Mark Scheme (Results)

October 2017

Pearson Edexcel International
Advanced Level In Chemistry (WCH04)
Paper 1 Rates, Equilibria and Further

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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.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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	Mark
1(a)	**1(a). The only correct answer is D** **A** *is not correct because there are equal numbers of moles of gas on each side so volume is unchanged in the reaction* **B** *is not correct because there are equal numbers of moles of gas on each side so pressure is unchanged in the reaction* **C** *is not correct because although HBr is acidic, in the absence of water pH will not change*	**(1)**

Question Number	Correct Answer	Mark
1(b)	**1(b). The only correct answer is D** **A** *is not correct because the rate law for a reaction cannot be deduced from its chemical equation* **B** *is not correct because the rate law for a reaction cannot be deduced from its chemical equation* **C** *is not correct because the rate law for a reaction cannot be deduced from its chemical equation*	**(1)**

Question Number	Correct Answer	Mark
2	**2. The only correct answer is B** **A** *is not correct because this is the graph for a zero order reaction* **C** *is not correct because concentration is increasing so this cannot be correct (shows zero order for product concentration)* **D** *is not correct because concentration is increasing so this cannot be correct (shows first order for product concentration)*	**(1)**

Question Number	Correct Answer	Mark
3	**3. The only correct answer is B** **A** *is not correct because the formula shows that half life is proportional to initial concentration so cannot increase as reactant is consumed* **C** *is not correct because the formula shows that half life is proportional to initial concentration so cannot remain constant* **D** *is not correct because the formula shows that half life is proportional to initial concentration so cannot remain constant*	**(1)**

Question Number	Correct Answer	Mark
4	**4. The only correct answer is C** **A** *is not correct because activation energy is a kinetic factor and has no bearing on thermodynamic feasibility* **B** *is not correct because* $\Delta S_{surroundings}$ *is negative for endothermic reactions* **D** *is not correct because if a reaction is thermodynamically feasible,* ΔS_{total} *must be positive*	**(1)**

Question Number	Correct Answer	Mark
5	**5. The only correct answer is A** **B** *is not correct because this is probably true but is not the best explanation* **C** *is not correct because this is a true statement but does not explain the decomposition at high temperature* **D** *is not correct because this is a true statement but does not explain the decomposition at high temperature*	**(1)**

Question Number	Correct Answer	Mark
6	**6. The only correct answer is A** **B** *is not correct because this is the reverse of the correct answer* **C** *is not correct because this is true but not relevant* **D** *is not correct because this is true but not relevant*	**(1)**

Question Number	Correct Answer	Mark
7	**7. The only correct answer is B** **A** *is not correct because there are more moles of gas on the RHS so the reverse statement is correct* **C** *is not correct because reactions do not zig-zag in this way when the pressure is changed* **D** *is not correct because this zig-zagging of reactions is a common misconception*	**(1)**

Question Number	Correct Answer	Mark
8	**8. The only correct answer is C** **A** *is not correct because this omits the p*(H2O(g)) **B** *is not correct because this is the reciprocal of response A* **D** *is not correct because this is the reciprocal of the correct response*	**(1)**

Question Number	Correct Answer	Mark
9(a)	**9(a). The only correct answer is A** **B** *is not correct because this shows the units the same for both equations* **C** *is not correct because this is derived from the reciprocals of the two equilibrium constant expressions* **D** *is not correct because this shows the units the same for both equations but using the reciprocal of the values in B*	**(1)**

Question Number	Correct Answer	Mark
9(b)	**9(c). The only correct answer is B** **A** *is not correct because it is an exothermic reaction so rate is increased and yield decreased when temperature increases* **C** *is not correct because it is an exothermic reaction so rate is increased and yield decreased when temperature increases* **D** *is not correct because it is an exothermic reaction so rate is increased and yield decreased when temperature increases*	**(1)**

Question Number	Correct Answer	Mark
10	**10. The only correct answer is D** **A** *is not correct because equilibrium constants are unaffected by pressure* **B** *is not correct because equilibrium constants only increase with temperature when the reactions are endothermic* **C** *is not correct because the effect of temperature on K only depends on* ΔS_{total}	**(1)**

