# 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**<br><br>**A** *is not correct because there are equal numbers of moles of gas on each side so volume is unchanged in the reaction*<br><br>**B** *is not correct because there are equal numbers of moles of gas on each side so pressure is unchanged in the reaction*<br><br>**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**<br><br>**A** *is not correct because the rate law for a reaction cannot be deduced from its chemical equation*<br><br>**B** *is not correct because the rate law for a reaction cannot be deduced from its chemical equation*<br><br>**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**<br><br>**A** *is not correct because this is the graph for a zero order reaction*<br><br>**C** *is not correct because concentration is increasing so this cannot be correct (shows zero order for product concentration)*<br><br>**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**<br><br>**A** *is not correct because the formula shows that half life is proportional to initial concentration so cannot increase as reactant is consumed*<br><br>**C** *is not correct because the formula shows that half life is proportional to initial concentration so cannot remain constant*<br><br>**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**<br><br>**A** *is not correct because activation energy is a kinetic factor and has no bearing on thermodynamic feasibility*<br><br>**B** *is not correct because* $\Delta S_{surroundings}$ *is negative for endothermic reactions*<br><br>**D** *is not correct because if a reaction is thermodynamically feasible,* $\Delta S_{total}$ *must be positive* | **(1)** |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **5** | **5. The only correct answer is A**<br><br>**B** *is not correct because this is probably true but is not the best explanation*<br><br>**C** *is not correct because this is a true statement but does not explain the decomposition at high temperature*<br><br>**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**<br><br>**B** *is not correct because this is the reverse of the correct answer*<br><br>**C** *is not correct because this is true but not relevant*<br><br>**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**<br><br>**A** *is not correct because there are more moles of gas on the RHS so the reverse statement is correct*<br><br>**C** *is not correct because reactions do not zig-zag in this way when the pressure is changed*<br><br>**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**<br><br>**A** *is not correct because this omits the p*(H2O(g))<br><br>**B** *is not correct because this is the reciprocal of response A*<br><br>**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**<br><br>**B** *is not correct because this shows the units the same for both equations*<br><br>**C** *is not correct because this is derived from the reciprocals of the two equilibrium constant expressions*<br><br>**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**<br><br>**A** *is not correct because it is an exothermic reaction so rate is increased and yield decreased when temperature increases*<br><br>**C** *is not correct because it is an exothermic reaction so rate is increased and yield decreased when temperature increases*<br><br>**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**<br><br>**A** *is not correct because equilibrium constants are unaffected by pressure*<br><br>**B** *is not correct because equilibrium constants only increase with temperature when the reactions are endothermic*<br><br>**C** *is not correct because the effect of temperature on K only depends on* $\Delta S_{total}$ | **(1)** |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **11** | **11. The only correct answer is B**<br><br>**A** *is not correct because* $HNO_3$ *is a base in this system*<br><br>**C** *is not correct because* $HNO_3$ *is a base in this system*<br><br>**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**<br><br>**A** *is not correct because the proportion of weak acid molecules dissociating increases with dilution*<br><br>**B** *is not correct because the proportion of weak acid molecules dissociating increases with dilution*<br><br>**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**<br><br>**A** *is not correct because the buffers have the same ratio of acid to conjugate base so the same* pH<br><br>**B** *is not correct because the buffers have the same ratio of acid to conjugate base so the same* pH<br><br>**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**<br><br>**A** *is not correct because* P *has five proton environments*<br><br>**B** *is not correct because* Q *has four proton environments*<br><br>**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**<br><br>**A** *is not correct because* P *cannot be reduced*<br><br>**C** *is not correct because* R *cannot be oxidised*<br><br>**D** *is not correct because* S *cannot be oxidised* | **(1)** |

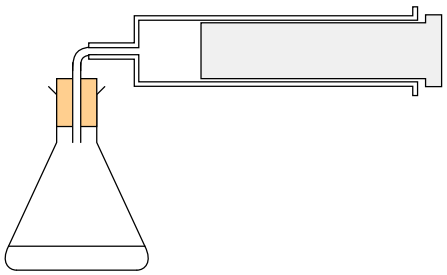
| Question Number | Correct Answer | Mark |
|---|---|---|
| **14(c)** | **14(c). The only correct answer is C**<br><br>**A** *is not correct because there is no reaction*<br><br>**B** *is not correct because there is no reaction*<br><br>**D** *is not correct because there is no reaction* | **(1)** |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **15** | **15. The only correct answer is A**<br><br>**B** *is not correct because this is inefficient in terms of energy consumption*<br><br>**C** *is not correct because this is inefficient in terms of energy consumption*<br><br>**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**<br><br>**A** *is not correct because* MRI *uses radio waves (it is based on* nmr*)*<br><br>**C** *is not correct because* MRI *uses radio waves (it is based on* nmr*)*<br><br>**D** *is not correct because* MRI *uses radio waves (it is based on* nmr*)* | **(1)** |

