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Mark Scheme (Results)

October 2020

Pearson Edexcel International Advanced Level
In Chemistry (WCH04)
Paper 1: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry (including synoptic assessment)

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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.

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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.

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1	**The only correct answer is B** (CHI_3) ***A*** *is not correct because the solid formed is triiodomethane / iodoform* ***C*** *is not correct because the solid formed is triiodomethane / iodoform* ***D*** *is not correct because the solid formed is triiodomethane / iodoform*	**(1)**

Question Number	Correct Answer	Mark
2 (a)	**The only correct answer is B** (The contents of the syringe initially turn darker and then go lighter in colour) ***A*** *is not correct because there would be a change in colour* ***C*** *is not correct because the colour change is back to front* ***D*** *is not correct because it is the wrong colour change*	**(1)**

Question Number	Correct Answer	Mark
2 (b)	**The only correct answer is A** (The equilibrium moves to the to the right and the mixture darkens) ***B*** *is not correct because the equilibrium moves to the to the right and the mixture darkens* ***C*** *is not correct because the equilibrium moves to the to the right and the mixture darkens* ***D*** *is not correct because the equilibrium moves to the to the right and the mixture darkens*	**(1)**

Question Number	Correct Answer	Mark
2 (c)	**The only correct answer is C** {total pressure x (moles of nitrogen dioxide gas ÷ total number of moles of gas)} ***A*** *is not correct because it has not been divided by the total number of moles* ***B*** *is not correct because it has not been divided by the total number of moles but has been multiplied by 2* ***D*** *is not correct because it has been divided by the mole fraction, not multiplied*	**(1)**

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Question Number	Correct Answer	Mark
2 (d)	**The only correct answer is D** (0.163) ***A*** *is not correct because the equation has been inverted and not squared* ***B*** *is not correct because the equation has been inverted and the* N_2O_4 *squared* ***C*** *is not correct because the pp of* NO_2 *has not been squared*	**(1)**

Question Number	Correct Answer	Mark
3	**The only correct answer is C** ☒**C** positive | negative ***A*** *is not correct because* ΔS_{system} *should be positive* ***B*** *is not correct because* $\Delta S_{surroundings}$ *should be negative and* ΔS_{system} *should be positive* ***D*** *is not correct because* $\Delta S_{surroundings}$ *should be negative*	**(1)**

Question Number	Correct Answer	Mark
4(a)	**The only correct answer is D** (Ultraviolet) ***A*** *is not correct because it does not initiate reactions* ***B*** *is not correct because it does not initiate reactions* ***C*** *is not correct because it does not initiate reactions*	**(1)**

Question Number	Correct Answer	Mark
4(b)	**The only correct answer is C** (Radio wave) ***A*** *is not correct because it is not used in nmr* ***B*** *is not correct because it is not used in nmr* ***D*** *is not correct because it is not used in nmr*	**(1)**

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Question Number	Correct Answer	Mark
5(a)	The only correct answer is **B** (**C**urve 2) **A** is not correct because the curve is the wrong way round **C** is not correct because the curve is the wrong way round **D** is not correct because it does not involve nitric acid	**(1)**

Question Number	Correct Answer	Mark
5(b)	**The only correct answer is C** (**C**urve 3) ***A*** *is not correct because it does not involve ammonia* ***B*** *is not correct because the curve is the wrong way round* ***D*** *is not correct because the curve is the wrong way round*	**(1)**

Question Number	Correct Answer	Mark
5(c)	**The only correct answer is C** (bromocrescol green) ***A*** *is not correct because methyl violet would change colour before the end-point* ***B*** *is not correct because methyl yellow would change colour before the end-point* ***D*** *is not correct because phenol red would change colour after the end-point*	**(1)**

Question Number	Correct Answer	Mark
6	**The only correct answer is A** ($K_w = [H^+] \times [OH^-]$) ***B*** *is not correct because* K_w *is a product not a ratio* ***C*** *is not correct because water should not be included in the expression* ***D*** *is not correct because water should not be included in the expression and it is inverted*	**(1)**