Question Number	Correct Answer	Mark
11	**11. The only correct answer is B** **A** *is not correct because* HNO_3 *is a base in this system* **C** *is not correct because* HNO_3 *is a base in this system* **D** *is not correct because both of these species are bases in this system*	**(1)**

Question Number	Correct Answer	Mark
12	**12.The only correct answer is C** **A** *is not correct because the proportion of weak acid molecules dissociating increases with dilution* **B** *is not correct because the proportion of weak acid molecules dissociating increases with dilution* **D** *is not correct because the* pH *increases as the concentration of protons decreases*	**(1)**

Question Number	Correct Answer	Mark
13	**13. The only correct answer is D** **A** *is not correct because the buffers have the same ratio of acid to conjugate base so the same* pH **B** *is not correct because the buffers have the same ratio of acid to conjugate base so the same* pH **C** *is not correct because the more concentrated buffer will have the greater resistance to* pH *change*	**(1)**

Question Number	Correct Answer	Mark
14(a)	**14(a). The only correct answer is C** **A** *is not correct because* P *has five proton environments* **B** *is not correct because* Q *has four proton environments* **D** *is not correct because* S *has four proton environments*	**(1)**

Question Number	Correct Answer	Mark
14(b)	**14(b). The only correct answer is B** **A** *is not correct because* P *cannot be reduced* **C** *is not correct because* R *cannot be oxidised* **D** *is not correct because* S *cannot be oxidised*	**(1)**

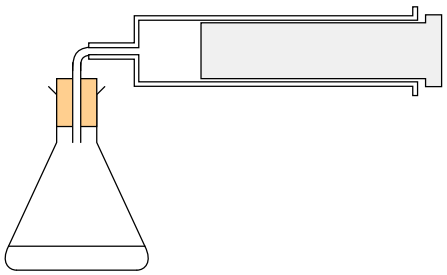
Question Number	Correct Answer	Mark
14(c)	**14(c). The only correct answer is C** **A** *is not correct because there is no reaction* **B** *is not correct because there is no reaction* **D** *is not correct because there is no reaction*	**(1)**

Question Number	Correct Answer	Mark
15	**15. The only correct answer is A** **B** *is not correct because this is inefficient in terms of energy consumption* **C** *is not correct because this is inefficient in terms of energy consumption* **D** *is not correct because this is inefficient in terms of energy consumption*	**(1)**

Question Number	Correct Answer	Mark
16	**16. The only correct answer is B** **A** *is not correct because* MRI *uses radio waves (it is based on* nmr*)* **C** *is not correct because* MRI *uses radio waves (it is based on* nmr*)* **D** *is not correct because* MRI *uses radio waves (it is based on* nmr*)*	**(1)**

