Mark Scheme (Results)

Summer 2026

Pearson Edexcel International Advanced Level In Chemistry
WCH14/01

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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 C** (PO_4^{3-}) ***A*** *is not correct because* H_3PO_4 *is the conjugate acid of* $H_2PO_4^-$ ***B*** *is not correct because* $H_2PO_4^-$ *is the conjugate base of* H_3PO_4 ***D*** *is not correct because* PO_3^- *is the conjugate base of* HPO_3	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is C** (2.0) ***A*** *is not correct because* $[H]^+$ *is 0.01 and not 0.1* ***B*** *is not correct because this is the pH when the total volume is 50* cm^3 ***D*** *is not correct because* $[H]^+$ *is 0.01 and not 0.005*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is B** (1.6×10^{-3}) ***A*** *is not correct because this is the square of the concentration of hydrogen ions,* $[H^+]^2$ ***C*** *is not correct because* CH_3COOH *is a weak acid and not a strong acid* ***D*** *is not correct because this is the pH of the solution*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is D** (13.18) ***A*** *is not correct because this is the pOH and not the pH* ***B*** *is not correct because* $Ba(OH)_2$ *is a diprotic base and not a monoprotic base and this is the pOH* ***C*** *is not correct because* $Ba(OH)_2$ *is a diprotic base and not a monoprotic base*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is A** (pure water is acidic at 50°C) ***B*** *is not correct because* $[H^+] = [OH^-]$ *at any temperature in pure water* ***C*** *is not correct because* $[H^+]$ *is higher when the pH is lower* ***D*** *is not correct because the dissociation of water is endothermic*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is D** (0.2 mol CH_3COOH and 0.1 mol $Mg(OH)_2$) ***A*** *is not correct because the solution contains significant concentrations of both* CH_3COOH *and* CH_3COO^- ***B*** *is not correct because the solution contains significant concentrations of both* CH_3COOH *and* CH_3COO^- ***C*** *is not correct because the solution contains significant concentrations of both* CH_3COOH *and* CH_3COO^-	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is D** ($[CH_3CH_2COOH] > [CH_3CH_2COO^-]$) ***A*** *is not correct because the pH is not equal to the* pK_a ***B*** *is not correct because the pH is equal to the* pK_a *when the concentrations of weak acid and conjugate base are equal* ***C*** *is not correct because the pH would be greater than the* pK_a	**(1)**

Question Number	Answer	Mark
8(a)	**The only correct answer is D** (phenol red) ***A*** *is not correct because the pH range of bromophenol blue is outside the vertical section* ***B*** *is not correct because the pH range of bromocresol green is outside the vertical section* ***C*** *is not correct because the pH range of methyl orange is outside the vertical section*	**(1)**

Question Number	Answer	Mark
8(b)	**The only correct answer is A** (12.0) ***B*** *is not correct because the concentration of HCOOH is 2.5 times (and not twice) the concentration of KOH* ***C*** *is not correct because the concentration of HCOOH is 2.5 times (and not equal to) the concentration of KOH* ***D*** *is not correct because the concentration of HCOOH is 2.5 times (higher and not lower than) the concentration of KOH*	**(1)**

Question Number	Answer	Mark
8(c)	**The only correct answer is B** (Key point **2**) ***A*** *is not correct because this is the pH of the methanoic acid solution* ***C*** *is not correct because this is the pH at the equivalence point* ***D*** *is not correct because this is the final pH when KOH is in excess*	**(1)**

Question Number	Answer	Mark
8(d)	**The only correct answer is C** ($[OH^-] < 0.040$) ***A*** *is not correct because the aqueous potassium hydroxide has been diluted by the neutralisation solution* ***B*** *is not correct because the aqueous potassium hydroxide has been diluted by the neutralisation solution* ***D*** *is not correct because this is the concentration of hydrogen ions, $[H^+]$, at Key point **4***	**(1)**

