Pearson Edexcel

Mark Scheme (Results)

Summer 2025

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

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Summer 2025
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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(a)	**The only correct answer is C** (nucleophilic addition) ***A*** *is not correct because the reaction is a nucleophilic reaction* ***B*** *is not correct because the reaction is nucleophilic addition* ***D*** *is not correct because the reaction is a nucleophilic addition*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is A** (the lone pair of electrons on the carbon of CN^- attacking the $C^{\delta+}$ of propanone) ***B*** *is not correct because the lone pair of electrons on the nitrogen is not involved* ***C*** *is not correct because the lone pair of electrons on the oxygen is not involved* ***D*** *is not correct because the lone pair of electrons on the oxygen is not involved*	**(1)**

Question Number	Answer	Mark
1(c)	**The only correct answer is D** (2-hydroxy-2-methylpropanenitrile) ***A*** *is not correct because the product is a nitrile not an amine* ***B*** *is not correct because the product is a nitrile not an amine* ***C*** *is not correct because it has the wrong number of carbon atoms in the nitrile*	**(1)**

Question Number	Answer	Mark
1(d)	**The only correct answer is A** (butanone) ***B*** *is not correct because the C=O is not adjacent to a* CH_3 ***C*** *is not correct because the C=O is not adjacent to a* CH_3 ***D*** *is not correct because the C=O is not adjacent to a* CH_3	**(1)**

Question Number	Answer	Mark
1(e)	**The only correct answer is B** (CHI_3) ***A*** *is not correct because the pale yellow crystals are not tetraiodomethane* ***C*** *is not correct because the pale yellow crystals are not diiodomethane* ***D*** *is not correct because the pale yellow crystals are not iodomethane*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is D** (a gas is given off that turns damp red litmus paper blue) ***A*** *is not correct because an amide is formed* ***B*** *is not correct because the reaction is exothermic* ***C*** *is not correct because misty fumes and white smoke are given off*	**(1)**

Question Number	Answer	Mark
3	**The only correct answer is D** ($FeCl_3$) ***A*** *is not correct because FeO is a less complex substance than* $FeCl_3$ ***B*** *is not correct because FeS is a less complex substance than* $FeCl_3$ ***C*** *is not correct because* $FeCl_2$ *is a less complex substance than* $FeCl_3$	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is B** (-0.097) ***A*** *is not correct because this is the negative value of the concentration* ***C*** *is not correct because the log of the concentration has been used, not the negative log* ***D*** *is not correct because this is the value of the concentration*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is C** (the dissociation of water is endothermic so the concentration of hydrogen ions is higher at 75ºC) ***A*** *is not correct because in pure water the concentrations of hydrogen ions and hydroxide ions are always equal* ***B*** *is not correct because the concentration of hydrogen ions increases* ***D*** *is not correct because the reaction is endothermic*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** (10) ***B*** *is not correct because this is the pH after a dilution of 10* ***C*** *is not correct because this is the pH after increasing the concentration by 10* ***D*** *is not correct because this is the pH after increasing the concentration by 100*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is B** (CH_3COOH) ***A*** *is not correct because this would have a mass of* 60.0573 ***C*** *is not correct because this would have a mass of* 60.0323 ***D*** *is not correct because this would have a mass of* 59.0733	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is C** (0.73) ***A*** *is not correct because the distance from the sample to the solvent front has been divided by the distance travelled by the solvent* ***B*** *is not correct because the distance from the bottom of the paper to the sample has been divided by the length of the whole paper* ***D*** *is not correct because this is the reciprocal of the* R_f *value*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is A** (quenching and titrating with an acid) ***B*** *is not correct because there is a change in mass as a gas is given off* ***C*** *is not correct because there is a change in colour* ***D*** *is not correct because a gas is given off so there will be a change in volume*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is B** (12) ***A*** *is not correct because this is the rate increase when the rate has been multiplied by 6 (2 × 3)* ***C*** *is not correct because this is the rate increase when the concentration of NO has been tripled and the O_2 doubled* ***D*** *is not correct because this is the rate increase when the concentrations of both the NO and O_2 have been tripled*	**(1)**