Section B

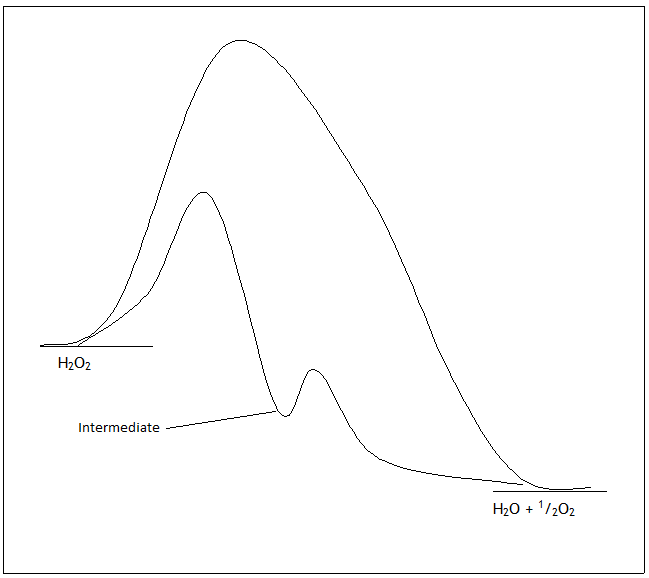
Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	Rate = $k[H_2O_2]$ ALLOW r/R	Round brackets	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	**Method 1**  Any gas-tight container **and** delivery tube (1) IGNORE Lack of liquid in conical flask Syringe Do not penalise gaps around the plunger ALLOW Collection over water with a **graduated** receiver **(1)** Measure volume (of oxygen/gas) **and** at various times ALLOW Regular intervals for time **(1)** **Method 2** ALLOW Diagram of conical flask on balance **(1)** Plug of cotton wool (to prevent loss of spray) **(1)** Measure mass and time(s) **(1)**	Delivery tube below the surface of the liquid Any form of heating except a water bath at constant temperature syringe without separate plunger time	**(3)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	<table><tr><th>$[H_2O_2(aq)]$ / mol dm^{-3}</th><th>Time / s</th></tr><tr><td>2.00</td><td>(0.0)</td></tr><tr><td>1.50</td><td>X</td></tr><tr><td>1.00</td><td>280</td></tr><tr><td>0.75</td><td>X</td></tr><tr><td>0.50</td><td>(560)</td></tr><tr><td>0.25</td><td>840</td></tr></table> 280/840 **(1)** Remaining three correct **(1)** ALLOW For 1.50 and 0.75 allow correctly calculated values at 0.75 mol dm^{-3}, t = X + 280		**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	**MP1** Plot a graph of concentration against time **(1)** **MP2** Draw a tangent at the required concentration and measure its gradient ALLOW Measure the gradient at the required concentration **(1)** MP2 depends on MP1	Just 'measure the gradient'	**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	(k = Rate / $[H_2O_2]$) = $1.9 \times 10^{-3} / 0.75$ **(1)** = $2.53 \times 10^{-3} / 0.00253\ s^{-1}$ **(1)** IGNORE SF except 1 SF Correct answer with units but no working scores (2) TE on incorrect rate equation if this is of the form Rate = $k[H_2O_2]^n$		**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(c)	 Left-hand /right-hand / only peak **lower** than original **(1)** Two peaks with trough above or below the level of reactant ALLOW Any representation of the intermediate point **(1)** IGNORE Omission of labels		**(2)**

(Total for Question 17 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)	$K_p = \frac{P^2(SO_3)}{P^2(SO_2) \times p(O_2)}$ OR Using subscripts for substances P^2_x OR $p(X)^2$ OR $(pX)^2$	square brackets	**(1)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)		Incorrect units	**(3)**

	SO_2	O_2	SO_3	
mol	0.500	0.100	0.750	
mole fraction (X)	0.5/1.35 = 0.3704	0.1/1.35 = 0.07407	0.75/1.35 = 0.556	**(1)**
Partial pressure = 2 x X	= 2 x 0.3704 = 0.741	2 x 0.07407 = 0.148	2 x 0.556 = 1.111	**(1)**

'Notional K_p'
$= 1.111^2 / (0.741^2 \times 0.148) = 15.2\ (atm^{-1})$

ALLOW

'Notional K_p'
$= 1.11^2 / (0.74^2 \times 0.15) = 15.0 = 15\ (atm^{-1})$ **(1)**

(as $\neq K_p$ / 2.50×10^{10} system is not at equilibrium)

TE on 18(a)

TE at each stage

IGNORE SF except 1 SF

Correct answer with no working scores (3)

Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	15.2 (atm^{-1}) << 2.50 x 10^{10} (atm^{-1})/K_p **and** So equilibrium moves to the right **(1)** Comment Mark may be awarded if this statement appears in 18(b)(i) So the value of the equilibrium **expression/quotient** has to increase (by increasing numerator and / or decreasing denominator therefore more SO_3 and / or less SO_2 and O_2) **(1)** IGNORE References to Le Chatelier's Principle References to temperature		**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(iii)	Ignore references to Le Chatelier's Principle and ΔS_{system} unless incorrect Accept reverse arguments The marks are stand alone **MP1** ($\Delta S_{surroundings}$ is positive because the reaction is exothermic) $\Delta S_{surroundings}$ increases as T decreases **and** because $\Delta S_{surroundings} = -\Delta H/T$ OR $\Delta S_{surroundings}$ becomes more positive as T decreases **and** because $\Delta S_{surroundings} = -\Delta H/T$ OR $\Delta S_{surroundings} = -\Delta H/T$ $\Delta S_{surroundings}$ (500) = 196000/(500+273) = 254 J K^{-1} mol^{-1} $\Delta S_{surroundings}$ (450) = 196000/(450+273) = 271 J K^{-1} mol^{-1} ALLOW $\Delta S_{surroundings}$ becomes more positive as temperature decreases **and** because the reaction is exothermic **(1)** **MP2** {As $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$} ΔS_{total} increases/ becomes more positive as temperature decreases **and** the reaction becomes more favourable **(1)** IGNORE So K increases (as $\Delta S_{total} = R\ln K$) References to the effect of temperature on ΔS_{system}	Becomes less negative Becomes less negative Just ΔS_{total} is positive	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(c)	Any two from: Building /operating / maintaining high pressure industrial plant is very expensive ALLOW Requires (more) energy **(1)** Equilibrium conversion to SO_3 must be very large (as *K* is so big) **(1)** Overall yield can be increased (more cheaply) by recycling unreacted SO_2 & O_2 (1) IGNORE References to the occupation of active sites on the catalyst Risk of explosion	just 'cost'	2

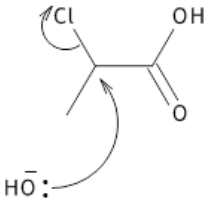
(Total for Question 18 = 10 marks)

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	Potassium dichromate ((VI)) OR Sodium dichromate ((VI)) ALLOW Potassium manganate(VII) / permanganate **(1)** IGNORE $K_2Cr_2O_7$ / $Na_2Cr_2O_7$ / $KMnO_4$ sulfuric acid / H_2SO_4 **and** (heat under)reflux ALLOW Acid / acidified / H^+ / H_3O^+ for sulfuric acid / H_2SO_4 **(1)** MP2 depends on the name or formula of an oxidising agent IGNORE Concentration of acid	Hydrochloric acid	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	(Free) radical **(1)** substitution **(1)** IGNORE Chain reaction / S_N1 / S_N2 / homolytic / heterolytic	Displacement	**(2)**

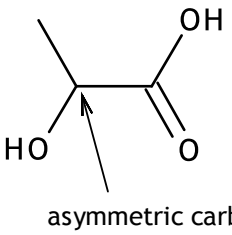
Question Number	Acceptable Answers	Reject	Mark
19(a)(iii)	Chlorine can substitute on C_3 OR 3-chloropropanoic acid formed OR Further (chlorine) substitution is possible OR Structure of possible product IGNORE Activation energy too high Reaction does not go to completion	Just 'other products formed' Propanoyl chloride formed	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(a)(iv)	Sulfuric acid / H_2SO_4 OR Any strong acid by name or formula **(1)** IGNORE Concentration of acid H^+ / H_3O^+ / Just 'acid' To convert the sodium salt to lactic acid OR Protonate the carboxylate ion / COO^- (formed after the reaction with NaOH) ALLOW React with carboxylate **(1)** IGNORE Reactions of acid with sodium hydroxide/ OH^- ions	Just 'to form lactic acid'	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	Accept skeletal, displayed or semi displayed structure Penalise incorrect position of the chlorine atom and incorrect carbon chain in the final mark  Curly arrow from C—Cl bond to Cl or just beyond it ALLOW Curly arrow on transition state **(1)** Curly arrow from **lone pair** of O on OH^- to carbon atom ALLOW Arrow starting nearer the lone pair than the oxygen **(1)**  Transition state including partial bonds **and** charge ALLOW Charge on any part of the intermediate Any geometry for intermediate **(1)**  Final organic product **and** chloride ion ALLOW NaCl as product **(1)** IGNORE Lone pairs on the chlorine and dipoles on C-Cl Penalise omission of negative charge on OH^- and Cl^- once ALLOW carboxylate ion (COO^-) throughout the mechanism. S_N1 can score MP1, MP2 and MP4 (max 3)	OH Other products such as OH^-	**(4)**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	S_N1 Rate = k[RCl] **(1)** S_N2 Rate = k[RCl][OH^-]/ k[RCl][NaOH] **(1)** Correct expressions but the wrong way round scores (1) Slow / rate-determining step in S_N1 involves just RCl **and** Slow step in S_N2 involves RCl and OH^- OR **and** Only one step in S_N2 which involves both RCl and OH^- ALLOW In the RDS S_N1 involves one reactant and S_N2 involves two reactants NaOH/ alkali for OH^- Any recognisable representation of the halogenoalkanes RDS for rate-determining step **(1)** IGNORE S_N1 is two steps and S_N2 is one step S_N1 for tertiary S_N2 for primary & secondary Just 'S_N1 involves one species and S_N2 two'	Round brackets OH for OH^-	**(3)**

