Pearson Edexcel

Mark Scheme (Results)

January 2024

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

Question Number	Answer	Mark
1(a)	**The only correct answer is B** (the collisions do not have sufficient energy) ***A*** *is incorrect because low reactant concentrations will reduce the number of collisions but not the proportion that are successful* ***C*** *is incorrect because at equilibrium both the forward and reverse reactions occur at the same rate* ***D*** *is incorrect because the reacting ratio does not reflect the mechanism of the reaction*	**(1)**

Question Number	Answer	Mark
1(b)	**The only correct answer is A** (atm) ***B*** *is incorrect because the expression for* K_p *is inverted* ***C*** *is incorrect because the different state of one of the products has not been taken into account* ***D*** *is incorrect because the expression for* K_p *is inverted and the different state of one of the products has not been taken into account*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is D** (0.125) ***A*** *is incorrect because this is the amount that has decomposed after three half-lives* ***B*** *is incorrect because this is the concentration remaining after one half-life* ***C*** *is incorrect because this is the concentration remaining after two half-lives*	**(1)**

Question Number	Answer	Mark
3(a)	**The only correct answer is C** (it alters the enthalpy change of the reaction) ***A*** *is incorrect because a catalyst does lower the activation energy of the reaction* ***B*** *is incorrect because a catalyst has no effect on the equilibrium constant for the reaction* ***D*** *is incorrect because a catalyst does reduce the energy cost of the reaction*	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is B** (a temperature of 400 K and a pressure of 200 atm) ***A*** *is incorrect because the pressure is lower and there is a reduction in volume in the forward direction* ***C*** *is incorrect because the temperature is higher and the forward reaction is exothermic and the pressure is lower and there is a reduction in volume in the forward direction* ***D*** *is incorrect because the temperature is higher and the forward reaction is exothermic*	**(1)**

Question Number	Answer	Mark
4	**The only correct answer is C** (K , J , L) ***A*** *is incorrect because J has a smaller reduction of gaseous moles than K* ***B*** *is incorrect because L has an increase in gaseous moles* ***D*** *is incorrect because L has an increase in gaseous moles*	**(1)**

Question Number	Answer	Mark
5	**The only correct answer is D** (+174) ***A*** *is incorrect because the standard entropy of products has been subtracted from that of reactants* ***B*** *is incorrect because the stoichiometry has not been considered* ***C*** *is incorrect because the stoichiometry has not been considered and the standard entropy of products has been subtracted from that of reactants*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is C** (negative, positive) ***A*** *is incorrect because a gas is changing to a liquid so* ΔS_{system} *is reduced* ***B*** *is incorrect because a gas is changing to a liquid so* ΔS_{system} *is reduced and condensation is exothermic* ***D*** *is incorrect because condensation is exothermic*	**(1)**

Question Number	Answer	Mark
7	**The only correct answer is B** (neutral with a pH of 6.6) ***A*** *is incorrect because this is the pH of water at 25* °C ***C*** *is incorrect because the water is neutral* $[H^+] = [OH^-]$ ***D*** *is incorrect because the water is neutral and the pH has been calculated incorrectly*	**(1)**

Question Number	Answer	Mark
8	**The only correct answer is B** ($CH_2ClCOOH$) *A is incorrect because hydrogen is not as electronegative as chlorine so acid is less dissociated* *C is incorrect because bromine is not as electronegative as chlorine so acid is less dissociated* *D is incorrect because iodine is not as electronegative as chlorine so acid is less dissociated*	**(1)**

Question Number	Answer	Mark
9	**The only correct answer is C** ($H_2PO_4^-$) *A is incorrect because H_3PO_4 is the conjugate acid of $H_2PO_4^-$* *B is incorrect because H_3O^+ is the conjugate acid of H_2O* *D is incorrect because PO_4^{3-} is the conjugate base of HPO_4^{2-}*	**(1)**