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Question Number	Correct Answer	Mark
7(a)	**The only correct answer is C** (12) ***A*** *is not correct because this is the overall order of the reaction* ***B*** *is not correct because the overall order of the reaction has been squared* ***D*** *is not correct because the overall order of the reaction has been multiplied by the factors (2 and 3)*	**(1)**

Question Number	Correct Answer	Mark
7(b)	**The only correct answer is D** *($dm^6mol^{-2}s^{-1}$)* ***A*** *is not correct because this is the product of the concentration units on the right-hand side* ***B*** *is not correct because some of the units of rate have been IGNOREd* ***C*** *is not correct because the signs of the indices of decimetres and mol are the wrong way round*	**(1)**

Question Number	Correct Answer	Mark
8	**The only correct answer is C (**Hydrogen bonds) ***A*** *is not correct because London forces are not strong enough to break the hydrogen bonds in water* ***B*** *is not correct because dipole-dipole forces are not strong enough to break the hydrogen bonds in water* ***D*** *is not correct because the concentration of ions is negligible*	**(1)**

Question Number	Correct Answer	Mark
9	**The only correct answer is B** (propanoic acid) ***A*** *is not correct because there is peak in the spectrum for a C=O* ***C*** *is not correct because there is peak in the spectrum for O-H* ***D*** *is not correct because there is peak in the spectrum for O-H*	**(1)**

Question Number	Correct Answer	Mark
10	**The only correct answer is D** (an alcohol to form an ester) ***A*** *is not correct because the reaction produces an amide* ***B*** *is not correct because the reaction produces a carboxylic acid* ***C*** *is not correct because halogenoalkanes do not react with ethanoyl chloride*	**(1)**

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Question Number	Correct Answer	Mark
11	**The only correct answer is B** ($H_2N(CH_2)_6NH_2$ and $ClOC(CH_2)_6COCl$) ***A*** *is not correct because these monomers will not react* ***C*** *is not correct because the reaction will not make the required polymer* ***D*** *is not correct because the reaction will not make the required polymer*	**(1)**

Question Number	Correct Answer	Mark
12	**The only correct answer is A** (-307 kJ mol^{-1}) ***B*** *is not correct because the cycle has been reversed* ***C*** *is not correct because the negative value for ΔH solution has been used* ***D*** *is not correct because the cycle has been reversed and the negative value for ΔH solution has been used*	**(1)**

Question Number	Correct Answer	Mark
13	**The only correct answer is A** (W) ***B*** *is not correct because the charge is only +1 and it is larger* ***C*** *is not correct because the ion is larger* ***D*** *is not correct because the charge is +1 and the ion is the largest*	**(1)**

(Total for Section A = 20 marks)

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Section B

Question Number	Acceptable Answer	Reject	Mark
14(a)(i)	$K_a = 10^{-6.35}$ / (shift log − 6.35) $= 4.4668 \times 10^{-7}$ (mol dm^{-3}) **(1)** $[H^+] \times [HCO_3^-] \div 0.00125 = 4.4668 \times 10^{-7}$ $[H^+]^2 = 5.5835 \times 10^{-10}$ $[H^+] = 2.3630 \times 10^{-5}$ (mol dm^{-3}) **(1)** TE on K_a pH = − log 2.3630×10^{-5} = 4.6265 / 4.63 **(1)** TE on $[H^+]$ provided pH is > 3 and < 7 IGNORE SF except 1SF		**(3)**

Question Number	Acceptable Answers	Reject	Mark
14(a)(ii)	ALLOW HA^- for HCO_3^- throughout $[HCO_3^-] = [H^+]$ OR No H^+ from water/ OR All H^+ from the acid ALLOW no dissociation of water **(1)** IGNORE No H^+ from the second ionisation of carbonic acid $[H_2CO_3]_{initial} = [H_2CO_3]_{eqm}$ ALLOW end for eqm OR $[H_2CO_3] = 0.00125$ mol dm^{-3} OR $[H_2CO_3]$ remains constant ALLOW Dissociation negligible **(1)** IGNORE Standard conditions		**(2)**