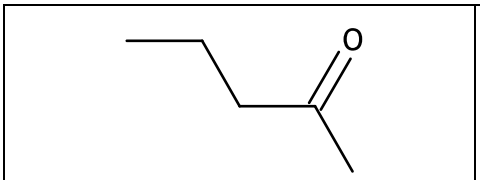
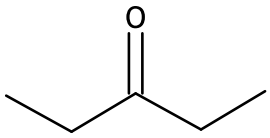
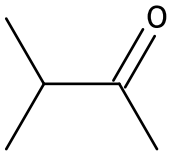
Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	Optical isomers **rotate** the plane of (plane) polarised light (equally but in opposite directions)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Both molecules exist as non-superimposable mirror images **(1)**  (or Cl for left hand OH) OR for the label 'asymmetric carbon' Chiral centre A carbon with four different groups attached **(1)** IGNORE * on asymmetric carbon without further explanation		**(2)**

Question Number	Acceptable Answers	Reject	Mark
***19(c)(iii)**	A single enantiomer / optical isomer will be formed ALLOW Product is optically active **(1)** Nucleophile / hydroxide ion / OH^- will attack only on the opposite side of the molecule to the Cl group ALLOW Nucleophile / hydroxide ion / OH^- will attack only on one side (of the molecule) **(1)** Due to steric hindrance by Cl OR Because the resulting transition state is energetically the most favourable OR Resulting molecule has the opposite configuration to the reactant ALLOW Product rotates plane polarised light in the opposite direction to the reactant **(1)** No TE for answer based on S_N1		**(3)**

Question Number	Acceptable Answers	Reject	Mark
19(d)	**Similarity** Both molecules will have (alcohol) O–H peaks in the range 3750-3200 cm^{-1} **(1)** **Difference** Only lactic acid will have a (carboxylic acid) O–H peak in the range 3300-2500 cm^{-1} OR Only lactic acid will have a C=O peak in the range 1725-1700 cm^{-1} ALLOW carboxylic acid for C=O **(1)** If no other mark is scored, one mark may be awarded for Both molecules will have (alcohol) O–H **and** only lactic acid will have a C=O / carboxylic acid O–H OR Both molecules will have peaks in the range 3750-3200 cm^{-1} and only lactic acid will have a peak in the range 3300-2500 cm^{-1} / 1725-1700 cm^{-1} IGNORE Reference to C–H peaks		**(2)**

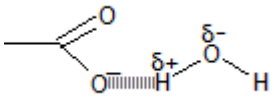
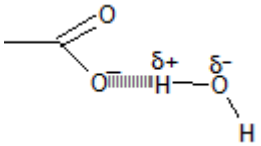
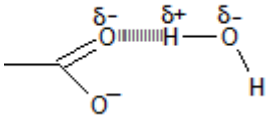
(Total for Question 19 = 22 marks)

Question Number	Acceptable Answers	Reject	Mark
20	 **(1)**  **(1)**  **(1)** OR Structural or displayed formulae Three aldehydes (and no ketones) score two out of the first three marks (Orange) ppt with DNPH indicates carbonyl group **(1)** No reaction with Tollen's reagent so ketone (not aldehyde) **(1)** *m* / *e* or molecular ion = 86 so must be $C_5H_{10}O$ OR *m* / *e* or molecular ion = 86 so M_r = 86 **(1)** IGNORE Names even if incorrect		**(6)**