Question Number	Answer	Mark
10	**The only correct answer is B** (13.6) *A is incorrect because the concentration of hydroxide ions has been ignored* *C is incorrect because only one mole of hydroxide ions has been used* *D is incorrect because the hydroxide ion concentration has been squared*	**(1)**

Question Number	Answer	Mark
11(a)	**The only correct answer is C** (optical isomerism only) ***A*** *is incorrect because carvone does not show geometric isomerism* ***B*** *is incorrect because does not show geometric isomerism and has optical isomers* ***D*** *is incorrect because carvone has optical isomers*	**(1)**

Question Number	Answer	Mark
11(b)	**The only correct answer is D** (2,4-dinitrophenylhydrazine) ***A*** *is incorrect because ammoniacal silver nitrate does not react with a ketone or C=C* ***B*** *is incorrect because sodium carbonate does not react with a ketone or C=C* ***C*** *is incorrect because iodine in the presence of an alkali only reacts with a methyl ketone*	**(1)**

Question Number	Answer	Mark
11(c)	**The only correct answer is A** (10) ***B*** *is incorrect because no carbon is equivalent to any other* ***C*** *is incorrect because no two carbons are equivalent to any others* ***D*** *is incorrect because no three carbons are equivalent to any others*	**(1)**

Question Number	Answer	Mark
12	**The only correct answer is A** (butanoic acid and pentan-1-ol) ***B*** *is incorrect because the alcohol from which the ester is made must have five carbon atoms* ***C*** *is incorrect because aldehydes do not react with alcohols to form esters* ***D*** *is incorrect because the acid from which the ester is made must have four carbon atoms*	**(1)**

Question Number	Answer	Mark
13	**The only correct answer is C** (reduction) ***A*** *is incorrect because the reaction involves addition of hydrogen and reduction* ***B*** *is incorrect because the reaction is reduction of the ethanoic acid by lithium tetrahydridoaluminate(III)* ***D*** *is incorrect because the reaction is reduction of the ethanoic acid by lithium tetrahydridoaluminate(III)*	**(1)**

Question Number	Answer	Mark
14	**The only correct answer is A** (propanal) ***B*** *is incorrect because both the oxygen and the hydrogen of the -OH group in propan-1-ol can form hydrogen bonds with water* ***C*** *is incorrect because propanoic acid is partially dissociated and both the ions and the acid can form hydrogen bonds with water* ***D*** *is incorrect because the salt is dissociated and the sodium ion is hydrated and the propanoate ion can form ion-dipole and hydrogen bonds with water*	**(1)**

Question Number	Answer	Mark
15(a)	**The only correct answer is A** (2-methylpropan-2-ol) ***B*** *is incorrect because M_r of pentane is 72, and loss of CH3 would give the major ion at m/z = 57* ***C*** *is incorrect because M_r of propanal is 58, so the major ion cannot be at m/z = 59* ***D*** *is incorrect because M_r of propanone is 58, so the major ion cannot be at m/z = 59.*	**(1)**

Question Number	Answer	Mark
15(b)	**The only correct answer is D** (propanone) ***A*** *is incorrect because there is no peak due to an O-H stretching vibration* ***B*** *is incorrect because pentane spectrum does not have a peak due to a C=O stretching vibration* ***C*** *is incorrect because propanal reacts with acidified aqueous sodium dichromate.*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
16(a)(i)	An answer that makes reference to the following point: • Blue(-)black	Accept (dark) blue /black/ black-blue	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(a)(ii)	An explanation that makes reference to the following points: • the thiosulfate must be used up (before the concentration of the other reagents change significantly) (1) • so the rate is unaffected by changes in concentration of the reagents during the reaction (1)	Allow the thiosulfate/it reacts completely/Reaction 1 is complete/ there must be (some) iodine produced to react with starch Allow (before) the concentration of the other reactants changes appreciably/so that the concentration of other reactants does not change much/so that the initial rate is determined If no other mark scored allow : if the concentration is high then no iodine produced / no complex formed/no colour change scores 1 Do not award references to an increase in the rate of the reaction of sodium thiosulfate and iodine if the concentration is high.	**(2)**

