Mark Scheme (Results)

October 2018

Pearson Edexcel International
Advanced Level
In Chemistry (WCH04)
Paper 01 Rates, Equlibria 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 (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	The only correct answer is **C** ***A*** *is not correct because rate constants always have units* ***B*** *is not correct because this shows the units of a first order reaction* ***D*** *is not correct because this shows the units of a second order reaction*		1

Question Number	Correct Answer	Reject	Mark
2	The only correct answer is **B** ***A*** *is not correct because there is no change in the numbers of moles of gas in the reaction* ***C*** *is not correct because the reaction is in aqueous solution* ***D*** *is not correct because the reaction is in aqueous solution*		1

Question Number	Correct Answer	Reject	Mark
3	The only correct answer is **A** ***B*** *is not correct because this is the shape of the graph of [reactant] v time for a first order reaction* ***C*** *is not correct because this shows rate decreasing with increasing [reactant]* ***D*** *is not correct because this is the shape of the graph of [product] v time for a first order reaction*		1

Question Number	Correct Answer	Reject	Mark
4	The only correct answer is **C** ***A*** *is not correct because* ΔS_{system} *is expected to be negative as three moles of gas becomes two moles of gas* ***B*** *is not correct because* ΔS_{system} *is expected to be negative as three moles of gas becomes two moles of gas and* $\Delta S_{surroundings}$ *must be positive as the reaction is exothermic* ***D*** *is not correct because* $\Delta S_{surroundings}$ *must be positive as the reaction is exothermic*		1

Question Number	Correct Answer	Reject	Mark
5	The only correct answer is **B** ***A*** *is not correct because this is irrelevant to the entropy of a substance* ***C*** *is not correct because these are the conditions for the standard enthalpy of formation of an element* ***D*** *is not correct because the molar entropy of a perfect crystal is not zero at the triple point*		1

Question Number	Correct Answer	Reject	Mark
6	The only correct answer is **D** ***A*** *is not correct because all gases mix regardless of their densities* ***B*** *is not correct because these correct values have no bearing on the mixing process* ***C*** *is not correct because the energy change is approximately zero.*		1

Question Number	Correct Answer	Reject	Mark
7	The only correct answer is **C** **A** *is not correct* because $R \ln K = \Delta S_{total}$ **B** *is not correct* because $R \ln K = \Delta S_{total}$ **D** *is not correct* because $R \ln K = \Delta S_{total}$		1

Question Number	Correct Answer	Reject	Mark
8	The only correct answer is **C** ***A** is not correct because water is in the gas state so p($H_2O(g)$) must be included in the K_p expression* ***B** is not correct because the expression is inverted and p($H_2O(g)$) has been omitted* ***D** is not correct because this is the K_p expression for the reverse reaction*		1

Question Number	Correct Answer	Reject	Mark
9	The only correct answer is **D** ***A** is not correct because equilibrium is reached before time t* ***B** is not correct because the concentrations continue to change after time t* ***C** is not correct because the concentrations continue to change after time t*		1

Question Number	Correct Answer	Reject	Mark
10	The only correct answer is **A** ***B** is not correct because water will have the smaller iodine concentration* ***C** is not correct because water will be the upper layer* ***D** is not correct because water will be the upper layer and have the smaller iodine concentration*		1

Question Number	Correct Answer	Reject	Mark
11	The only correct answer is **A** ***B** is not correct because NH_2^- is a base* ***C** is not correct because NH_2^- is a base* ***D** is not correct because NH_3 is an acid also*		1

Question Number	Correct Answer	Reject	Mark
12	The only correct answer is **B** ***A** is not correct because the pH is 7.1* ***C** is not correct because water is not alkaline* ***D** is not correct because water is not alkaline.* *$7.2 = \log(6.4 \times 10^{-15}) - 7.0$*		1

Question Number	Correct Answer	Reject	Mark
13	The only correct answer is **B** ***A** is not correct because the degree of dissociation increases with dilution* ***C** is not correct because the solution becomes less acidic and the degree of dissociation increases with dilution* ***D** is not correct because the solution becomes less* acidic with dilution		1