Question Number	Answer	Mark
9(a)	**The only correct answer is B** (first) ***A*** *is not correct because the reaction is first order as $[I^-]$ remains almost constant* ***C*** *is not correct because the reaction is first order as $[I^-]$ remains almost constant* ***D*** *is not correct because the reaction is first order as $[I^-]$ remains almost constant*	**(1)**

Question Number	Answer	Mark
9(b)	**The only correct answer is B** (Step **2**) ***A*** *is not correct because the reaction would be second order and the rate equation would be rate = k* $[Fe^{3+}]$ $[I^-]$ ***C*** *is not correct because the reaction would be fourth order and the rate equation would be rate = k* $[Fe^{3+}]^2$ $[I^-]^2$ ***D*** *is not correct because the reaction would be fourth order and the rate equation would be rate = k* $[Fe^{3+}]^2$ $[I^-]^2$	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is D** (only 2) ***A*** *is not correct because a red precipitate would form with Fehling's solution and an orange precipitate would form with 2,4-dinitrophenylhydrazine* ***B*** *is not correct because a red precipitate would form with Fehling's solution* ***C*** *is not correct because a red precipitate would form with Fehling's solution and an orange precipitate would form with 2,4-dinitrophenylhydrazine*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is A** ($CH_3CHOHCOONa$) ***B*** *is not correct because the sodium salt of the carboxylic acid would be produced and the chloroalkane group would also be substituted to form an alcohol* ***C*** *is not correct because the sodium salt of the carboxylic acid would be produced* ***D*** *is not correct because the chloroalkane group would also be substituted to form an alcohol*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is C** (only 2 and 3) ***A*** *is not correct because misty fumes and not a white smoke are observed in the reaction with* H_2O ***B*** *is not correct because misty fumes and not a white smoke are observed in the reaction with* H_2O ***D*** *is not correct because a white smoke would also be observed in the reaction with* CH_3NH_2	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is C** ($CH_3CH_2CONHCH_2CH_3$) ***A*** *is not correct because this organic compound is formed when ethanoyl chloride reacts with propylamine* ***B*** *is not correct because this organic compound is formed when ethanoyl chloride reacts with propylamine* ***D*** *is not correct because this organic compound is formed when butanoyl chloride reacts with methylamine*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is A** (CH_3CH_2OH and CH_3CH_2COOH) ***B*** *is not correct because these are the products from the acid hydrolysis of propyl ethanoate* ***C*** *is not correct because these are the products from the acid hydrolysis of propyl propanoate* ***D*** *is not correct because these are the products from the acid hydrolysis of ethyl butanoate*	**(1)**

Question Number	Answer	Mark
15(a)	**The only correct answer is C** (three) ***A*** *is not correct because* ***E, F*** *and* ***G*** *have an* R_f *value between 0.1 and 0.3* ***B*** *is not correct because* ***E, F*** *and* ***G*** *have an* R_f *value between 0.1 and 0.3* ***D*** *is not correct because only* ***E, F*** *and* ***G*** *have an* R_f *value between 0.1 and 0.3*	**(1)**