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Question Number	Acceptable Answer	Reject	Mark
14(b)(i)	$[H^+] = 3.9811 \times 10^{-8}$ (mol dm^{-3}) **(1)** $[H^+] = 3.9811 \times 10^{-8} = 4.4668 \times 10^{-7} \times \frac{[H_2CO_3]}{[HCO_3^-]}$ **(1)** TE on $[H^+]$ $[H_2CO_3] : [HCO_3^-] = 0.089125 : 1$ ALLOW $[HCO_3^-] : [H_2CO_3] = 11.220 : 1$ **(1)** IGNORE SF including 1SF ALLOW [HA] and $[A^-]$ instead of $[H_2CO_3]$ and $[HCO_3^-]$ Correct answer without working scores (3) $pH = pKa - \log [HA]/[A]$ $7.4 = 6.35 - \log [H_2CO_3]/[HCO_3^-]$ $[H_2CO_3]/[HCO_3^-] = 0.089125$		**(3)**

Question Number	Acceptable Answers	Reject	Mark
***14(b)(ii)**	There is a (large) reservoir of HCO_3^- (aq) (and H_2CO_3) ALLOW Large amount/concentration **(1)** Which reacts with the H^+ ions or $H^+(aq) + HCO_3^-$ (aq) $\rightarrow H_2CO_3(aq)$ **(1)** IGNORE Reactions involving OH^- and H_2CO_3 Ratio of $[H_2CO_3]$: $[HCO_3^-]$ hardly changes **(1)** Penalise use of HA instead of H_2CO_3 or A^- for HCO_3^- once only		**(3)**

(Total for Question 14 = 11 marks)

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Question Number	Acceptable Answers	Reject	Mark
15(a)(i)	% mass of oxygen = (100− 54.55− 9.09) = 36.36 (%) **(1)** Moles C (54.55 ÷ 12) = 4.546 Moles H (9.090 ÷ 1) = 9.090 Moles O (36.36 ÷ 16) = 2.273 **(1)** C = 4.546 ÷ 2.273 = 2 H = 9.090 ÷ 2.273 = 4 O = 2.273 ÷ 2.273 = 1 (So empirical formula is C_2H_4O) **(1)** <u>Alternative method</u> M_r = 44 **(1)** C = 24/44 x 100 = 54.55% H = 4/44 x 100 = 9.09 % **(1)** O= 16/44 x 100 = 36.36% **(1)** If % oxygen not calculated M2 only is available		**(3)**

Question Number	Acceptable Answers	Reject	Mark
15(a)(ii)	88 ÷ 44 = 2 so $C_4H_8O_2$ ALLOW n(2 x 12 + 4 + 16)		**(1)**

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Question Number	Acceptable Answers	Reject	Mark
*15(b)	Test **1** (Sodium) Contains an OH Group / hydroxyl / hydroxy OR an alcohol/OH **or** a carboxylic acid/COOH IGNORE 1º, 2º or 3º **(1)** Test **2** (sodium hydrogencarbonate) Contains an alcohol/not a carboxylic acid/not a carboxyl group ALLOW not acid if both groups given in test 1 **(1)** Test **3** (2,4− dinitrophenylhydrazine) Contains a carbonyl/ C=O OR aldehyde or ketone **(1)** Test **4** (Tollens') Does not contain an aldehyde ALLOW Contains a ketone **(1)**	Hydroxide Just alcohol / just carboxylic acid Just aldehyde or just ketone	**(4)**

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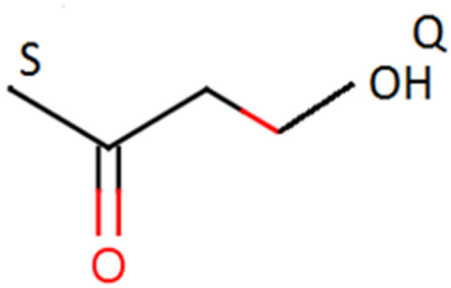
Question Number	Acceptable Answers	Reject	Mark
15(c)(i)	 Correct structure **(1)** Identification of Q **(1)** Identification of S **(1)** ALLOW Structured, displayed or any combination of formulae IGNORE P or R ALLOW M3 for any 2− one and the CH_3 group identified as S ALLOW OH or CH_3 circled to identify Q and S in structural or displayed formulae.		**(3)**