Question Number	Correct Answer	Reject	Mark
14	The only correct answer is **B** **A** is not correct because $13.0 = pK_w + \log_{10}[Ba(OH)_2]$ **C** is not correct because $13.8 = pK_w - 2x[Ba(OH)_2]$ **D** is not correct because $13.9 = pK_w - [Ba(OH)_2]$		1

Question Number	Correct Answer	Reject	Mark
15	The only correct answer is **A** ***B** is not correct because pure propanone does not form hydrogen bonds* ***C** is not correct because while propanone forms stronger London forces than butane this is insufficient to account for the difference* ***D** is not correct because although this is correct it does not account for the difference*		1

Question Number	Correct Answer	Reject	Mark
16	The only correct answer is **B** ***A** is not correct as copper is not formed with ethanal* ***C** is not correct as copper is not formed with ethanal and the ethanal is oxidised not reduced* ***D** is not correct as the ethanal is oxidised not reduced*		1

Question Number	Correct Answer	Reject	Mark
17	The only correct answer is **D** ***A** is not correct because this would form ethanol* ***B** is not correct because this would form ethanol* ***C** is not correct because this would form ethanoic acid*		1

Question Number	Correct Answer	Reject	Mark
18	The only correct answer is **D** ***A** is not correct because propyl methanoate forms methanoic acid and ethanenitrile forms ethanoic acid* ***B** is not correct because propyl methanoate forms methanoic acid* ***C** is not correct because ethanenitrile forms ethanoic acid*		1

Question Number	Correct Answer	Reject	Mark
19	The only correct answer is **A** ***B** is not correct because this is not formed* ***C** is not correct because this is not formed* ***D** is not correct because this is not formed*		1

Question Number	Correct Answer	Reject	Mark
20	The only correct answer is **C** ***A*** *is not correct because radio waves have insufficient energy to initiate reactions* ***B*** *is not correct because radio waves have insufficient energy to initiate reactions* ***D*** *is not correct because ultraviolet radiation does initiate organic reactions*		1

(Total for Section A = 20 marks)

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)	(entropy change) will be positive OR $\Delta S_{system} > 0$ **and** because (3 mol of) a gas is formed (from a solid) ALLOW (for second point) because 5 mol of product from 2 mol reactant OR because mol of product > mol reactant OR 2 mol goes to 5 mol IGNORE disorder is increasing Reference to ΔS_{surr} / ΔS_{total} / ΔH	Use of atoms or molecules for moles	1

Question Number	Acceptable Answers	Reject	Mark
21(b)	Penalise 1 SF once in (b), (c), (d) $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$ S^{o}_{298} / J K^{-1} mol^{-1} : ($NaN_3(s)$ = 70.5) Na(s) = 51.2 $\frac{1}{2}N_2(g)$ = 95.8 (1) ΔS_{system} = 2 x 51.2 + 6 x 95.8 − 2 x 70.5 (1) = 102.4 + 574.8 − 141 = (+)536.2 **J K^{-1} mol^{-1}** (1) IGNORE SF except 1 SF Correct answer with **units** scores (3) TE on incorrect values Using 3 x 95.8 gives +248.8 **J K^{-1} mol^{-1}** scores (2) Using $\frac{1}{2}N_2(g)$ = 0 gives −38.6 **J K^{-1} mol^{-1}** this scores (2) only if factor x6 used	Incorrect sign from expression	3

Question Number	Acceptable Answers	Reject	Mark
21(c)	$\Delta S_{surroundings} = \frac{-\Delta H_{reaction}}{T}$ = −(−42600)/298 (1) = (+)142.953 / 143 (J K^{-1} mol^{-1}) (1) OR = −(−42.6)/298 (1) = (+)0.142953(J K^{-1} mol^{-1}) / (+)0.143 **kJ K^{-1} mol^{-1}** (1) Doubling the value (giving (+)285.906 (J K^{-1} mol^{-1}) / (+)0.285906 **kJ K^{-1} mol^{-1}** scores (1) unless already penalised in (b) −0.142953 / 0.143 **kJ K^{-1} mol^{-1}** scores (1) IGNORE SF except 1 SF Correct answer (with units if 0.142953) scores (2)	incorrect units incorrect units	2