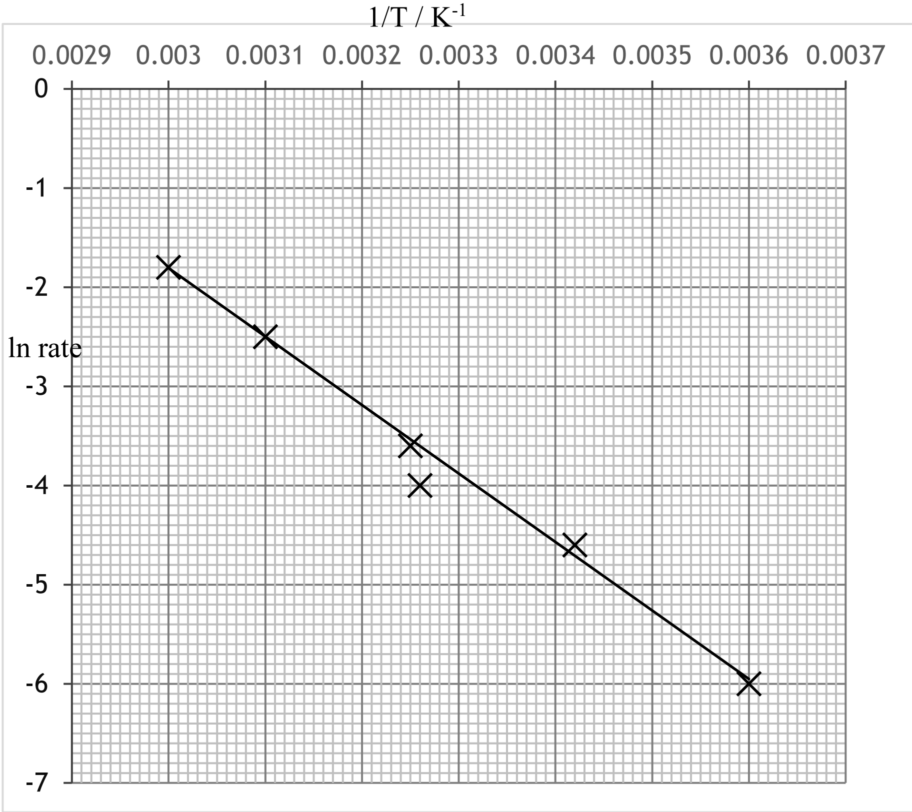
Question Number	Answer	Additional Guidance	Mark
16(b)(i)	An answer that makes reference to three of the following points: • (reaction is) first order in hydrogen peroxide because as the concentration is halved, the reciprocal of time/the rate is halved **(1)** • (reaction is) zero order in hydrogen ions as the rate does not change with a change in concentration of hydrogen ions **(1)** • (reaction is) first order in iodide ions because as the concentration is doubled the reciprocal of time/rate is doubled **(1)**	Marks can be scored from annotation on table Allow as the concentration of hydrogen peroxide is halved (changed in mixtures one and two) the time is doubled Allow reverse argument Allow as the concentration of hydrogen ions is changed (between mixtures one and four) (by a factor of ten) there is little/no change in rate Allow as the concentration of iodide ions is doubled (in mixtures one and three) the time is halved Allow reverse argument If no other mark is scored award one mark if all three orders of reaction are correct with no or incorrect justification.	**(3)**

Question Number	Answer	Additional Guidance	Mark
16(b)(ii)	An answer that makes reference to the following point: • rate = $k[H_2O_2][I^-]$	Allow rate = $k[H_2O_2][I^-][H^+]^o$ Allow species in any order TE from (b)(i)	**(1)**

Question Number	Answer	Additional Guidance	Mark
16(b)(iii)	• calculation of the amount of iodine which reacted with the thiosulfate	Example of calculation $8.50 \times 10^{-5} \div 2 = 4.25 \times 10^{-5}$ (mol) Correct answer with no working scores 1 Ignore SF except 1 SF	**(1)**