Question Number	Answer	Mark
11	**The only correct answer is B** ($(CH_3)_3CCl$) ***A*** *is not correct because CH_3CH_2Cl is a primary halogenoalkane* ***C*** *is not correct because $CH_3CHClCH_3$ is a secondary halogenoalkane* ***D*** *is not correct because $(CH_3)_3CCH_2Cl$ is a primary halogenoalkane*	**(1)**

Question Number	Answer	Mark
12(a)	**The only correct answer is C** (Curve 3) ***A*** *is not correct because Curve 1 is a strong base being added to a strong acid* ***B*** *is not correct because Curve 2 is a strong acid being added to a strong base* ***D*** *is not correct because Curve 4 is a weak acid being added to a strong base*	**(1)**

Question Number	Answer	Mark
12(b)	**The only correct answer is C** (thymol blue (base) ; 8.0-9.6) ***A*** *is not correct because the indicator would not change colour at the end-point* ***B*** *is not correct because the indicator would not change colour at the end-point* ***D*** *is not correct because the indicator would not change colour at the end-point*	**(1)**

Question Number	Answer	Mark
13(a)	**The only correct answer is C** ($K_p = \frac{(pSO_3)^2}{(pSO_2)^2 \times (pO_2)}$) *A is not correct because the partial pressures in the equation have been multiplied by 2 instead of squared* *B is not correct because this is the expression for K_c* *D is not correct because the expression has been inverted*	**(1)**

Question Number	Answer	Mark
13(b)	**The only correct answer is B** (decreasing the pressure decreases the equilibrium yield of SO_3) *A is not correct because changing pressure has no effect on K_p* *C is not correct because a catalyst will not affect the equilibrium yield* *D is not correct because a catalyst will not affect K_p*	**(1)**

Question Number	Answer	Mark
13(c)	**The only correct answer is A** ($\Delta S_{total} = R \ln K$) ***B*** *is not correct because the ln is on the wrong side* of the equation ***C*** *is not correct because the relationship involves ln not log* ***D*** *is not correct because the relationship involves ln not log*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
14(a)	An explanation that makes reference to the following points: • (after initially getting darker) the mixture would turn yellower / more yellow **(1)** • (so eqm shifts left / favours the LHS as there are) fewer molecules/ mol on the LHS **(1)**	Allow less green Allow more yellow gas Allow darker yellow Allow just turns yellow Ignore initial colour Allow mole ratio2:3 and this may be shown on the equation Allow reverse argument Do not award eqm shifts right There is no TE	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(b)(i)	An answer that makes reference to the following point: • $(K_c =) \frac{[NO]^2[Cl_2]}{[NOCl]^2}$	Ignore state symbols Do not award round brackets/ pp Do not award if the ^{2} is inside the bracket	**(1)**

Question Number	Answer	Additional Guidance	Mark
14(b)(ii)	An answer that makes reference to the following points: • second row correct **(1)** • third row correct **(1)**	<table><tr><th>Substance</th><th>NOCl</th><th>NO</th><th>Cl_2</th></tr><tr><td>Initial mol</td><td>0.250</td><td>0</td><td>0</td></tr><tr><td>Equilibrium mol</td><td>0.218</td><td>0.032</td><td>0.016</td></tr><tr><td>Concentration / mol dm^{-3}</td><td>0.436</td><td>0.064</td><td>0.032</td></tr></table> Allow TE on second row	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(b)(iii)	• correct use of K_c expression **(1)** • correct answer **(1)** • with units and 1 to 3 SF **(1)**	<u>Example of calculation:</u> $(0.064)^2 \times 0.032 \div 0.436^2$ 6.8950×10^{-4} / 0.00068950 6.9×10^{-4} / 6.90×10^{-4} / 7×10^{-4} mol dm^{-3} Allow TE from *Kc* expression in (b)(i) and numbers in (b)(ii)	**(3)**