Question Number	Acceptable Answers	Reject	Mark
21(d)	$\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$ = 536.2 + 142.953 (1) = (+)679.153(J K^{-1} mol^{-1}) (1) OR = 0.5362 + 0.142953 (1) = (+)0.679153 kJ K^{-1} mol^{-1} (1) No TE on incorrect expression IGNORE SF except 1 SF Correct answer scores (2) TE on (b) and (c) unless final value is negative when max 1 mark Value with $\Delta S_{surroundings}$ doubled = (+)822.106 (J K^{-1} mol^{-1}) / (+)0.822106 (kJ K^{-1} mol^{-1}) scores (2) Value from ΔS_{system} = +248.8 **J K^{-1} mol^{-1} is** **391.75** (J K^{-1} mol^{-1}) **/ 0.39175** (kJ K^{-1} mol^{-1})		2

Question Number	Acceptable Answers	Reject	Mark
21(e)	The (molar) entropy of a substance (always) increases / becomes more positive with (increasing) temperature ALLOW The (molar) entropy of a gas increases the most with (increasing) temperature (1) There are more moles of product than of reactant OR 3 mol of gas are formed (from a solid) OR Na changes from solid to liquid (1) so ΔS_{system} must increase (1) MP3 dependent on **MP1** being scored If no other mark is scored, 'ΔS_{system} increases because increasing temperature increases the disorder of the system / reaction' scores (1) IGNORE Explanations based on K_c or Le Chatelier OR Based on the change in $\Delta S_{surroundings}$ with temperature		3

(Total for Question 21 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	**MP1** Explanation of K_{a1} values $K_{a1} \gg K_{a2}$ or $pK_{a1} \ll pK_{a2}$ so first ionisation / dissociation is much greater than second ionisation / dissociation ALLOW pK_{a2} larger (than pK_{a1}) **and** so K_{a2} smaller (than K_{a1}) OR As pK_a increases acid strength decreases (1) **MP2** Effect of first dissociation (relatively) high $[H^+]$ suppresses second / further ionisation / dissociation ALLOW First ionisation suppresses / weakens second ionisation OR Ionising / dissociating / removing a proton from a negative ion requires more energy / is more difficult (1) IGNORE Reference to 'weak acid' Reference to H-bonding Reference to third ionisation / dissociation	Reference to ionisation energy Alcohol OH ionises	2

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	$H_3A \rightleftharpoons H^+ + H_2A^-$ OR $H_3A + H_2O \rightleftharpoons H_3O^+ + H_2A^-$ ALLOW Single headed arrow or '=' for $\rightleftharpoons$ IGNORE State symbols even if incorrect K_a expression		1

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	$K_{a1} = [H^+][H_2A^-] / [H_3A]$ (1) $= [H^+]^2 / [H_3A]$ $10^{-3.13} = (10^{-1.98})^2 / [H_3A]$ (1) $[H_3A] = (10^{-1.98})^2 / 10^{-3.13}$ $= 0.14791$ $= 0.148 / 0.15$ (mol dm^{-3}) (1) IGNORE SF except 1 SF Correct answer with some correct working scores (3) $[H_3A] = 0.1487 / 0.149$ (mol dm^{-3}) (from rounding 0.01047 to 0.0105) scores (3) $[H_3A] = 0.135 / 0.14$ (from rounding 0.01047 to 0.01) scores (2) $[H_3A] = 3.503 \times 10-5 / 0.0003503$ (mol dm^{-3}) from $K_{a1} = 3.13$ scores (2) If no other mark is scored allow (1) for $[H^+] = 10^{-1.98}$ $= 0.010471 / 0.0105 / 0.010$ (mol dm^{-3})	0.01 (mol dm^{-3})	3

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	The pulp could block (the tip of) the pipette OR The pipetted volume might be too **low**	Pulp causes side reactions / reacts with NaOH Just 'causes blockages'	1