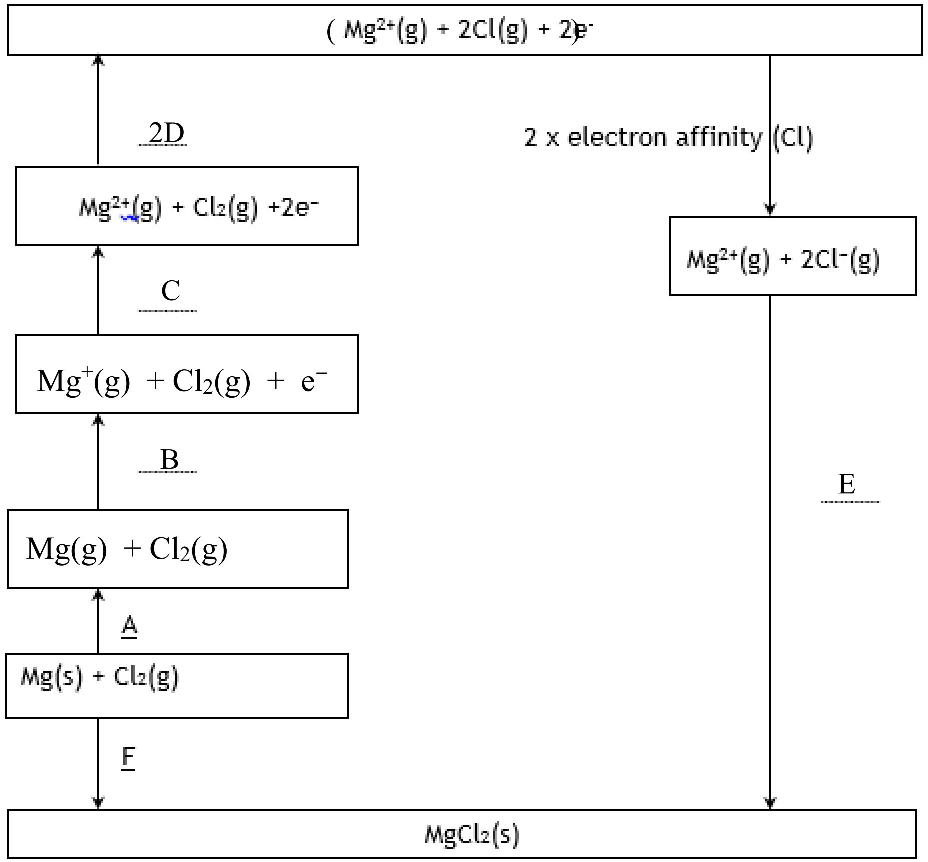
Question Number	Answer	Additional Guidance	Mark
16(b)(iv)	• calculation of rate of loss of amount of iodine / loss of hydrogen peroxide in mols **(1)** • calculation of reaction rate in mol dm^{-3} s^{-1}) **(1)**	Example of calculation $4.25 \times 10^{-5} \div 195 = 2.1795 / 2.18/ 2.2 \times 10^{-7}$ (mol s^{-1}) $2.1795 \times 10^{-7} \div 0.05 = 4.3590/4.36/4.4 \times 10^{-6}$ (mol dm^{-3} s^{-1}) Correct answer with no working scores 2 Ignore SF except 1SF TE from (iii)	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(b)(v)	• rearrangement of the rate equation and calculation of the rate constant **(1)** • units **(1)**	<u>Example of calculation</u> k = rate ÷ ($[H_2O_2] \times [I^-]$) $k = 4.359 \times 10^{-6} \div (5.4 \times 10^{-2} \times 8.2 \times 10^{-3})$ $= 4.359 \times 10^{-6} \div 4.428 \times 10^{-4}$ $= 9.844 \times 10^{-3}$ Ignore SF except 1SF $dm^3\ mol^{-1}\ s^{-1}$ Accept units in any order Correct answer with no working and units scores 2 TE from (ii) (iii) and (iv)	**(2)**