Question Number	Answer	Additional Guidance	Mark
14(b)(iv)	An explanation that makes reference to the following points: • (forward) reaction is endothermic/ ΔH is positive **(1)** • (at the lower temperature) reaction moves in the exothermic direction/backwards/to the left (making the value of K_c smaller) **(1)**	Standalone marks Allow reverse argument if reverse reaction is stated Allow equilibrium shifts left Allow favours instead of moves/shifts Allow makes more reactants/NOCl	**(2)**

(Total for Question 14 = 10 marks)

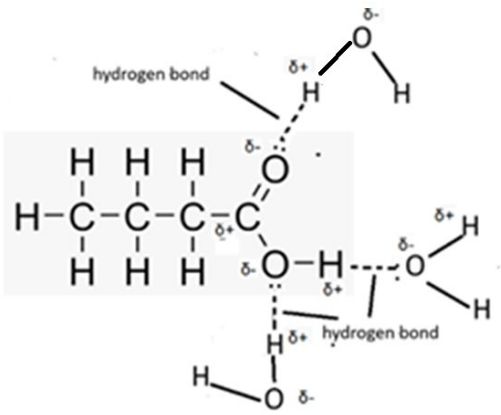
Question Number	Answer	Additional Guidance	Mark
15(a)(i)	An answer that makes reference to the following points: • lithium tetrahydridoaluminate / lithium aluminium hydride / $LiAlH_4$ **(1)** • dry **and** ether / ethoxyethane/ diethyl ether **(1)**	 Allow Lithal Allow anhydrous ether Do not award reference to heat/reflux M2 dependent on M1 or near miss	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(a)(ii)	An answer that makes reference to the following point: • hydrolysis	 Ignore acid or base / alkali	**(1)**

Question Number	Answer	Additional Guidance	Mark
15(a)(iii)	An answer that makes reference to the following points: • $CH_3CH_2CH_2COOCH_3$/ $CH_3CH_2CH_2CO_2CH_3$/ $C_3H_7COOCH_3$/ $CH_3O_2CCH_2CH_2CH_3$ **(1)** • methyl butanoate **(1)**	Standalone marks Allow displayed Allow $CH_3OCOCH_2CH_2CH_3$ Do not award$CH_3COOCH_2CH_2CH_3$ Ignore any hyphens and numbers Do not award methane/meth(y) No TE on wrong ester	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(a)(iv)	An answer that makes reference to the following points: • PCl_5 / phosphorus(V) chloride/ phosphorus pentachloride **(1)** • steamy / misty fumes **(1)**	 Allow $SOCl_2$ Allow PCl_3 but this does not allow access to M2 Do not award PCl_5 (aq) Do not award with other reagents Allow white fumes Allow gas/ vapour as an alternative to fumes Ignore HCl produced Ignore heat produced Do not award fruity/ester smell M2 dependent on M1 or near miss	**(2)**

Question Number	Answer	Additional Guidance	Mark
15(a)(v)	• equation	Example of equation: $CH_3CH_2CH_2COOH + NaHCO_3 \rightarrow CH_3CH_2CH_2COONa + CO_2 + H_2O$ AllowC_3H_7COOH and CH_3H_7COONa Accept $CH_3CH_2CH_2COO^- Na^+$ Do not award $CH_3CH_2CH_2COO - Na$ Allow H_2CO_3 instead of CO_2 and H_2O	**(1)**

Question Number	Answer	Additional Guidance	Mark
15(b)	An answer that makes reference to the following points: • B1diagram showing **one** water molecule correctly aligned with an angle of 160−200° • B2 hydrogen bond identified and correctly labelled/ allow H bond • B3lone pair on relevant O atom lined up with hydrogen bond • B4 dipole on the two atoms involved in the hydrogen bond (showing both delta + and –) • B5 dipole on the two atoms bonded to the atoms involved in the hydrogen bond (showing both delta + and –)	Example of diagram:  5 correct points scores 3 marks 3-4 correct points scores 2 marks 2 correct points scores 1 mark If HO_2 is used B1 cannot be awarded so max 2.	**(3)**

(Total for Question 15 = 11 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>16*</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.