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	Phenolphthalein OR Thymol blue (base) / 8.0−9.6 OR Thymolphthalein ALLOW Phenol red (1) Indicator range should cover roughly the mid-point of 6.4 (=pK_{a3} = pH of second buffer region) and 13 (pH of NaOH) OR Indicator range mid-point needs to be about 2 units above 6.4 ALLOW Indicator range needs to be from 6.5—8.0 to 10—13 (1) IGNORE Weak acid-strong base titration General statements about the vertical section of the titration curve Statement of selected indicator's range	Just 'thymol blue'	2

Question Number	Acceptable Answers	Reject	Mark
22(b)(iii)	**MP1** Calculates moles NaOH = 0.095 x 19.65 x 10^{-3} = 1.86675 x 10^{-3} / 0.00186675 (mol) (1) **MP2** Calculates moles citric acid = mol NaOH ÷ 3 = 6.2225 x 10^{-4} /0.00062225 (mol) (1) **MP3** Scales mol citric acid to 250 cm^3 (x 10) **and** scales **original** volume of lemon juice to 1 dm^3 (x 1000/25) = answer to **MP2** x 10 x 40 = 0.2489 mol dm^{-3} (1) **MP4** Calculates molar mass of citric acid molar mass (citric acid) = 6 x 12 + 8 + 7 x16 = 192 (1) **MP5** Calculates concentration of citric acid = molar mass of citric acid x answer to **MP3** **=** 192 x 0.2489 = 47.7888 (g dm^{-3}) (1) IGNORE SF except 1 SF TE at each stage Correct answer with no working scores (5) 143.37 (g dm^{-3}) [**MP2** incorrect] scores 4 **COMMENT** ALLOW **MP5** for multiplying the calculated M_r by **MP2** OR **MP2** x 10 or **MP2** x 40 Note that all the scaling is in **MP3**	Just a number x M_r	5

Question Number	Acceptable Answers	Reject	Mark
22(b)(iv)	The citric acid content / amount / concentration varies for different lemons	Reference to errors and uncertainties in the procedure.	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	A buffer resists change in pH OR Maintains a **fairly / nearly** constant pH ALLOW 'large / small change' for 'change' 'withstands change in pH' (1) on the addition of **small** amounts of acid **and / or** of alkali ALLOW Base / OH^- for alkali and H^+ for acid (1)	Keeps pH constant pH remains the same prevents change in pH	2

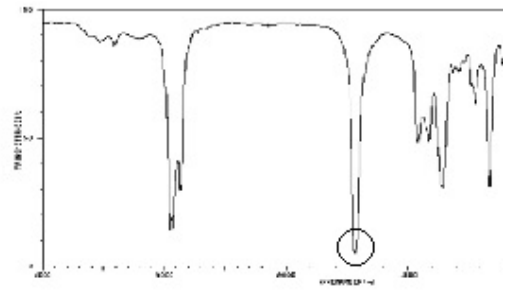
Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	3.13 OR pH = 3.13 OR pH = pK_{a1} = 3.13	pK_{a1} = 3.13	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	Allow use of $C_6H_7O_7Na$ for $C_6H_7O_7^-$ throughout **MP1** Citric acid / $C_6H_8O_7$ and dihydrogen citrate / $C_6H_7O_7^-$ are present in high concentration (and so their values do not change significantly when small amounts of acid or alkali are added) ALLOW 'large amount' / '(large) excess' for high concentration (Large) reservoir of $C_6H_8O_7$ and $C_6H_7O_7^-$ OR reservoir of $C_6H_8O_7$ and its conjugate base (1) **MP2** When acid is added the $C_6H_7O_7^-$ is protonated / reacts, removing the H^+ ion from the solution ALLOW $C_6H_7O_7^- + H^+ \rightarrow C_6H_8O_7$ (1) **MP3** When alkali is added the $C_6H_8O_7$ is deprotonated / reacts, removing the OH^- ion from the solution ALLOW $C_6H_8O_7 + OH^- \rightarrow C_6H_7O_7^- + H_2O$ (1) **MP2** and **MP3** may be scored by **referring** to the equilibrium $C_6H_7O_7^- + H^+ \rightleftharpoons C_6H_8O_7$ Use of HA and A^- or general 'weak acid and salt' scores **MP2** and **MP3** only IGNORE Reference to ratio of $C_6H_8O_7$ and $C_6H_7O_7^-$ concentrations		3