Question Number	Answer	Additional Guidance	Mark
16(c)(i)	• axes correct with scales allowing plot to cover at least half the grid and ln rate values becoming more negative down the axis **(1)** • both axes labelled with units K^{-1} on x axis **(1)** • points correctly plotted and best fit line drawn **(1)** • gradient in the range −7200 to −6800 **(1)** • $E_a = -(-7000 \times 8.31) \div 1000$ $= +58.2$ ($kJ\ mol^{-1}$) range 56.5 to 59.9 TE on incorrect gradient value but Ea must be positive Ignore SF except 1 SF **(1)**	Example of calculation Allow horizontal axis at bottom of graph Ignore extrapolation  Allow plotting of all points except the incorrect one TE on incorrect gradient Ignore SF	**(5)**

Question Number	Answer	Additional Guidance	Mark
16(c)(ii)	An explanation that makes reference to the following points: • correct value of 1/T from the graph **(1)** • conversion to temperature **(1)**	 0.00331 ± 0.00001 302K (Range 301K -303K) TE from incorrect 1/T read from graph Ignore SF	**(2)**

(Total for Question 16 = 19 marks)

Question Number	Answer	Additional Guidance	Mark
17(a)(i)	An answer that makes reference to six of the following points: Clockwise from enthalpy change A • $Mg(g) + Cl_2(g)$ **(1)** • B / (+)738 **(1)** • $Mg^+(g) + Cl_2(g) + e^-$ **(1)** • C/ (+)1451 **(1)** • 2D / (+)244 **(1)** • E / (-)2526 **(1)** All 6 points correct three marks 4/5 points correct two marks 2/3 points correct one mark	 Allow any unambiguous labels for the arrows including words or values If the value is given correctly ignore an incorrect letter. Penalise missing or incorrect state symbol once only	(3)

Question Number	Answer	Additional Guidance	Mark
17(a)(ii)	• correct expression **(1)** • correct rearrangement **and** evaluation of 1st electron affinity of chlorine **(1)**	<u>Example of calculation</u> $-641 = 148 + 738 + 1451 + (2 \times 122) + 2EACl_2 - 2526$ $2EACl_2 = -641 - (148 + 738 + 1451 + (2 \times 122)) + 2526$ $= -696$ $\Delta H(EA\text{chlorine}) = -696 \div 2 = -348$ (kJ mol^{-1}) Correct answer with no working scores 2 No TE on incorrect expression except Failure to multiply atomisation energy by 2 i.e. $2EACl_2 = -574$ (kJ mol^{-1}) and then $\Delta H(EA\text{chlorine}) = -574 \div 2 = -287$ (kJ mol^{-1}) for 1 mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iii)	An explanation that makes reference to the following points: • the third ionisation energy for magnesium is very high (because the third electron is being removed from the 2p orbital / an inner shell) **(1)** • which would not be compensated for by the lattice energy **(1)**	Allow the enthalpy of formation of $MgCl_3$ would be (highly) endothermic/the energy released when $MgCl_3$ is formed would need to be more than that released when $MgCl_2$ forms	**(2)**

Question Number	Answer	Additional Guidance	Mark
17(a)(iv)	• calculation of the combined hydration enthalpies of the gaseous ions **(1)** • subtraction of the lattice energy of the solid **(1)**	Example of calculation $-1920-2(364) = -2648$ (kJ mol^{-1}) $-2648 - -2526 = -122$ (kJ mol^{-1}) Correct answer scores 2 Sign reversed (+)122 scores 1	**(2)**

Question Number	Answer	Additional Guidance	Mark
*17(b)	See below	See below	(6)

Answer

This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5-4	3
3-2	2
1	1
0	0

The following table shows how the marks should be awarded for structure and lines of reasoning

	Number of marks awarded for structure of answer and sustained lines of reasoning
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Additional Guidance

Guidance on how the mark scheme should be applied.

The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

In general it would be expected that
5 or 6 indicative points would get 2 reasoning marks
3 or 4 indicative points would get 1 reasoning mark
0, 1 or 2 indicative points would get zero reasoning marks

If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).