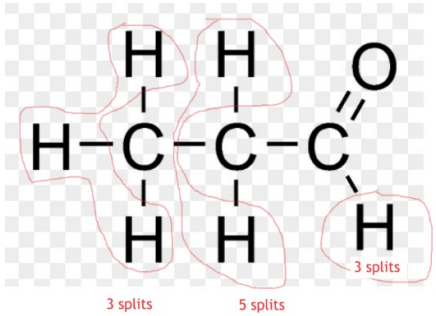
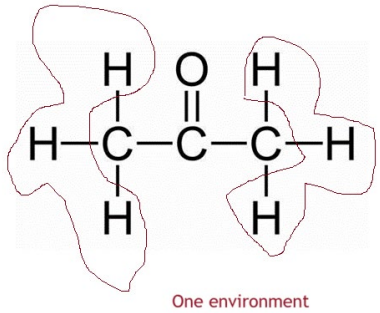
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some 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 **Proton NMR spectroscopy** • **IP1** (propanal would have) 3 peaks as there are three proton environments • **IP2** propanal relative peak areas of 3:2:1 • **IP3** (propanone would have) 1 peak as there is only one proton environment Ignore any reference to area/splitting even if incorrect • **IP4** statement or diagram showing splitting patterns in propanal of triplet, quintet/pentet/5 triplet Note the actual spectrum is 3/8/3 so allow this if seen Penalise lack of proton environments once in IP1 and 1P3. But these may be shown by diagrams. **Mass spectrometry** • **IP5** propanal and propanone (have the same molecular ion peak) *m/z* = 58 Or propanal and propanone (have the same peak due to the splitting off of the CH_3 group) *m/z* = 43 Or Propanal and propanone have a peak due to due to CH_3^+) *m/z* = 15	Ignore any reference to high or low resolution NMR Ignore any chemical shift ranges even if incorrect   Just the *m/z* is required for IP5	

	• **IP6** propanal has a peak at *m/z* =29 due to $C_2H_5^+$ or CHO^+ (but not propanone does not) Or propanone has a peak at *m/z* = 43 due to CH_3CO^+ group (but propanal does not)	*m/z* value or mass, + charge **and** the ion are required for IP6 Note if they score IP5 via the 43 peak they can only score IP6 via the peak at 29	

(Total for Question 16 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
17(a)(i)	• correct expression for K_a	Example of expression: $K_a = \frac{[CH_3COO^-]\,[H^+]}{[CH_3COOH]}$ Allow H_3O^+ Ignore state symbols even if incorrect Do not award curly brackets Do not award HA etc	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(a)(ii)	• calculation of $[H^+]$ **(1)** • calculation of pH **(1)**	Example of calculation: No TE from wrong Ka expression in i for M1 $\sqrt{(1.7 \times 10^{-5} \times 0.25)} = 2.0616 \times 10^{-3}$ / 0.0020616 (mol dm^{-3}) $-\log 2.0616 \times 10^{-3} = 2.6858/2.69/2.7$ TE from $[H^+]$ as long as the pH is below 7 Ignore SF except 1 Correct answer without working scores 2	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iii)	An answer that makes reference to the following point: • degree of ionisation/dissociation of the acid is very small / negligible/ Or $[CH_3COOH]_{eqm} = [CH_3COOH]_{initial}$ Or $[H+] = [CH_3COO^-]$ Or all of the hydrogen ions come from the acid	Allow HA and A^- Allow H_3O^+ Allow no hydrogen ions come from the water	**(1)**

Question Number	Answer	Additional Guidance	Mark
17(b)(i)	An answer that makes reference to the following point: • the Cl is electron withdrawing / (highly) electronegative/ negatively inductive **and** so stabilises the COO^- anion/ weakens the O−H bond (causing the H^+ to be removed more easily)		**(1)**