Question Number	Answer	Mark
15(b)	**The only correct answer is B** (**F** and **J**) ***A*** *is not correct because the* R_f *value of* ***H*** *is not the same as either compound in* ***L*** ***C*** *is not correct because the* R_f *values of* ***G*** *and* ***H*** *are not the same as either compound in* ***L*** ***D*** *is not correct because the* R_f *value of* ***G*** *is not the same as either compound in* ***L***	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
16(a)	An answer that makes reference to the following points: • RX is first order **and** (as from Expts 1 to 2, $[OH^-]$ constant and) [RX] × 2, rate × 2 **(1)** • OH^- is first order **and** (as from Expts 1 to 3) $[OH^-]$ × 2, [RX] × 0.5, rate unchanged or (as from Expts 2 to 3) $[OH^-]$ × 2, [RX] × 0.25, rate × 0.5 **(1)**	Ignore just rate is directly proportional to [RX] Ignore just rate is directly proportional to $[OH^-]$ If no other mark awarded, two correct orders without justification scores (1)	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(b)	An answer that makes reference to the following point: • (rate =) k [RX] $[OH^-]$	Allow (rate =) k $[RX]^1$ $[OH^-]^1$ Allow TE on orders from (a) where rate equation is incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(c)	An answer that makes reference to the following points: • primary **and** (as) second order / S_N2 or (as) OH^- is involved in the rate determining / slow step / appears in the rate equation or (as) first order in both reactants	Ignore any reference to carbocation stability Ignore any reference to secondary Allow bimolecular for second order Allow nucleophile for OH^- Allow both reactants in rate equation / rate determining step / slow step Allow TE on (b) only where RX is first order and OH^- is zeroth order: tertiary **and** (as) first order / S_N1 or (as) OH^- is not involved in the slow step / does not appear in the rate equation / is only involved in the fast step or (as) only RX is involved in the slow step / appears in the rate equation	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(d)	• rearrangement of rate equation **(1)** • calculation of k **(1)** • units of k **(1)**	Example of calculation Allow use of data from any Experiment Allow TE on any rate equation from (b) $k = \frac{\text{rate}}{[RX][OH^-]}$ $k = \frac{3.2 \times 10^{-6}}{0.02 \times 0.01} = 0.016$ Do not award 1SF No TE on M1 $dm^3\ mol^{-1}\ s^{-1}$ Allow units in any order No TE on M1 Correct answer and units with no working scores (3)	**(3)**

(Total for Question 16 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
17(a)(i)	• calculation of number of moles of SO_2	Example of calculation $n = 1.00 \times 10^3 \div 64.1$ $= 15.601$ (mol) Ignore SF except 1 SF	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(a)(ii)	• ideal gas equation rearranged for n **(1)** • conversion of temperature from °C to K **(1)** • calculation of n **(1)**	Example of calculation $n = \frac{pV}{RT}$ $T = 427 + 273 = 700$ (K) $n = \frac{(8.00 \times 10^5 \times 57.0 \times 10^{-3})}{(8.31 \times 700)} = 7.8391$ (mol) Ignore SF except 1 SF Allow TE on M2 No TE on M1	**(3)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iii)	• equilibrium moles of SO_2 **(1)** • equilibrium moles of O_2 **(1)**	Example of calculation $n = 15.601 - 15.3 = 0.30062$ (mol) Allow 0.3 Allow TE on (a)(i) that gives a positive answer $n = 7.8391 - (15.3 \div 2) = 0.18909$ (mol) Ignore SF except 1 SF Allow TE on (a)(ii) that gives a positive answer	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iv)	• total equilibrium moles **(1)** • all three partial pressures **(1)**	Example of calculation $n = 15.3 + 0.30062 + 0.18909 = 15.790$ (mol) Allow TE on (a)(iii) Do not award any other equilibrium moles for SO_3 than 15.3 $p(SO_3) = \frac{15.3}{15.790} \times 8.00 \times 10^5 = 7.7519 \times 10^5$ (Pa) $p(SO_2) = \frac{0.30062}{15.790} \times 8.00 \times 10^5 = 1.5231 \times 10^4$ (Pa) $p(O_2) = \frac{0.18909}{15.790} \times 8.00 \times 10^5 = 9.5805 \times 10^3$ (Pa) Allow TE on M1 Allow answers in kPa, eg 7.7519×10^2 (kPa) Ignore SF	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(a)(v)	• calculation of K_p **(1)** • units of K_p **(1)**	Example of calculation $K_p = \frac{(7.7519 \times 10^5)^2}{\left((1.5231 \times 10^4)^2 \times 9.5805 \times 10^3\right)} = 0.27036 / 2.7036 \times 10^{-1}$ Ignore SF except 1 SF Allow TE on (a)(iv) Pa^{-1} Allow working in kPa, giving $270.36 / 2.7036 \times 10^2$ kPa^{-1}	**(2)**