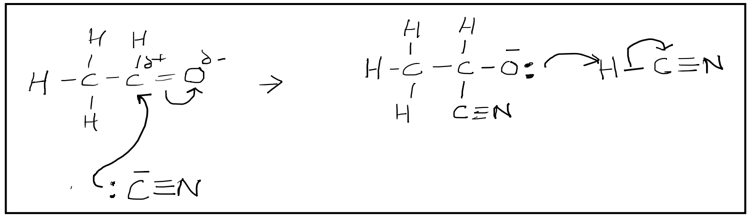
Comment: Look for the indicative marking points first, then consider the mark for the structure of the answer and sustained line of reasoning

Mark: (6)

	Indicative content	Allow reverse arguments throughout	
	IP1 The magnesium (ion) has larger charge/smaller **ionic** radius than the sodium (ion)	Allow sodium ion has 1+ charge and magnesium ion has 2+charge/sodium has smaller charge density than magnesium	
	IP2 The attraction between the ions/ionic bond is stronger in magnesium fluoride (so lattice energies of sodium fluoride are less exothermic)	Cannot get this mark just for comparing values in table	
	IP3 The magnesium ion is more polarising than the sodium ion	Magnesium ion causes more distortion of anion than sodium ion	
	IP4 The chloride ion is larger/ more polarisable than the fluoride ion		
	IP5 The difference between theoretical and experimental values is greatest for magnesium chloride / the difference between theoretical and experimental values is least for sodium fluoride	Accept the electronegativity **difference** between sodium and fluorine is greater than that between magnesium and chlorine	
	IP6 Magnesium chloride has the greatest degree of covalent character/Sodium fluoride has the greatest degree of ionic character	Allow $MgCl_2$ has more covalent character than NaF Allow NaF is 100% ionic and $MgCl_2$ is partially covalent Ignore references to the number of bonds mention of intermolecular forces loses 1 reasoning mark	

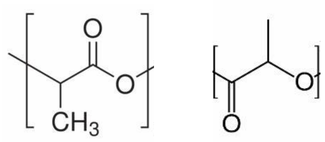
(Total for Question 17 = 15 marks)

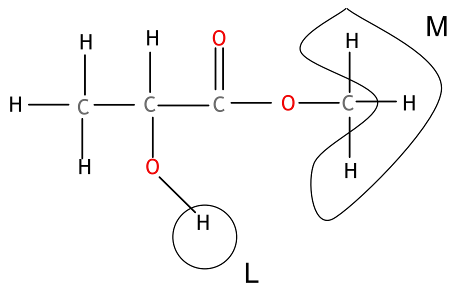
Question Number	Answer	Additional Guidance	Mark
18(a)	An explanation that makes reference to the following points: • Step 1 Hydrogen cyanide and potassium/sodium cyanide HCN and KCN / KCN and H^+ / HCN and a trace of base **(1)** Step 2 • (dil) hydrochloric acid /HCl/ sulfuric acid / H_2SO_4 (and water) **(1)**	If names and formulae are given both must be correct Allow named strong acids Accept HCN/hydrogen cyanide Do not award just cyanide ions If HCN used accept trace of base/NaOH//at pH5-8 Accept NaOH/sodium hydroxide/KOH/potassium hydroxide **then** hydrochloric/sulfuric acid to produce free carboxylic acid Do not award just concentrated acid Do not award H^+ or H^+ and water	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(b)(i)	An answer that makes reference to the following points: • lone pair on carbon of CN^- • dipole shown on C=O • arrow from lone pair on CN^- to carbonyl C • arrow from C=O double bond to O or just beyond • correct formula and charge on intermediate • lone pair on O of intermediate • arrow from (:)O^- to H of HCN/H^+ 7 points correct scores 4 marks 5/6 points correct scores 3 marks 3/4 points correct scores 2 marks 1/2 points correct scores 1 mark	Accept arrow from C if no lone pair shown Ignore vertical connectivity Penalise missing H atoms Allow to H^+ Ignore any dipole on HCN and curly arrow from H-C bond to C Example of mechanism 	**(4)**