Question Number	Answer	Additional Guidance	Mark
17(b)(ii)	• correct equation **(1)** • correct conjugate acids and bases **(1)**	Example of equation: $CH_3COOH + CH_2ClCOOH \rightleftharpoons CH_3COOH_2^+ + CH_2ClCOO^-$ B1 A2 A1 B2 Or B2 A1 A2 B1 M2 dependent on M1 or near miss such as missing a charge or a subscript 2 Allow any indication of linkage eg lines	**(2)**

Question Number	Answer		Additional Guidance	Mark
17(c)	concentration route		Example of calculation:	**(4)**
	• calculation of [CH_3COONa]	**(1)**	$8.2 \div 82 \times 1000 / 250 = 0.4$ (mol dm^{-3})	
	• rearrangement of K_a equation	**(1)**	$[H^+] = K_a \times \frac{[HA]}{[A^-]}$ OR $\frac{[H^+]}{K_a} = \frac{[HA]}{[A^-]}$	
	• calculation of $[H^+]$	**(1)**	$[H^+] = 1.7 \times 10^{-5} \times \frac{0.7}{0.4} = 2.975 \times 10^{-5}$ (mol dm^{-3})	
	• calculation of pH	**(1)**	$-\log 2.975 \times 10^{-5} = 4.5265$	
	moles route			
	• calculation of moles CH_3COONa **and** calculation of moles CH_3COOH	**(1)**	$8.2 \div 82 = 0.1$(mol) **and** $250 \times 0.7 \div 1000 = 0.175$(mol)	
	• rearrangement to get $[H^+]$	**(1)**	$[H^+] = K_a \times 0.175 \div 0.1$	
	• calculation of $[H^+]$	**(1)**	$[H^+] = 1.7 \times 10^{-5} \times 0.175 \div 0.1 = 2.975 \times 10^{-5}$ (mol dm^{-3})	
	• calculation of pH	**(1)**	$-\log 2.975 \times 10^{-5} = 4.5265$	
			Correct answer with or without working scores 4 Allow TE throughout but if final answer is above pH 7, do not award M4.	

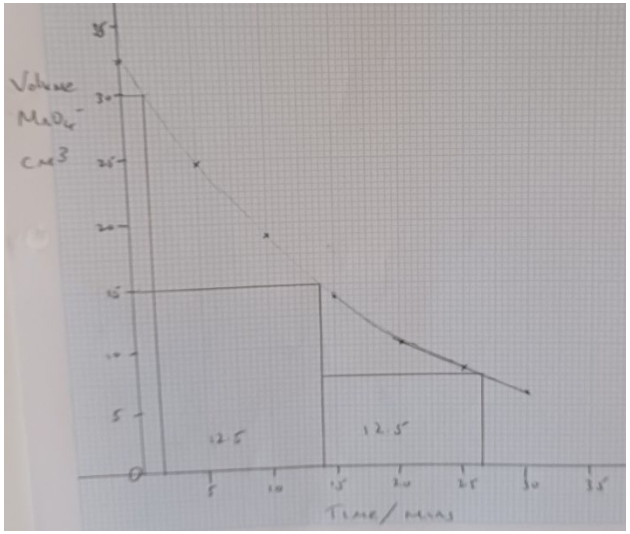
	Henderson-Hasselbalch route • calculation of [CH_3COONa] or moles of CH_3COONa and CH_3COOH	**(1)**	$8.2 \div 82 \times 1000 / 250 = 0.4$ (mol dm^{-3}) $8.2 \div 82 = 0.1$(mol) **and** $250 \times 0.7 \div 1000 = 0.175$(mol)	
	• HH equation	**(1)**	$pH = pK_a - \log \frac{[HA]}{[A^-]}$ or $pH = pK_a + \log \frac{[A^-]}{[HA]}$	
	• calculation of pK_a	**(1)**	$-\log 1.7 \times 10^{-5} = 4.76955$	
	• calculation of pH	**(1)**	Put the numbers into HH = 4.5265 Correct answer with or without working scores 4 Allow TE throughout but if final answer is above pH 7, do not award M4.	