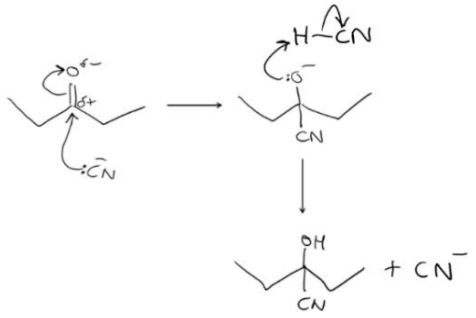
Question Number	Answer	Additional Guidance	Mark
17(b)	An explanation that makes reference to the following points: • value of K_p does not change / is constant **(1)** • denominator increases more (than numerator in K_p expression) **(1)** • equilibrium shifts right **and** increasing yield (of SO_3) **(1)**	Allow pressure has no effect on K_p Allow only temperature changes K_p Allow (equilibrium shifts to) restore/maintain K_p Allow partial pressures of reactants increases more (than products) Allow (reaction) quotient / $Q_{(p)}$ decreases Allow equilibrium shifts in forward direction / toward the products / toward SO_3 for shifts right Ignore any reference to Le Chatelier's principle, eg equilibrium shifts to side with fewer moles of gas	**(3)**

(Total for Question 17 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)	An explanation that makes reference to the following points: • stronger London forces **(1)** • (as) more contact between molecules **(1)**	Accept more energy to break for stronger Allow dispersion / instantaneous-induced dipole / temporary-induced dipole / van der Waals forces for London Ignore abbreviations, eg IDID / vdW forces Ignore just intermolecular forces Ignore comparison of permanent dipole-dipole forces Do not award any reference to presence of hydrogen bonds Allow (as) more electrons Allow greater contact surface area Ignore just greater surface area Ignore longer carbon chain Ignore higher *Mr* / larger molecule	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)	A description that makes reference to the following points: • (collect and) recrystallise (precipitates) **(1)** • measure melting temperature (of derivative) **and** compare with Data (Booklet) **(1)**	Allow purify and crystallise Ignore descriptions of the recrystallisation Ignore any reference to colour of precipitates Do not award measure boiling temperature Allow melting temperature (of derivative) is lower with propanone / higher with pentan-3-one Ignore any reference to IR / NMR / mass spectrometry	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(c)	An answer that makes reference to the following points: • (pale) yellow precipitate with propanone **(1)** • no change with pentan-3-one **(1)**	Allow crystals / solid / ppt / ppte Allow antiseptic smell with propanone Ignore solution decolourises from brown Ignore cream Do not award any other colour, eg orange Do not award bright Do not award additional incorrect observations, eg effervescence Allow no reaction / no observation for no change	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(d)	An answer that makes reference to the following points: • P1: cyanide ion nucleophile • P2: curly arrow from lone pair on C of $CN^{(-)}$ to C of C=O • P3: C=O dipole • P4: curly arrow from C=O bond to O • P5: intermediate • P6: curly arrow from lone pair on O atom of intermediate to H of HCN • P7: organic product 7 marking points scores 4 marks 6 marking points scores 3 marks 4 or 5 marking points scores 2 marks 2 or 3 marking points scores 1 mark	Penalise use of curly half arrows once only Ignore position of negative charge on CN^- Do not award omission of negative charge in P1 Do not award omission of negative charge Allow curly arrow to H^+ or H of H_2O Ignore omission of negative charge on intermediate Ignore omission of curly arrow from H–CN bond Ignore omission of CN^- byproduct Ignore any dipoles on CN of HCN Do not award organic product from propanone <u>Example of mechanism</u>  	**(4)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>18(e)</td><td>An answer that makes reference to the following points:

• any two or three boxes correct scores (1)

• all four boxes correct scores (2)</td><td><u>Example of completed table</u>

<table><tr><th>Ketone</th><th>m / z of peak 1</th><th>m / z of peak 2</th></tr><tr><td>propanone</td><td>58 / 43 / 15</td><td>58 / 43 / 15</td></tr><tr><td>pentan-3-one</td><td>86 / 71 / 57 / 29 / 15</td><td>86 / 71 / 57 / 29 / 15</td></tr></table>
Ignore formulae of fragment ions, even if incorrect</td><td>(2)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*18(f)</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><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded fo 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
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></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