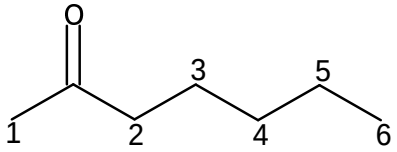
(Total for Question 22 = 21 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)	Brady's reagent OR 2,4-dinitrophenylhydrazine ALLOW 2,4-DNPH / 2,4-DNP / DNPH (1) Red /orange / yellow **and** precipitate (forms in both cases) ALLOW ppt / ppte / solid / crystals for precipitate (1) Observation mark depends on correct reagent or near miss (e.g. DNHP)	 Incorrect abbreviation e.g. DNHP / DPNH solution	2

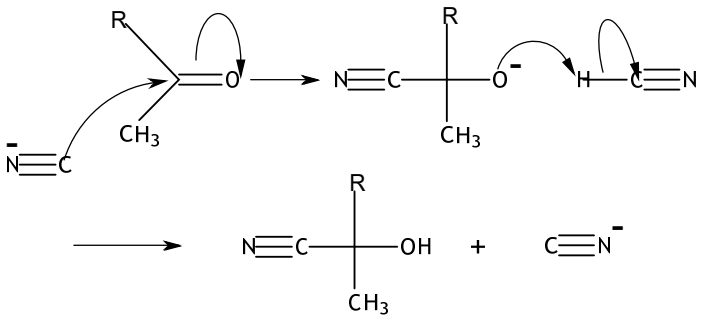
Question Number	Acceptable Answers	Reject	Mark
23(b)	(Warm with) iodine and sodium hydroxide OR (Warm with) potassium iodide and sodium chlorate(I) ALLOW iodine in alkali / I_2 and OH^- (1) With heptan-2-one Antiseptic smell observed OR (Pale) yellow crystals form ALLOW precipitate / ppt / ppte / solid / suspension for crystals (1) With heptan-3-one No (observed) change ALLOW no reaction / observation / negative result (1) No TE on any other test but if 'iodoform test' stated, MP2 and MP3 may be awarded. IGNORE Physical tests including on derivatives	 Just 'smell' Brown solution	3

Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	 Carbonyl peak circled ALLOW Any means of selecting this peak (1) Carbonyl group / C=O (responsible) (1) These marks are standalone	Just 1700−1680 (cm^{-1})	2

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	Yes because the IR spectra of the isomers would have different fingerprint regions. OR Yes by comparing the spectrum to reference spectra. ALLOW No because they have the same functional group / bonds OR Both are ketones IGNORE Just 'spectra would be different' OR 'Spectra have different peaks'		1

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)			1

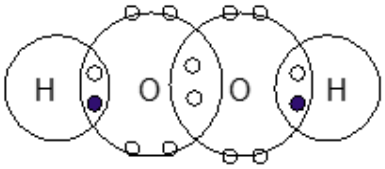
Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	<table><tr><th>Proton environment</th><th>Relative peak area</th><th>Splitting pattern</th></tr><tr><td>1</td><td>3</td><td>singlet</td></tr><tr><td>2</td><td>2</td><td>triplet</td></tr><tr><td>3</td><td>2</td><td>quintet</td></tr><tr><td>4</td><td>2</td><td>quintet</td></tr><tr><td>5</td><td>2</td><td>sextet</td></tr><tr><td>6</td><td>3</td><td>triplet</td></tr></table> All relative peak areas correct (1) IGNORE Any peak area for the carbonyl carbon All splitting patterns correct (2) Four or five splitting patterns correct scores (1) If the carbonyl carbon has been labelled as a proton environment, correct splitting pattern for 3, 4, 5 and 6 scores (1) ALLOW Use of non-standard terms for splitting e.g. 1 for singlet etc '3 splits', 'pentate' / 'pentet' / 'pentlet'		3