(Total for Question 20 = 6 marks)

Section C

Question Number	Acceptable Answers	Reject	Mark
***21(a)**	**MP1 Name the force** London / dispersion ALLOW van der Waals forces **(1)** **MP2 Describe the force** A temporary / instantaneous dipole forms which induces a dipole in a neighbouring molecule ALLOW instantaneous / temporary dipole-induced dipole forces **(1)** **MP3 Further information about the formation or nature of the interaction** Random movement of electrons results in a (temporary) dipole ALLOW The opposite charges of the two (temporary) dipoles mutually attract **(1)** IGNORE Just 'random movement of electrons produces London forces'	Other intermolecular forces Covalent / ionic bonds	**(3)**

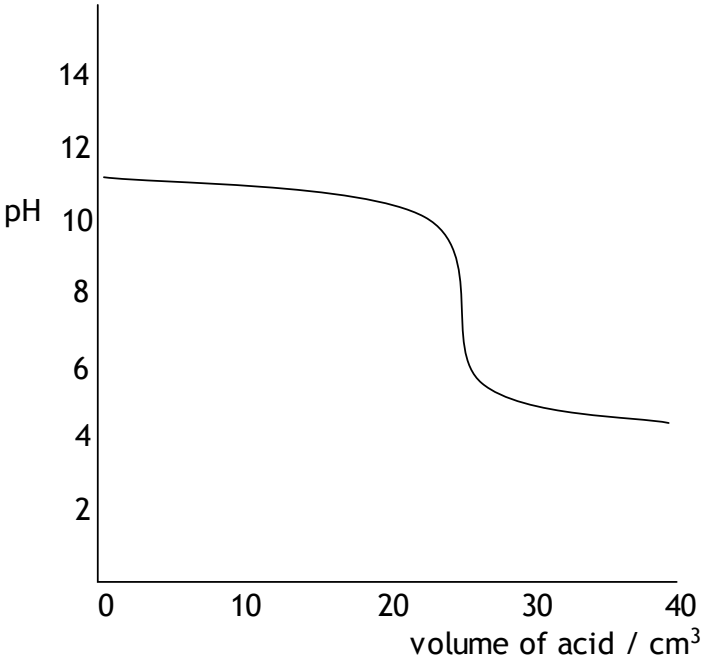
Question Number	Acceptable Answers	Reject	Mark
21(b)	**Method 1** Ion-dipole interaction **(1)**  OR Delocalised carboxylate ion (dipole must be shown) ALLOW Co-ordination numbers >1 Any O^{-}IIIIH—O bond angle **(1)** **Method 2** (ALLOW) Hydrogen bonding (between H of water molecule(s) and O^{-} / carbonyl oxygen) **(1)**  OR  **(1)** Do not penalise omission of δ+ and δ– in the hydrogen bond IGNORE Diagrams involving water and Na^{+} ions	Dipole-dipole forces Carbonyl oxygen Carboxylate oxygen without a full negative charge Dipole-dipole forces Carboxylate oxygen without a full negative charge non-linear O- - -H—O for H bond	**(2)**