Question Number	Answer	Additional Guidance	Mark
17(d)	An answer that makes reference to the following points: • (because of the weak acid) the pH of the bubble bath is lower (or equal) than 3.8 at the start so (the bromocresol green) is yellow **(1)** • when diluted/ water added (to the bath) **and** the $[H^+]$ decreases/ the pH increases/less acidic **(1)** • (the bromocresol green) turns (green then) blue as the pH is equal or higher than **5.4** **(1)**	Allow just yellow in acidic solution/low pH Do not award any mention of water acting as a base/ acid being neutralised/reacting with OH^- Allow at a pH of 4.7 the colour will be green Do not award if they state that pH 5.4 is alkaline Ignore any reference to acid dissociating	**(3)**

(Total for Question 17 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
18(a)(i)	An answer that makes reference to the following point: • the reaction mixture is separated from the catalyst	Allow any indication that the catalyst is no longer in contact with the solution. Allow the catalyst is removed Allow granules for catalyst Ignore reference to dilution/ quenching	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(a)(ii)	An answer that makes reference to the following point: • the concentration (of hydrogen peroxide is directly) proportional to the volume of (potassium) manganate (VII)	Allow they react in a specific ratio / 5:2 ratio Allow the other way round Allow it is proportional to the volume of manganate	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(a)(iii)	• axes labelled with time and mins on x axis and volume ($KMnO_4$) and cm^3 on y axis **(1)** • suitable scale so the points cover at least 50% of the graph in both directions **(1)** • points plotted correctly to (+/−) square **and** smooth **curve** through points **(1)**	Example of graph:  Ignore extension beyond 30 minutes as long as it follows the curve	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(a)(iv)	An answer that makes reference to the following points: • (first order as) the half-life is constant/similar **(1)** • two half-lives drawn on the graph **(1)** • two stated half-lives values within the range of 11.5 - 13.5 (mins) **(1)**		**(3)**

Question Number	Answer	Additional Guidance	Mark
18(b)	An answer that makes reference to the following points: • the slow step/rate determining step involves two molecules/mol (of hydrogen peroxide) so the mechanism is not consistent with being a first order reaction **(1)** • the slow step/rate determining step involves one molecule/mol (of hydrogen peroxide) so the mechanism is consistent with being a first order reaction **(1)**	Allow the slow step/rate determining step involves two molecules/mol (of hydrogen peroxide) so not first order/ is second order Allow the slow step/rate determining step involves two H_2O_2 so not first order/ is second order Allow the slow step/rate determining step involves one molecule/mol (of hydrogen peroxide) so is first order Allow the slow step/rate determining step involves one H_2O_2 so is first order If they state that mechanism 1 is second order and mechanism 2 first order (so consistent) award one mark if no other marks have been scored. This can also be shown by two rate equations. Ignore any reference to S_N1, S_N2 etc	**(2)**

