<tr><td>alcohol</td><td>2.0-4.0</td><td>3</td></tr>
<tr><td>CH_2</td><td>3.0-4.0</td><td>6</td></tr>
</table>
If labels are given, they must be correct.

Use the list principle if 4 peaks are shown, then 3 must be in the right area to score M3.

5 or more peaks score 0</td>
<td>(3)</td>
</tr>
</table>

Question Number	Answer	Additional Guidance	Mark
22(b)(i)	An explanation that makes reference to the following points: • Tris accepts (small amounts of) H^+/protons **(1)** • base and conjugate acid are present in high concentrations / (large) reservoir of both **(1)** • the ratio of [base]/[acid] only changes very slightly **and** pH changes only slightly **(1)**	Allow increase in H^+ causes the equilibrium to move to the right Allow reacts with/removes Ignore mops up Allow large amounts of tris and salt/acid Allow pH/[H^+] is unchanged with ratio comment Allow ratio changes a little / changes slightly with comment on pH Ignore there is no change in concentrations / the ratio is unchanged Ignore references to base/alkali/molecules/ions	**(3)** **Expert**

Question Number	Answer	Additional Guidance	Mark
22(b)(ii)	• correct expression	Allow use of skeletal structure or molecular formula $K_a = \frac{[C_4H_{11}NO_3][H^+]}{[C_4H_{12}NO_3^+]}$ Do not accept round brackets **NB If no answer is given here, check in the answer to 22(b)(iii)**	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(b)(iii)	• M_r of $C_4H_{12}NO_3Cl$ **(1)** • concentration of $C_4H_{12}NO_3Cl$ **(1)** • substitution and rearrangement of K_a **(1)** • H^+ concentration **(1)** • pH calculation **(1)**	Example of a calculation: M_r = 157.5 100 ÷ 157.5 = 0.6349 mol 0.6349 ÷ 0.5 = 1.2698 mol dm^{-3} $[H^+] = \frac{8.413 \times 10^{-9} \times [1.2698]}{[0.2]}$ TE on inverted K_a expression from (b)(ii) $[H^+] = 5.342 \times 10^{-8}$ pH = $-\log_{10}[H^+]$ = 7.27 They can also use moles rather than conc$^{\underline{n}}$s as the volume terms cancel out in the expression $[H^+] = K_a \times$ ([acid]/[salt]) M1, M4 and M5 are the same as above. M2 – Moles base = 0.2 × 0.5 = 0.1 **and** 0.6349 mol of $C_4H_{12}NO_3Cl$ M3 – substitution and rearrangement: $[H^+] = 8.413 \times 10^{-9} \times (0.635 \div 0.1)$ TE throughout, for M5 the answer must be above 7 to score Correct answer with some working scores 5 Ignore SF except 1 SF 8.88 scores 4 marks with a correct expression in (b)(ii) or 5 marks if their expression was inverted in (b)(ii). <u>Henderson-Hasselbalch solution:</u> M1 and M2 as above M3 = pK_a = 8.075 (1) M4 = pH = $pK_a + \log_{10}\left(\frac{[A^-]}{[HA]}\right)$ OR pH = $8.075 + \log_{10}\left(\frac{[0.2]}{[1.2698]}\right)$ (1) M5 pH correct for expression and above 7	**(5)**

Question Number	Answer	Additional Guidance	Mark
22(c)	• calculation of concentration of acid **(1)** • calculation of $[H^+]$ value **(1)** • expression or substitution into expression **(1)** • evaluation of K_a **(1)**	Example of a calculation: $0.0150 \div 94.5 = 0.0001587$ / 1.59×10^{-4} $0.0001587 \div 1.5 = 0.00010582$ / $\mathbf{1.058 \times 10^{-4}}$ (mol dm^{-3}) $[H^+] = 10^{-3.42} = \mathbf{3.802 \times 10^{-4}}$ (mol dm^{-3}) ($[H^+]^2 = 1.445 \times 10^{-7}$) $K_a = \frac{[H^+]^2}{[acid]}$ or $K_a = \frac{[1.445 \times 10^{-7}]}{[1.058 \times 10^{-4}]}$ $K_a = 0.0013655$ / 1.37×10^{-3} (mol dm^{-3}) TE from M3 if answer < 1 Allow 1.36×10^{-3} (mol dm^{-3}) for 4 marks Ignore SF except 1 SF Correct answer with no working scores 4 Penalise incorrect units for M4	**(4)** **Expert**

Question Number	Answer	Additional Guidance	Mark
22(d)(i)	An explanation that makes reference to the following points: • over a large range from 4 to 16.4 (cm^3) of acid added **(1)** • there is little difference in pH **(1)**	Allow a range between 2 and 16.4 of acid added Allow no (significant) change M2 is dependent on M1 Large volume of acid added before a change in pH is seen scores 1 The pH doesn’t change when a large volume of acid is added scores 1	**(2)** **Expert**

Question Number	Answer	Additional Guidance	Mark
22(d)(ii)	• 5.8	Allow answers in the range 5.6-6.2	**(1)**

Question Number	Answer	Additional Guidance	Mark
22(d)(iii)	An answer that makes reference to one of the following points: • pH is important for enzyme function • constant pH is important for living organisms • pH regulates growth of bacteria and fungi • pH is linked to oxygen availability in water	 Allow enzymes may be denatured at high or low pH Allow enzymes may be denatured at the wrong pH NB The word denatured is not on the specification so not essential Allow to have the correct pH for metabolic processes / reactions Allow to maintain the pH of blood Allow sudden pH change can be dangerous to organs of the body Ignore "resists change to pH"	**(1)** **Expert**

(Total for Question 22 = 20 marks)
TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

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