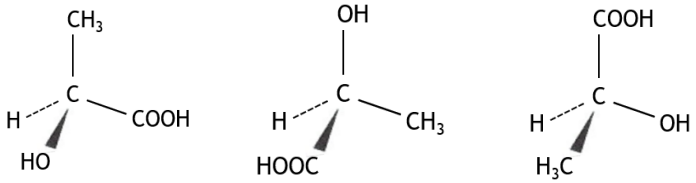
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded, do not deduct mark(s).

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>

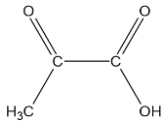
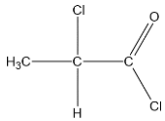
	Indicative points: **IP1 similarity in carbon-13 NMR spectra** both have (one) peak at 190–225 ppm (due to **C**=O) **IP2 difference in carbon-13 NMR spectra** propanone has (one) peak and pentan-3-one has two peaks at 0–60 ppm (due to **C**−C) **IP3 number of peaks in proton NMR spectra** propanone has one peak **and** pentan-3-one has two peaks **IP4 chemical shifts in proton NMR spectra** 1.5–2.9 ppm (due to **H**−C−C=O) for both **and** –0.2–1.8 ppm (due to **H**−C−C) for pentan-3-one **IP5 relative peak areas in proton NMR spectrum for pentan-3-one** 2H (due to CH_2) and 3H (due to CH_3) **IP6 splitting in proton NMR spectra** propanone has no splitting / singlet **and** pentan-3-one has triplet **and** quartet	Allow all IPs from **labelled** diagrams / structures / spectra / tables, ie IPs may be implied Allow any value or range within the specified ranges for chemical shifts Ignore any reference to TMS in all IPs Allow number of carbon environments for number of peaks in IP1 and IP2 Ignore omission of carbon environments in IP1 / IP2 Do not allow incorrect numbers of peaks in IP1 / IP2 Allow singlet peak for one peak (for propanone), which can also contribute to IP6 Allow number of proton environments for number of peaks Ignore omission of proton environments Do not allow incorrect assignment of environments Allow height for relative peak area Allow 4H (due to CH_2) and 6H (due to CH_3) Ignore relative peak area for propanone Allow unambiguous alternatives, eg single peak for singlet / three-split for triplet / quadruplet for quartet Ignore numbers of singlets / triplets / quartets in IP6 Ignore any reference to peak heights in IP6	

(Total for Question 18 = 18 marks)

Question Number	Answer	Additional Guidance	Mark
19(a)(i)	An answer that makes reference to the following point: • (molecules which are) non-superimposable **and** mirror images	Ignore any reference to optical activity / rotation of plane-polarised light / racemic / 50-50 mixtures Ignore chiral centre / carbon atom attached to 4 different groups	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	An answer that makes reference to the following point: • completed diagram of other enantiomer	<u>Examples of completed diagram</u>  Do not award incorrect connectivity	**(1)**