Question Number	Acceptable Answers	Reject	Mark
23(e)(i)	 All four curly arrows correct ALLOW curly arrow from any part of CN^- including from the charge (2) Intermediate (1) Both final products (1) Mechanism with curly arrow from intermediate to H^+ and formation of cyanohydrin only scores (3) Any two or three correct curly arrows scores 1 Curly arrows must start and finish reasonably close to the relevant atoms / bonds If the nucleophilic attack is in two stages (via $^+C—O^-$) do not award the intermediate mark (max 3) Dipoles are not required but if shown must be correct CN bond does not need to be displayed Lone pairs are not required Penalise omission of charges once only	CN^- charge omitted	4

Question Number	Acceptable Answers	Reject	Mark
23(e)(ii)	A racemic mixture is formed (1) heptan-2-one is planar **and** about the carbonyl carbon ALLOW Bonds about C=O (trigonal) planar OR carbonyl carbon is (trigonal) planar (1) So the CN^- attacks equally from above and below / either side of the molecule ALLOW Nucleophile / CN for CN^- (1)	 ion / molecule is planar	3

(Total for Question 23 = 19 marks)
(Total for Section B = 51 marks)

Section C

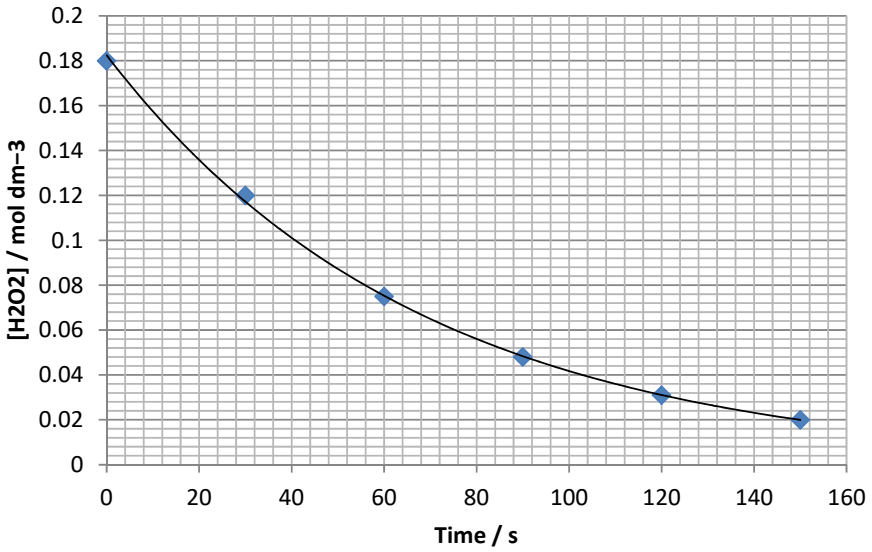
Question Number	Acceptable Answers	Reject	Mark
24(a)	 ALLOW Any representation of the electrons, (including all electrons the same) Bond electrons horizontal (H xo O) IGNORE Bonds shown as lines Position of lone pairs H−O−O−H Omission of circles		1

Question Number	Acceptable Answers	Reject	Mark
24(b)	Any two from: Hydrogen peroxide has a bigger dipole (moment than water) / larger dipole-dipole forces ALLOW Hydrogen peroxide is more polar (than water) (1) Hydrogen peroxide has greater London / dispersion forces (than water) ALLOW van der Waals / vdW / induced dipole-induced dipole forces (1) Hydrogen peroxide forms a higher proportion of hydrogen bonds in its liquid state (than water) ALLOW Hydrogen peroxide forms more hydrogen bonds in its liquid state (than water) OR Hydrogen peroxide forms stronger hydrogen bonds (than water) (1) For more hydrogen bonds allow specified numbers e.g. hydrogen peroxide forms 2 but water forms 1 The comparisons are required		2

Question Number	Acceptable Answers	Reject	Mark
24(c)	The oxygen- oxygen /O—O /peroxide (single) bond is weak ALLOW O=O is strong so the products are thermodynamically more stable IGNORE Entropy arguments	Just 'weak bonds'	1