**Section B**

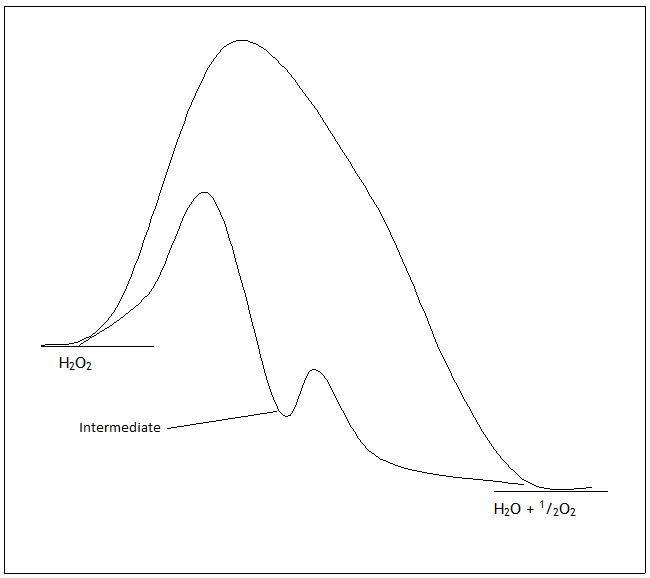
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **17(a)(i)** | Rate = $k[H_2O_2]$<br>ALLOW<br>r/R | Round brackets | **(1)** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **17(a)(ii)** | **Method 1**<br>  <br>Any gas-tight container **and** delivery tube (1)<br>IGNORE<br>Lack of liquid in conical flask<br><br>Syringe<br>Do not penalise gaps around the plunger<br>ALLOW<br>Collection over water with a **graduated** receiver **(1)**<br>Measure volume (of oxygen/gas) **and** at various times<br>ALLOW<br>Regular intervals for time **(1)**<br><br>**Method 2**<br>ALLOW<br>Diagram of conical flask on balance **(1)**<br>Plug of cotton wool (to prevent loss of spray) **(1)**<br>Measure mass and time(s) **(1)** | Delivery tube below the surface of the liquid<br><br>Any form of heating except a water bath at constant temperature<br><br>syringe without separate plunger<br><br>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><br>280/840 **(1)**<br>Remaining three correct **(1)**<br>ALLOW<br>For 1.50 and 0.75 allow correctly calculated values<br>at 0.75 mol $dm^{-3}$, t = X + 280 | | **(2)** |

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

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **17(b)(iii)** | ($k$ = Rate / $[H_2O_2]$)<br>= $1.9 \times 10^{-3}$ / 0.75 **(1)**<br>= $2.53 \times 10^{-3}$ / 0.00253 $s^{-1}$ **(1)**<br>IGNORE SF except 1 SF<br>Correct answer with units but no working scores (2)<br>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)** |  <br>Left-hand /right-hand / only peak **lower** than original **(1)**<br>Two peaks with trough above or below the level of reactant<br>ALLOW<br>Any representation of the intermediate point **(1)**<br>IGNORE<br>Omission of labels | | **(2)** |

**(Total for Question 17 = 12 marks)**

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **18(a)** | $K_p = \frac{P^2(SO_3)}{P^2(SO_2) \times p(O_2)}$<br>OR<br>Using subscripts for substances $P^2_x$<br>OR<br>$p(X)^2$<br>OR<br>$(pX)^2$ | 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 $\neq K_p$ / $2.50 \times 10^{10}$ 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)** | $15.2\ (atm^{-1}) << 2.50 \times 10^{10}\ (atm^{-1})/K_p$<br>**and**<br>So equilibrium moves to the right **(1)**<br>Comment<br>Mark may be awarded if this statement appears in 18(b)(i)<br>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)**<br>IGNORE<br>References to Le Chatelier's Principle<br>References to temperature | | **(2)** |

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

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

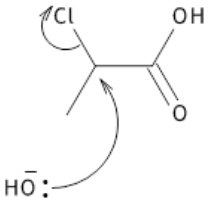
**(Total for Question 18 = 10 marks)**

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

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

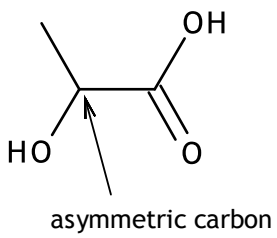
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **19(a)(iii)** | Chlorine can substitute on $C_3$<br>OR<br>3-chloropropanoic acid formed<br>OR<br>Further (chlorine) substitution is possible<br>OR<br>Structure of possible product<br>IGNORE<br>Activation energy too high<br>Reaction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