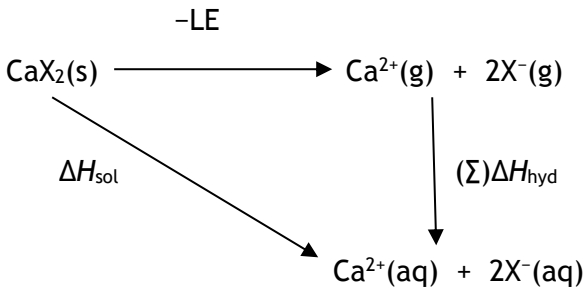
Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	**MP1** Comparison of London forces in ethanoic acid stearic acid e.g. London forces between ethanoic acid molecules are weak but those between stearic acid molecules are strong ALLOW More London forces in stearic acid **(1)** **MP2** Comparison of hydrogen bonds and London Forces Formation of acid-water hydrogen bonds compensates for the breaking of London forces in ethanoic acid but not in stearic acid ALLOW The London forces in stearic acid are stronger than the hydrogen bonds (with water) Both acids form hydrogen bonds with water **(1)** If neither of these marks is scored then For a substance to dissolve, the solute-solvent forces must be similar to the average of solute-solute and solvent-solvent forces scores one mark ALLOW Dispersion forces and van der Waals forces for London forces throughout IGNORE References to acid strength and pK_a values	Ethanoic acid has more/ stronger H bonds than stearic acid	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	$C_{17}H_{35}COOH(aq) \rightleftharpoons C_{17}H_{35}COO^-(aq) + H^+(aq)$ OR $C_{17}H_{35}COOH(aq) + H_2O(l) \rightleftharpoons C_{17}H_{35}COO^-(aq) + H_3O^+(aq)$ ALLOW Non-reversible arrow		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iii)	$K_a = \frac{[C_{17}H_{35}COO^-(aq)] \times [H^+(aq)]}{[C_{17}H_{35}COOH(aq)]}$ OR $H_3O^+(aq)$ for $H^+(aq)$ ALLOW $K_a = \frac{[A^-(aq)] \times [H^+(aq)]}{[HA]}$ IGNORE absence of state symbols in this part No TE on equation that is not the ionisation of a weak acid		**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iv)	No TE on 21(c)(iii) $M_r(C_{17}H_{35}COOH) = 284$ **(1)** Concentration of saturated stearic acid solution at 25°C = 0.34 / 284 $= 1.1972 \times 10^{-3}$ mol dm^{-3} **(1)** $K_a = 10^{-4.89} = [H^+(aq)]^2 / [C_{17}H_{35}COOH(aq)]$ $1.2882 \times 10^{-5} = [H^+(aq)]^2 / 1.1972 \times 10^{-3}$ $[H^+(aq)] = \sqrt{(1.5423 \times 10^{-8})}$ **(1)** $= 1.2419 \times 10^{-4}$ (mol dm^{-3}) pH = 3.9059 = 3.91 / 3.9 **(1)** TE at each stage Correct answer with no working scores (2) If $[C_{17}H_{35}COOH(aq)] = 0.34$ used pH = 2.68/2.7 scores (2) IGNORE SF but **do not** allow pH = 4 and **do** penalise incorrect final answer due to incorrect rounding		**(4)**

Question Number	Acceptable Answers	Reject	Mark
21(c)(v)	**MP1 calculation** ($[OH^-] = 1.1972 \times 10^{-3}$ mol dm^{-3}) pH = 14 – log (1.1972×10^{-3}) = 11.1 TE on concentration of stearic acid in (c)(iv) **(1)** Correct answer with no working scores (1) **MP2 and MP3 graph**  • Start at pH 10.6 – 11.4 • Vertical section at 25 cm^3 • Curve approaching pH 4 (4.4–3.6) at 40 cm^3 TE on pH calculation for the start and finish pH values All three points correct scores (2) Any two points correct scores (1) IGNORE pH of equivalence point If alkali added pH 4.4 – 3.6 **and** vertical section at 25 cm^3 **and** final pH = 10.6–11.4 scores (1) (out of (2))	pH rising after start line not asymptotic	**(3)**

Question Number	Acceptable Answers	Reject	Mark
***21(d)** **Alternative**	 ALLOW Lattice dissociation enthalpy for -LE **(2)** All three energy / enthalpy changes by name or symbol scores (2) Two energy / enthalpy changes scores (1) $\Delta H_{sol} = (\Sigma)\Delta H_{hyd}$ – LE **(1)** No TE on incorrect cycle If ΔH_{sol} is exothermic OR has a small endothermic value, CaX_2 is more likely to be soluble OR Calcium stearate must have more exothermic LE or less exothermic ΔH_{hyd} than calcium alkylbenzene sulphonate (or both) OR Reverse arguments **(1)**	(+)LE	**(4)**

(Total for Question 21 = 20 marks)

TOTAL FOR PAPER = 90 MARKS