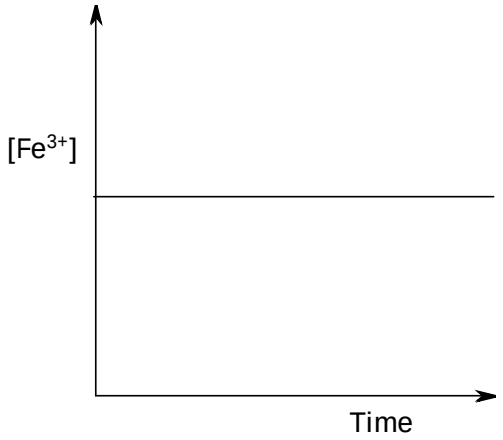
Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	Add sample to (ice-cold) water ALLOW Dilute sample in water	Addition of any chemical apart from H_2O Place in ice-bath	1

Question Number	Acceptable Answer	Reject	Mark
24(d)(ii)	See below for example Sensible choice scale (to cover at least half the grid in both directions) **and** labelled axes with units on both axes ALLOW [] for $[H_2O_2]$ (1) All points given in table correctly plotted Dependent on linear axes used (1) Any sensible reasonably smooth best fit curve reasonably close to the points (1)	Non-linear scale scores (0) point to point	3



Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	$t_{½}(1)$ = 47 s $t_{½}(2)$ = 47 s ALLOW 44-50 s Values may be shown on the graph No TE on a badly drawn line	no working shown	1

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	Because both values are the same / similar the reaction is first order (with respect to hydrogen peroxide) This mark may only be awarded if half lives in 24(d)(iii) are the same (within 6 seconds of each other) OR half lives are given as (e.g.) 47 and 94 s Allow this mark if only 1 correct half life is given in 24d(iii) but 2 structure lines are shown on the graph	Just 'first order'	1

Question Number	Acceptable Answers	Reject	Mark
24(d)(v)	 Any line parallel to the x axis		1

Question Number	Acceptable Answers	Reject	Mark
24(e)(i)	First order / order 1 **and** (e.g.) Because doubling / halving $[Fe^{3+}]$ results in a doubling / halving of the rate OR Because tripling $[Fe^{3+}]$ results in a tripling of the rate		1

Question Number	Acceptable Answers	Reject	Mark
24(e)(ii)	Rate / R = $k[H_2O_2][Fe^{3+}]$ TE on (d)(iv and (e)(i) Score (0) if these are blank		1

Question Number	Acceptable Answers	Reject	Mark
24(f)(i)	(e.g. from graph) $\frac{1000 \times (6.98 - 5.86)}{-(3.55 - 3.15)} = -\frac{1.12}{0.40}$ x 1000 (1) $= -2.80 \times 10^3$ (K) ALLOW -2.70×10^3 to -2.90×10^3 Answer as a fraction (1) -2.80×10^{-3} (K) / −2.80 (K) (or values within the 2.70 - 2.90 range) score (1) Coefficient with correct sign and no units or correct units scores (1) Correct magnitude scores (1)	positive value Incorrect units	2

Question Number	Acceptable Answers	Reject	Mark
24(f)(ii)	gradient = $-E_a/R$ $-2.80 \times 10^3 = -E_a/8.31$ (1) E_a = +23268 J mol^{-1} / +23.268 kJ mol^{-1} ALLOW 22.4 to 24.1 kJ mol^{-1} (2) Value with sign (1) units (1) Units must be correct for the calculation done IGNORE SF except 1 SF TE on (f)(i) for value and sign If the answer to (f)(i) is positive then E_a has to be negative (even though this is chemically incorrect) If 'kilo' prefix used even in an incorrect unit 8.31 x gradient must be divided by 1000 otherwise the value from (f)(i) x 8.31 scores the mark		3

Question Number	Acceptable Answers	Reject	Mark
24(g)	Hydrogen peroxide decomposes to form (only) water / H_2O **and** oxygen / O_2 (which are environmentally harmless) IGNORE Forms harmless products		1

(Total for Question 24 = 19 marks)
(Total for Section C = 19 marks)
(Total for Paper = 90 marks)

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