Question Number	Acceptable Answers	Reject	Mark
15(c)(ii)	(nmr) chemical shift values ALLOW ppm values		**(1)**

Question Number	Acceptable Answers	Reject	Mark
15(c)(iii)	Explanation of n+1 rule e.g Hydrogen environment (**P** and/or **R)** have two adjacent hydrogen atoms so are triplets	**P**/**R** have 2 hydrogens	**(1)**

(Total for Question 15 = 13 marks)

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Question Number	Correct Answer	Reject	Mark
16(a)(i)	2 x 95.8 + 6 x 65.3 = 583.4 (J K^{-1} mol^{-1}) **(1)** 2 x 192.3 = 384.6 (J K^{-1} mol^{-1}) **(1)** 384.6 − 583.4 = − 198.8 J K^{-1} mol^{-1} Correct answer sign and units **(1)** TE on wrong entropies used/ IGNORE SF except 1 Correct answer without working scores (3) Incorrect units are only penalised once in (a) and (b)		**(3)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	(Yes) negative value as 4 mol (of gas) go to 2 mol (of gas) IGNORE reference to disorder ALLOW I would expect it to be negative as 4 mol go to 2 mol (but my answer is positive)	If positive value is given in **(a)(i)** no mark can be scored.	**(1)**

Question Number	Correct Answer	Reject	Mark
16(b)(i)	Correct expression for $\Delta S_{surroundings}$ = −(−92.2 x 1000)/400 **(1)** Correct answer, sign and units (+)230.5 J K^{-1} mol^{-1} /(+)0.2305 kJ K^{-1} mol^{-1} **(1)** IGNORE SF except 1 SF Correct answer without working scores **(2)**		**(2)**

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Question Number	Correct Answer	Reject	Mark
16(b)(ii)	−198.8 (J $K^{-1}mol^{-1}$) +230.5 (J $K^{-1}mol^{-1}$) = (+) 31.7 (J $K^{-1}mol^{-1}$) / (+) 0.0317 kJ $K^{-1}mol^{-1}$ ALLOW TE on (a)(i) and (b)(i) **(1)** Positive answer so reaction is feasible **(1)** IGNORE SF except 1 SF ALLOW TE on negative value saying the reaction is not feasible.		**(2)**

(Total for Question 16 = 8 marks)

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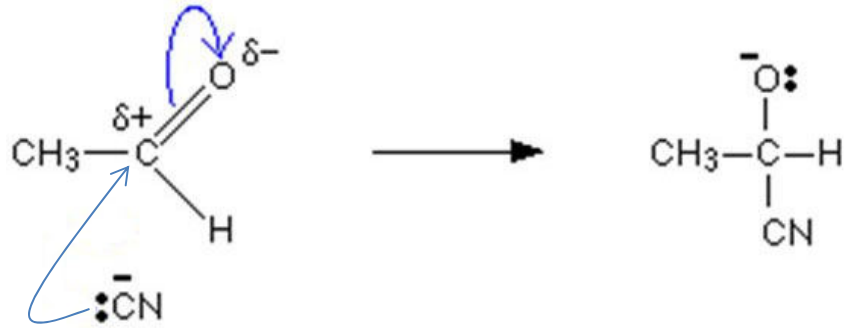
Question Number	Acceptable Answers	Reject	Mark
17(a)	Stage 1  Stage 2  Stage 1 **M1** dipole on C=O **and** charge **and** lone pair on CN^- **(1)** ALLOW The formation of CN^- from HCN **M2** 2 correct curly arrows from **lone pair** on carbon of CN^- to δ+C **and** from C=O bond to O or just beyond **(1)** **M3** Correct intermediate (lone pair not required) **(1)** Stage 2 **M4** Correct curly arrow from lone pair on O^- to H of HCN or to H^+ ALLOW Curly arrow from negative charge or oxygen atom **(1)**		**(4)**