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **19(a)(iv)** | Sulfuric acid / $H_2SO_4$<br>OR<br>Any strong acid by name or formula **(1)**<br>IGNORE<br>Concentration of acid<br>$H^+$ / $H_3O^+$ / Just 'acid'<br><br>To convert the sodium salt to lactic acid<br>OR<br>Protonate the carboxylate ion / $COO^-$<br>(formed after the reaction with NaOH)<br>ALLOW<br>React with carboxylate **(1)**<br>IGNORE<br>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<br>Penalise incorrect position of the chlorine atom and incorrect carbon chain in the final mark<br>  <br><br>Curly arrow from C—Cl bond to Cl or just beyond it<br>ALLOW<br>Curly arrow on transition state **(1)**<br>Curly arrow from **lone pair** of O on $OH^-$ to carbon atom<br>ALLOW<br>Arrow starting nearer the lone pair than the oxygen **(1)**<br>  <br><br>Transition state including partial bonds **and** charge<br>ALLOW<br>Charge on any part of the intermediate<br>Any geometry for intermediate **(1)**<br>  <br><br>Final organic product **and** chloride ion<br>ALLOW<br>NaCl as product **(1)**<br>IGNORE<br>Lone pairs on the chlorine and dipoles on C-Cl<br>Penalise omission of negative charge on $OH^-$ and $Cl^-$ once<br>ALLOW<br>carboxylate ion ($COO^-$) throughout the mechanism.<br>$S_N1$ can score MP1, MP2 and MP4 (max 3) | OH<br>Other products such as $OH^-$ | **(4)** |

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

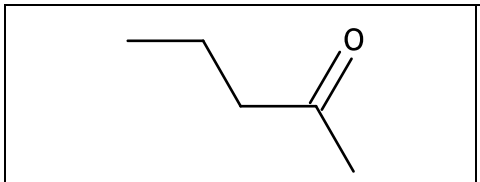
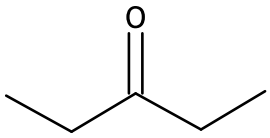
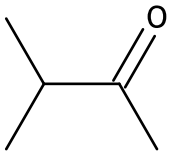
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **19(c)(i)** | Optical isomers **rotate** the plane of (plane) polarised light (equally but in opposite directions) | | **(1)** |

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

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

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

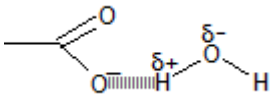
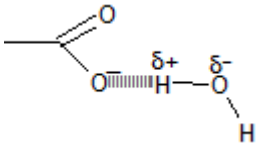
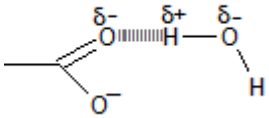
**(Total for Question 19 = 22 marks)**

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **20** |  **(1)**<br>  **(1)**<br>  **(1)**<br>OR<br>Structural or displayed formulae<br>Three aldehydes (and no ketones) score two out of the first three marks<br>(Orange) ppt with DNPH indicates carbonyl group **(1)**<br>No reaction with Tollen's reagent so ketone (not aldehyde) **(1)**<br>*m* / *e* or molecular ion = 86 so must be $C_5H_{10}O$<br>OR<br>*m* / *e* or molecular ion = 86 so $M_r$ = 86 **(1)**<br>IGNORE<br>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**<br>London / dispersion<br>ALLOW<br>van der Waals forces **(1)**<br><br>**MP2 Describe the force**<br>A temporary / instantaneous dipole forms which induces a dipole in a neighbouring molecule<br>ALLOW<br>instantaneous / temporary dipole-induced dipole forces **(1)**<br><br>**MP3 Further information about the formation or nature of the interaction**<br>Random movement of electrons results in a (temporary) dipole<br>ALLOW<br>The opposite charges of the two (temporary) dipoles mutually attract **(1)**<br>IGNORE<br>Just 'random movement of electrons produces London forces' | Other intermolecular forces<br>Covalent / ionic bonds | **(3)** |