Question Number	Answer	Additional Guidance	Mark
18(b)(ii)	An explanation that makes reference to the following points: • a racemic mixture is formed / two enantiomers are formed **(1)** • because the (molecule is planar around the carbon of the) aldehyde group/(H)C=O/carbonyl is (trigonal) planar **(1)** • the nucleophile/CN^- is equally likely to attack the C of C=O from above or below (the plane) **(1)**	Allow reaction site is planar Do not award carbocation/molecule/ethanal is planar Do not award S_N1 or S_N2	**(3)**

Question Number	Answer	Additional Guidance	Mark
18(c)(i)	An answer that makes reference to the following point: • esterification	Allow condensation	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(c)(ii)	An answer that makes reference to the following point: • correct formula including extension bonds **(1)**	Examples of correct formulae:  — [$OCH(CH_3)CO$] — — [$CH(CH_3)COO$] — Ignore absence of square brackets and/or n Accept two correct repeat units	**(1)**

Question Number	Answer	Additional Guidance	Mark
18(d)(i)	An answer that makes reference to the following points: • L on —OH proton **(1)** • M on all methyl ester protons **(1)**	 Allow inclusion of C in CH_3 and O in OH Ignore labels J and K If no labels, but both protons are clearly correct allow one mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
18(d)(ii)	An answer that makes reference to the following points: • Any two correctly filled boxes **(1)** • All four correctly filled boxes **(1)**	(see table below)	**(2)**

Peak	δ / ppm	Number of hydrogen atoms	Splitting pattern
J	1.3	**3**	**doublet**
K	4.1	**1**	**quartet/quadruplet**
L	3.6	1	singlet
M	3.7	3	singlet

(Total for Question 18 = 15 marks)
TOTAL FOR SECTION B = 49 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
19(a)(i)	• expression for K_c **(1)** • calculation of equilibrium quantities of reactants **(1)** • calculation of equilibrium concentrations of products **and** use of volume **(1)** • evaluation of K_c **(1)**	Example of calculation: $K_c = \frac{[CH_3CH_2COOH]\,[CH_3CH_2OH]}{[CH_3CH_2COOCH_2CH_3]\,[H_2O]}$ Ignore state symbols Brackets must be square brackets $CH_3CH_2COOCH_2CH_3$ = (0.100−0.0440) = 0.056(0) (mol) H_2O = (0.2−0.0440) = 0.156 (mol) $[CH_3CH_2COOH]$ = 0.044(0) /V (mol dm^{-3}) $[CH_3CH_2OH]$ = 0.044(0) /V (mol dm^{-3}) Allow volumes cancel $K_c = \frac{0.044 \times 0.044}{0.056 \times 0.156}$ = 0.22161 = 0.222 / 0.22 TE on incorrect moles Answer to 2/3 SF and no units	**(4)**

Question Number	Answer	Additional Guidance	Mark
19(a)(ii)	An explanation that makes reference to the following points: • Same number and type of bonds are being broken (in reactants) and made (in products) **(1)** • but the bonds are in different molecules/ environments (so not exactly the same) **(1)**	Allow similar bonds are being broken (in reactants) and made (in products). Do not award: incorrect bonds identified	**(2)**