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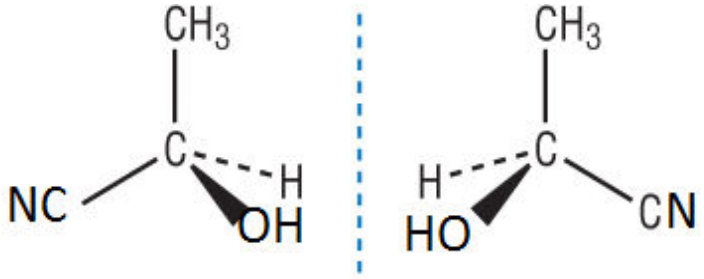
Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	**High concentration of H^+** Insufficient CN^- / decreases $[CN^-]$ (for stage 1) OR will react with CN^- OR $HCN \rightleftharpoons H^+ + CN^-$ **and** eqm shifts to the left **(1)** **Low concentration of H^+** insufficient H^+ for stage 2 **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	 Clear 3D shape **and** Mirror images ALLOW Omission of wedges and dots if 3D shape is clear.		**(1)**

Question Number	Acceptable Answers	Reject	Mark
*17(b)(iii)	Ethanal is planar around the CHO / reaction site / carbonyl / C=O **(1)** CN− can attack on either side / both sides / above and below **and** Giving a 50:50 / equimolar / racemic mixture (so not optically active) **(1)**	Planar molecule intermediate / ion/carbocation/ just planar	**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	(Acid)Hydrolysis ALLOW Alkaline hydrolysis		**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	2−-hydroxypropanoic acid		**(1)**

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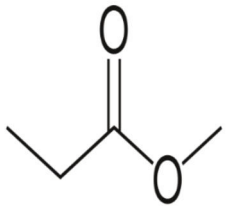
Question Number	Acceptable Answers	Reject	Mark
17(d)	Weak: partially dissociates / ionises OR Doesn't fully dissociate / ionise ALLOW Small dissociation constant IGNORE Dissociates less **(1)** Acid: donates protons/H^+/dissociates to form H^+ **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(e)	Name: methyl propanoate ALLOW methyl propionate **(1)**  **(1)** IGNORE structural/displayed etc		**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(f)(i)	$\underline{[CH_3CH_2COOCH_3]\ [H_2O]}$ $[CH_3CH_2COOH]\ [CH_3OH]$ IGNORE state symbols		**(1)**

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<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>17(f)(ii)</td><td>
<table>
<tr><td></td><td>Propanoic acid</td><td>methanol</td><td>ester</td><td>water</td></tr>
<tr><td>Moles start</td><td>1.0</td><td>1.0</td><td>0</td><td>2.0</td></tr>
<tr><td>Moles eqm</td><td>0.52</td><td>0.52</td><td>0.48</td><td>2.48</td></tr>
<tr><td>(Conc mol dm^{-3} ÷ 0.134)</td><td>(3.88)</td><td>(3.88)</td><td>(3.58)</td><td>(18.51)</td></tr>
</table>

eqm moles row (1)

$K_c = \frac{3.58 \times 18.51}{3.88 \times 3.88}$ or $\frac{0.48 \times 2.48}{0.52 \times 0.52}$ or $\frac{0.48/V \times 2.48/V}{0.52/V \times 0.52/V}$ (1)

= 4.4012 / 4.4024 / 4.4 (1)

No units or appropriate units for their K_c equation
and answer to 2 SF (1)

TE on wrong concentrations

TE on wrong K_c equation

Correct answer without working scores (4)
</td><td></td><td>(4)</td></tr>
</table>

(Total for Question 17 = 20 marks)
(Total for Section B = 52 marks

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SECTION C

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	Sulfur / S (solid / precipitate) is formed IGNORE Just solid / precipitate is formed Reference to colours		**(1)**