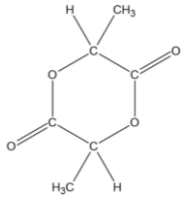
Question Number	Answer	Additional Guidance	Mark
19(b)(i)	An answer that makes reference to the following points: • $LiAlH_4$ **(1)** • dry **and** ether **(1)**	If name and formula given, both must be correct Accept lithium tetrahydridoaluminate(III) Allow lithium aluminium hydride Ignore lithal Do not award $NaBH_4$ / sodium tetrahydridoborate Accept anhydrous for dry Ignore heat Do not award any indication of (aq) Allow ethoxyethane / (di)ethyl ether / $CH_3CH_2OCH_2CH_3$ / $(CH_3CH_2)_2O$ for ether	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(b)(ii)	An answer that makes reference to the following points: • organic product for Reaction **2** **(1)** • organic product for Reaction **3** **(1)**	Allow skeletal, structural or displayed formulae or any correct combination Ignore any inorganic products, even if incorrect Ignore connectivity <u>Examples of correct structures</u>  / $CH_3COCOOH$  / $CH_3CHClCOCl$	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(b)(iii)	An answer that makes reference to the following points: • $POCl_3$ and HCl products **(1)** • rest of equation **and** balancing **(1)**	Example of equation $CH_3CH(OH)COOH + 2PCl_5 \rightarrow CH_3CHClCOCl + 2POCl_3 + 2HCl$ Allow structural, displayed, skeletal or molecular formulae for organic species Ignore omission of brackets in structural formulae Ignore state symbols, even if incorrect **M2 dependent on M1** Allow multiples Allow TE, for 2 marks, on (b)(ii) for monosubstitution eg, $CH_3CH(OH)COOH + PCl_5 \rightarrow CH_3CH(OH)COCl + POCl_3 + HCl$	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(c)	• M_r of 2000 repeat units **or** M_r of 2000 molecules of lactic acid **(1)** • working to show M_r of polymer **(1)**	Example of calculation (2000 × 72 =) 144 000 (2000 × 90 =) 180 000 144 000 + 18 = 144 018 or 180 000 – 1999 × 18 = 144 018	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(i)	An answer that makes reference to the following points: • $C_6H_8O_4$ **(1)** • $2H_2O$ **(1)**	Example of equation $2C_3H_6O_3 \rightarrow C_6H_8O_4 + 2H_2O$ Allow elements in any order Do not award any other type of formula Do not award additional species	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(d)(ii)	An answer that makes reference to the following points: • cyclic structure with two ester linkages **(1)** • rest of $C_6H_8O_4$ structure **(1)**	Example of structure  Allow any correct combination of formulae Ignore bond lengths and bond angles	**(2)**

(Total for Question 19 = 14 marks)
TOTAL FOR SECTION B = 52 MARKS

Section C

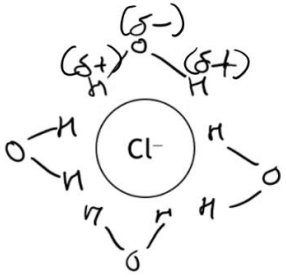
Question Number	Answer	Additional Guidance	Mark
20(a)(i)	An answer that makes reference to the following point: • (standard enthalpy change of) formation is for one mole	Accept equation for (standard enthalpy change of) formation is $Al(s) + 1.5Cl_2(g) \rightarrow AlCl_3(s)$ (and Equation **1** is twice this) Allow two moles ($AlCl_3$) formed from elements in standard state(s) Ignore molecules for moles	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(a)(ii)	• use of $\Delta S_{system} = \Sigma(S^{\ominus}\text{products}) - \Sigma(S^{\ominus}\text{reactants})$ **(1)** • calculation of ΔS_{system} **(1)**	<u>Example of calculation</u> $\Delta S_{system} = (2 \times 109) - (2 \times 28.3 + 3 \times 223)$ -507.6 ($J\ K^{-1}\ mol^{-1}$) Allow -0.5076 **kJ** ($K^{-1}\ mol^{-1}$) Ignore SF except 1 SF Correct answer scores (2)	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iii)	An explanation that makes reference to the following points: • (negative sign expected as) decreases in disorder **(1)** • (as) gas forming solid **(1)**	Accept products more ordered than reactants Accept fewer ways of dispersing energy in products Allow randomness for disorder If answer to (a)(ii) is positive, M1 can only score if it is stated that the sign is unexpected Allow moles of gas decreases / goes from 3 to 0 Allow just moles decrease / go from 5 to 2 Ignore just solid formed Ignore molecules / particles for moles Do not award incorrect numbers of moles	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(a)(iv)	• expression for $\Delta S_{surroundings}$ **(1)** • calculation of $\Delta S_{surroundings}$ **(1)** • calculation of ΔS_{total} **(1)**	Example of calculation $\Delta S_{surroundings} = \frac{-\Delta H}{T}$ $\Delta S_{surroundings} = \frac{-(-1408 \times 10^3)}{298}$ $\Delta S_{surroundings}$ = (+)4724.8 (J K^{-1} mol^{-1}) Allow (+)4.7248 **kJ** (K^{-1} mol^{-1}) No TE on incorrect expression for $\Delta S_{surroundings}$ $\Delta S_{total} = \Delta S_{surroundings} + \Delta S_{system}$ ΔS_{total} = 4724.8 + (–507.6) = 4217.2 (J mol^{-1} K^{-1}) Allow (+)4.2172 **kJ** (K^{-1} mol^{-1}) Allow TE on $\Delta S_{surroundings}$ and ΔS_{system} from (a)(ii) No TE on incorrect expression for ΔS_{total} Correct answer with no working scores (3)	**(3)**