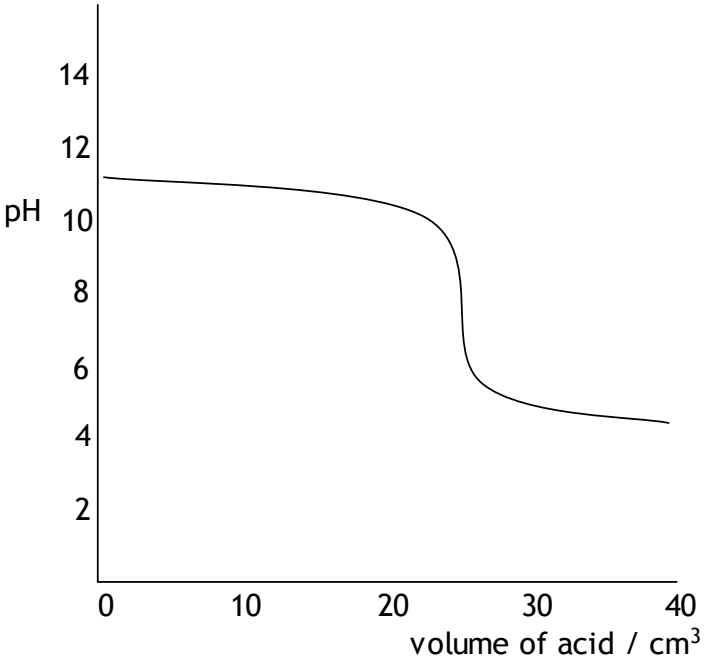
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(b)** | **Method 1**<br>Ion-dipole interaction **(1)**<br>  <br>OR<br>Delocalised carboxylate ion<br>(dipole must be shown)<br><br>ALLOW<br>Co-ordination numbers >1<br>Any $O^{-}$IIIIH—O bond angle **(1)**<br><br>**Method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

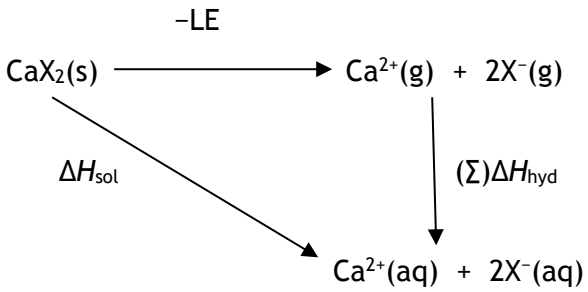
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(c)(i)** | **MP1**<br>Comparison of London forces in ethanoic acid stearic acid e.g.<br>London forces between ethanoic acid molecules are weak but those between stearic acid molecules are strong<br>ALLOW<br>More London forces in stearic acid **(1)**<br>**MP2**<br>Comparison of hydrogen bonds and London Forces<br>Formation of acid-water hydrogen bonds compensates for the breaking of London forces in ethanoic acid but not in stearic acid<br>ALLOW<br>The London forces in stearic acid are stronger than the hydrogen bonds (with water)<br>Both acids form hydrogen bonds with water **(1)**<br>If neither of these marks is scored then<br>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<br>ALLOW<br>Dispersion forces and van der Waals forces for London forces throughout<br>IGNORE<br>References to acid strength and p$K_a$ values | Ethanoic acid has more/ stronger H bonds than stearic acid | **(2)** |

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

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(c)(iii)** | $K_a = \frac{[C_{17}H_{35}COO^-(aq)] \times [H^+(aq)]}{[C_{17}H_{35}COOH(aq)]}$<br>OR<br>$H_3O^+(aq)$ for $H^+(aq)$<br>ALLOW<br>$K_a = \frac{[A^-(aq)] \times [H^+(aq)]}{[HA]}$<br>IGNORE absence of state symbols in this part<br>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)<br>$M_r(C_{17}H_{35}COOH) = 284$ **(1)**<br>Concentration of saturated stearic acid solution at 25°C = 0.34 / 284<br>$= 1.1972 \times 10^{-3}$ mol dm$^{-3}$ **(1)**<br>$K_a = 10^{-4.89} = [H^+(aq)]^2 / [C_{17}H_{35}COOH(aq)]$<br>$1.2882 \times 10^{-5} = [H^+(aq)]^2 / 1.1972 \times 10^{-3}$<br>$[H^+(aq)] = \sqrt{(1.5423 \times 10^{-8})}$ **(1)**<br>$= 1.2419 \times 10^{-4}$ (mol dm$^{-3}$)<br>pH = 3.9059 = 3.91 / 3.9 **(1)**<br>TE at each stage<br>Correct answer with no working scores (2)<br>If $[C_{17}H_{35}COOH(aq)] = 0.34$ used<br>pH = 2.68/2.7 scores (2)<br>IGNORE<br>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**<br>($[OH^-] = 1.1972 \times 10^{-3}$ mol $dm^{-3}$)<br>pH = 14 – log ($1.1972 \times 10^{-3}$)<br>= 11.1<br>TE on concentration of stearic acid in (c)(iv) **(1)**<br>Correct answer with no working scores (1)<br>**MP2 and MP3 graph**<br>  <br><br>• Start at pH 10.6 – 11.4<br>• Vertical section at 25 $cm^3$<br>• Curve approaching pH 4 (4.4–3.6) at 40 $cm^3$<br>TE on pH calculation for the start and finish pH values<br>All three points correct scores (2)<br>Any two points correct scores (1)<br>IGNORE<br>pH of equivalence point<br>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<br>line not asymptotic | **(3)** |

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

**(Total for Question 21 = 20 marks)**

**TOTAL FOR PAPER = 90 MARKS**