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	The rate of reaction = mass of sulfur(formed) ÷ time ALLOW concentration for mass **(1)** The same mass of sulfur is needed to cover the cross in each experiment so rate is proportional to 1/*t* (**1**)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	<table><tr><td>(338)</td><td>2.96×10^{-3}</td><td>(9)</td><td>0.111</td><td>− 2.20/− 2.197</td></tr></table> All 3 correct **(2)** 1 or 2 correct **(1)** Penalise rounding errors once only		**(2)**

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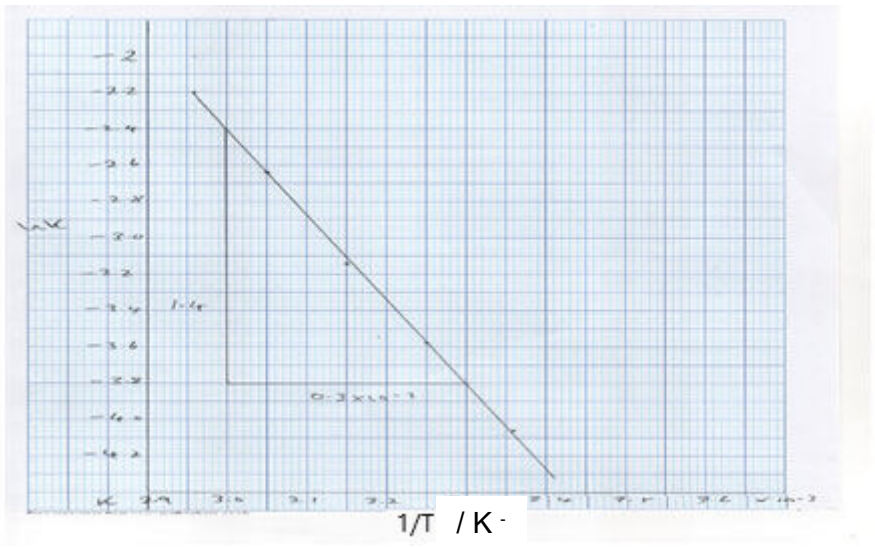
Question Number	Correct Answer	Mark
18(b)(ii)	 Axes labelled with units **and** At least 4x4 big squares used Note 1/*T* axis can be at the top or bottom of the graph paper **(1)** 4/5 points plotted correctly **(1)** straight line of best fit **(1)**	**(3)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(iii)	**Minimum** energy (of collision) needed for a reaction to take place ALLOW Energy required to initiate a reaction/start a reaction	Just energy	**(1)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(iv)	$(-1.4 / 0.3 \times 10^{-3} =)(-)4670$ ALLOW −4170 to −5170 **(1)** Negative sign and units (*K*) **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(v)	$\frac{-E_a}{8.31}$ = gradient = −4670 $E_a = 4670 \times 8.31 = 38807.7$ **(1)** $= (+)39$ kJ mol^{-1} Correct sign and units **(1)** TE on gradient IGNORE SF except 1 SF		**(2)**

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Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	So only the concentration of sodium thiosulfate changes OR only sodium thiosulfate will affect the rate OR HCl concentration (effectively) remains constant OR (the slight change in) HCl concentration will not affect the rate ALLOW The concentration of sodium thiosulfate is the limiting factor IGNORE All the thiosulfate reacts To measure the order with respect to thiosulfate Omission of 'concentration'		(1)

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	First order **(1)** The graph is a straight line (through the origin so rate must be proportional to the concentration) **(1)** M2 dependent on M1		(2)

Question Number	Acceptable Answers	Reject	Mark
18(d)(i)	**Slowest** step (in the reaction mechanism) ALLOW Slow step		(1)

Question Number	Acceptable Answers	Reject	Mark
18(d)(ii)	$HS_2O_3^-$		(1)

(Total for Question 18 = 18 marks)
(Total for Section C = 18 marks)
(Total for Paper = 90 marks)

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