(Total for Question 18 = 10 marks)
TOTAL FOR SECTION B = 51 MARKS

Section C

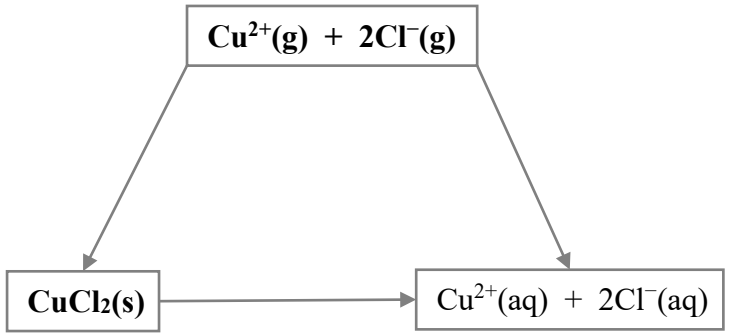
Question Number	Answer	Additional Guidance	Mark
19(a)(i)	• correct use of data **(1)** • correct answer **(1)**	Example of calculation: −285.8 × 5 (+) −771.4 (–) –2279.6 (kJ mol^{-1}) (+)79.2 / 79 (kJ mol^{-1}) Correct answer with or without working scores 2 TE M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	• $\sum S$ products **(1)** • $\Delta S = \sum S$ products − $\sum S$ reactants **(1)**	Example of calculation: S = products (5 × 69.9) + 109.0 = 458.5 (J K^{-1} mol^{-1}) 458.5 – 300.4 = (+)158.1 / 158 / 160 (J K^{-1} mol^{-1}) TE on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(a)(iii)	• rearrangement of expression **(1)** • numbers inserted into rearranged expression **(1)** • calculation of temperature **(1)**	Example of calculation: T= $\frac{\Delta H}{\Delta S_{system}}$ $T = \frac{79.2 \times 1000}{158.1}$ 500.95(K) / 500.9(K) / 501(K) / 227.95ºC / 228ºC K is in brackets but if converted to ºC the units must be seen	**(3)**

Question Number	Answer		Additional Guidance	Mark
19(b)	• calculation of mol of copper sulfate	**(1)**	<u>Example of calculation:</u> 21.36 ÷ 249.6 = 0.085577 (mol)	**(4)**
	• calculation of joules	**(1)**	12.3 × 0.085577 × (1000) = 1052.6 (J) or 1.0526 (kJ)	
	• rearrangement to give ΔT	**(1)**	ΔT = 1052.6 (J) ÷ (121.36 × 3.7)	
	• correct answer	**(1)**	= (–) 2.344 / 2.3 / 2(°C) Ignore SF Ignore sign Correct answer without working scores 4	

Question Number	Answer	Additional Guidance	Mark
19(c)(i)	An explanation that makes reference to the following points: • enthalpy change when 1 mol of **gaseous** ions **(1)** • **completely** hydrated (in water)/ forms an infinitely dilute solution (with water)/ dissolve until there is no further temperature or heat change **(1)**	Do not award any reference to heat needed or energy required. Allow is **completely** dissolved (in water) Allow dissolved in water to produce a 1.0 mol dm^{-3} solution Ignore any reference to standard conditions Do not award dissolved in 1 mol of water	**(2)**

Question Number	Answer	Additional Guidance	Mark
19(c)(ii)	• both bold boxes correct scores 1		**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(iii)	• $\Delta_{sol}H$ = (sum of) $\Delta_{hyd}H$ − Lattice energy OR $\Delta_{sol}H$ = − Lattice energy + (sum of) $\Delta_{hyd}H$	Allow $\Delta_{hyd}H$ (Cu^{2+}) + $2\Delta_{hyd}H$ (Cl^{-}) for $\Delta_{hyd}H$	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(c)(iv)	• calculation of enthalpy of hydration of copper(II) chloride **(1)** • calculation of enthalpy of solution **(1)**	<u>Example of calculation</u> −2100 + − (378 × 2) = −2856 (kJ mol^{-1}) −2856 (−) −2811 = −45 (kJ mol^{-1}) (+) 45 (kJ mol^{-1}) scores 1 Allow TE from M1 to M2 Ignore SF except 1SF Correct answer with or without working scores 2	**(2)**

Question Number	Answer		Additional Guidance	Mark
19(c)(v)	• Cu^+ less highly charged/ less positive (than Cu^{2+})	**(1)**	Allow Cu^+ (has a) is larger (ionic radius) (than Cu^{2+}) Allow Cu^+ (has a) lower charge density (than Cu^{2+}) Do not award reference to atoms	**(2)**
	• less strong (electrostatic) forces of attraction with **water** (so less energy is released when the ions are hydrated)	**(1)**	Allow there is a weaker attraction between the Cu^+ ions and **water** molecules. Allow weaker bonds with **water** Accept weaker ion- dipole forces with **water** Do not award intermolecular forces Do not award if there is any indication of energy required Allow reverse argument for both points	

(Total for Question 19 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 90 MARKS

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