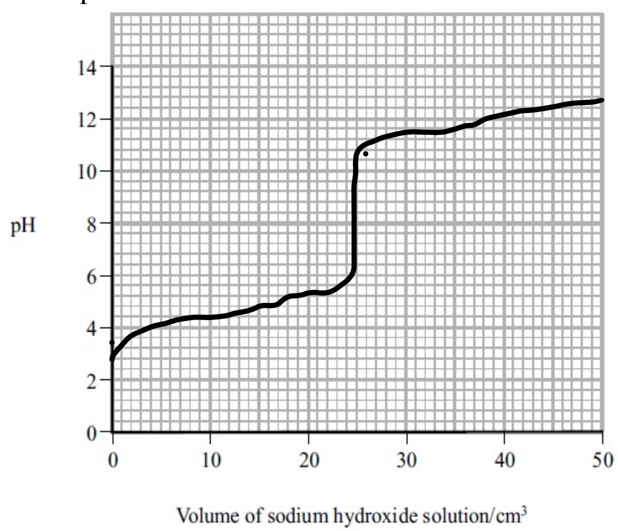
Question Number	Answer	Additional Guidance	Mark
19(a)(iii)	An explanation that makes reference to three of the following points • $\Delta S_{\text{surroundings}} = \frac{-\Delta H}{\text{T}}$ **(1)** • (since ΔH is close to zero) then $\Delta S_{\text{surroundings}}$ / ΔS_{total} does not change / only changes by a small amount (with a change in temperature) **(1)** • ΔS_{total} = R ln$K$ so K_c does not change (much) (with a change in temperature) **(1)**	Ignore references to Le Chatelier's principle and predictions based on position of equilibrium Allow expression for $\Delta S_{\text{surroundings}}$ in an expression for ΔS_{total}	**(3)**

Question Number	Answer	Additional Guidance	Mark
19(b)(i)	• a weak acid is dissociated (into its ions) to a small extent and a strong acid is (almost) completely dissociated	Allow propanoic acid is partially ionised and hydrochloric acid is fully ionised	**(1)**

Question Number	Answer	Additional Guidance	Mark
19(b)(ii)	• calculation of pH	pH = $-\log_{10}(0.500)$ = 0.30103 / 0.301 / 0.30 / 0.3 Ignore SF	(1)

Question Number	Answer	Additional Guidance	Mark
19(b)(iii)	• expression for acid dissociation constant (1) • calculation of hydrogen ion concentration (1) • evaluation of pH (1)	<u>Example of calculation:</u> $K_a = \frac{[CH_3CH_2COO^-][H^+]}{[CH_3CH_2COOH]}$ Allow $K_a = \frac{[H^+][A^-]}{[HA]}$ Allow $K_a = \frac{[H^+][salt]}{[acid]}$ Allow $1.3 \times 10^{-5} = \frac{[H^+]^2}{0.5}$ $[H^+] = 2.5495 \times 10^{-3}$ (mol dm^{-3}) If M2 is scored assume M1 is correct even if not shown pH = $-\log_{10}[H^+]$ = 2.59/ 2.6 Correct answer with some working scores 3 Ignore SF except 1SF	(3)

Question Number	Answer		Additional Guidance	Mark
19(c)(i)	An explanation that makes reference to the following points: • (when half the acid has been neutralised) $[CH_3CH_2COOH] = [CH_3CH_2COO^-]$ • evaluation of pH	 **(1)** **(1)**	Allow in words Allow pH at half neutralisation = pK_a propanoic acid Allow $[H^+]$ at half neutralisation = Ka propanoic acid pH = $-\log_{10} 1.30 \times 10^{-5}$ =4.8861 = 4.89/4.9 Ignore SF except 1SF Correct answer scores 2	**(2)**

Question Number	Answer		Additional Guidance	Mark
19(c)(ii)	An answer that makes reference to three of the following points: • start pH between 2 and 4 **and** finish at 12-14 • vertical section of at least 3 pH units starting at or above 6 and finishing at or below 11. • S-shaped curve with equivalence(vertical section) at 25 cm^3	 **(1)** **(1)** **(1)**	Example of sketch 	**(3)**

Question Number	Answer	Additional Guidance	Mark
19(c)(iii)	An answer that makes reference to two of the following points: • phenolphthalein/ bromothymol blue / phenol red **(1)** • because the indicator pH range / pK_{ind} ± 1 lies (completely) within the vertical section of the graph **(1)**	TE from incorrect vertical section provided indicator chosen from Data Booklet Allow a pH range for their vertical section	**(2)**

(Total for Question 19 = 21 marks)
TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER =90 MARKS

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