Question Number	Answer	Additional Guidance	Mark
20(a)(v)	An answer that makes reference to the following point: • (reaction has) high activation energy / E_a	Accept (aluminium has a protective) oxide layer Accept (there is a) physical barrier between reactants Ignore just (aluminium is) unreactive Allow reaction is kinetically inert / stable Allow reaction is very slow Ignore temperature is too low / not high enough If answer to (a)(iv) is negative, Allow (reaction is thermodynamically) unfeasible as $\Delta S_{total} < 0$	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)(i)	An answer that makes reference to the following point: • completed diagram showing hydrogen(s) of at least two water molecules surrounding the chloride ion	If more than one water molecule shown, all must be correct Ignore distance between water molecules and chloride ion Ignore omission of dipoles Do not award incorrect dipoles <u>Example of completed diagram</u>  	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)(ii)	• –364 (kJ mol^{-1})	<u>Example of calculation</u> hydration enthalpy = −1092 ÷ 3 = –364 (kJ mol^{-1}) Ignore any working Ignore units, even if incorrect Do not award +364 (kJ mol^{-1})	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)(iii)	An explanation that makes reference to the following points: • stronger attraction between water (molecules) and the aluminium ion **(1)** • (as) higher (ionic) charge **(1)**	Ignore any reference to polarising power / polarisation / polarisability Accept stronger ion-dipole interactions / forces Allow (ions form) stronger bonds with water Ignore more energy released Do not award more energy required Accept greater charge density (of ion) Allow three times the charge Do not award just more positive charge Allow just smaller (ionic radius) Ignore smaller atomic radius Do not award same / similar / larger (ionic) radius	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(iv)	• (+)2740 (kJ mol^{-1})	<u>Example of calculation</u> third ionisation energy = 5137 − 1820 – 577 = (+)2740 (kJ mol^{-1}) Ignore working Ignore units, even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
20(b)(v)	An explanation that makes reference to two of the following points: • positive charge (on ion) increases **(1)** • (ionic) radius decreases **(1)** • shielding decreases **(1)**	Accept proton to electron ratio increases Accept **effective** nuclear charge increases Do not award just nuclear charge increases Allow distance between nucleus and electron(s) decreases Allow electron(s) removed from inner shell after third ionisation Allow just (ions become) smaller Ignore atomic radius for ionic radius Accept electron repulsion decreases Ignore any reference to spin-pair repulsion If no other mark awarded, nuclear attraction on electron(s) increases scores (1)	**(2)**

Question Number	Answer	Additional Guidance	Mark
20(b)(vi)	• correct use of cycle **(1)** • calculation of lattice energy **(1)**	<u>Example of calculation</u> lattice energy = −4690 − 1092 − (−311) = −5782 + 311 OR lattice energy = −(−1047) − 5137 − 677 − 704 = 1047 – 6518 −5471 (kJ mol^{-1}) No TE on incorrect cycle Correct answer with no working scores (2)	**(2)**

(Total for Question 20 = 18 marks)

TOTAL FOR SECTION C = 18 MARKS
TOTAL FOR PAPER = 90 MARKS