Mark Scheme (Results)

October 2025

Pearson Edexcel International Advanced Level in Chemistry
WCH14/01

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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	**The only correct answer is B** (second order first order) *A is incorrect because from Experiment 2 to 3 doubling the concentration of O_2 causes a double of rate and so the effect of doubling the concentration of NO causes a quadrupling of rate, so NO is second order* *C is incorrect because from Experiment 1 to 2 doubling the concentration of O_2 causes a double of rate so O_2 is first order* *D is incorrect because from Experiment 1 to 2 doubling the concentration of O_2 causes a double of rate so O_2 is first order*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is A** $(-(-1.23 \div 2.7 \times 10^{-4}) \times 8.31)$ *B is incorrect because the gradient is $-E_a / R$* *C is incorrect because the gradient calculation is inverted* *D is incorrect because the gradient is $-E_a / R$ and the gradient calculation is inverted*	**(1)**

Question Number	Answer	Mark
3(a)	**The only correct answer is D** (arrow Y) ***A*** *is incorrect because this is the sum of the first two ionisation energies of magnesium* ***B*** *is incorrect because this is the sum of the first two electron affinities of oxygen* ***C*** *is incorrect because this is the sum of the atomisation of magnesium and of oxygen*	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is B** (arrow W) ***A*** *is incorrect because both ionisation energies are endothermic* ***C*** *is incorrect because both atomisation energies are endothermic* ***D*** *is incorrect because this is a single exothermic process (formation of magnesium oxide)*	**(1)**

Question Number	Answer	Mark
3(c)	**The only correct answer is C** (the oxide ion is not very polarisable**)** ***A*** *is incorrect because the magnesium ion is polarising* ***B*** *is incorrect because magnesium oxide is almost perfectly ionic* ***D*** *is incorrect because the ions will be almost perfectly spherical*	**(1)**

Question Number	Answer	Mark
4(a)	**The only correct answer is A** ($\Delta_{hyd}H(Cl^-) = \Delta_{sol}H(NaCl) - \Delta_{hyd}H(Na^+) + \Delta_{LE}H(NaCl)$) ***B*** *is incorrect because* $\Delta_{sol}H = \Sigma\Delta_{hyd} - \Delta_{LE}H$ so $\Delta_{hyd}H(Na^+)$ should be subtracted not added ***C*** *is incorrect because* $\Delta_{sol}H = \Sigma\Delta_{hyd} - \Delta_{LE}H$ so $\Delta_{sol}H(NaCl)$ and $\Delta_{LE}H(NaCl)$ should be added not subtracted ***D*** *is incorrect because* $\Delta_{sol}H = \Sigma\Delta_{hyd} - \Delta_{LE}H$ so $\Delta_{sol}H(NaCl)$ should be added not subtracted	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is D** (the reaction has a positive entropy change of the system) ***A*** *is incorrect because activation energy does not affect thermodynamic feasibility* ***B*** *is incorrect because enthalpy changes of hydration of ion are always negative* ***C*** *is incorrect because the enthalpy change is positive so the entropy change of the surrounding will be negative*	**(1)**

Question Number	Answer	Mark
5(a)	**The only correct answer is C** (−0.3) ***A*** *is incorrect because this is the concentration of the hydrogen ions not the pH* ***B*** *is incorrect because this is the value for* $\log_{10}[H^+]$ *not* $-\log_{10}[H^+]$ ***D*** *is incorrect because this is minus the concentration of hydrogen ions not* $-\log_{10}[H^+]$	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is D** (13.6) ***A*** *is incorrect because this is the value of pOH* ***B*** *is incorrect because this value for pH assumes 0.2 mol barium hydroxide produces 0.1 mol hydroxide ions* ***C*** *is incorrect because this value for pH assumes 0.2 mol barium hydroxide produces 0.2 mol hydroxide ions*	**(1)**

Question Number	Answer	Mark
5(c)	**The only correct answer is C** (0.6) ***A*** *is incorrect because this is the pH of the original hydrochloric acid* ***B*** *is incorrect because this is the pH of the hydrochloric acid diluted with 20* cm^3 *of water* ***D*** *is incorrect because this assumes equal volumes of the same concentration were mixed*	**(1)**

Question Number	Answer	Mark
5(d)	**The only correct answer is C** (4.8) ***A*** *is incorrect because this is the value for pH of the ethanoic acid before the sodium hydroxide is added* ***B*** *is incorrect because this is the value for pH if 20 cm^3 of water were added, not sodium hydroxide* ***D*** *is incorrect because this is the value obtained from multiplying the number of moles of acid in excess by K_a and then using this answer without square rooting for the pH calculation*	**(1)**

Question Number	Answer	Mark
6(a)	**The only correct answer is D** (S_N2 because they have little steric hindrance) ***A*** *is incorrect because primary halogenoalkanes react by S_N2* ***B*** *is incorrect because primary halogenoalkanes react by S_N2* ***C*** *is incorrect because they do not readily form a carbocation*	**(1)**

Question Number	Answer	Mark
6(b)	**The only correct answer is D** (a mixture containing more of enantiomer 2 than enantiomer 1) ***A*** *is incorrect because this is the product for S_N1 reactions* ***B*** *is incorrect because this is the product of an S_N2 reaction* ***C*** *is incorrect because a mixture is formed with more enantiomer 2 than enantiomer 1*	**(1)**

Question Number	Answer	Mark
7(a)	**The only correct answer is B** (compounds **P** and **Q** only) ***A*** *is incorrect because although* ***P*** *will react (as it is an aldehyde)* ***Q*** *will too (as it is a ketone)* ***C*** *is incorrect because* ***R*** *(an ester) and* ***S*** *(a carboxylic acid) will not react with 2,4-DNPH* ***D*** *is incorrect because* ***R*** *(an ester) and* ***S*** *(a carboxylic acid) will not react with 2,4-DNPH*	**(1)**

Question Number	Answer	Mark
7(b)	**The only correct answer is A** (compound **P** only) ***B*** *is incorrect because* ***P*** *has a chiral carbon, but* ***R*** *does not* ***C*** *is incorrect because none of these contains a chiral carbon* ***D*** *is incorrect because only* ***P*** *has a chiral carbon*	**(1)**

Question Number	Answer	Mark
7(c)	**The only correct answer is A** (compound **Q** only) ***B*** *is incorrect because* ***P*** *will form a primary alcohol* ***C*** *is incorrect because* ***P*** *and* ***S*** *will form primary alcohols* ***D*** *is incorrect because* ***S*** *will form a primary alcohol*	**(1)**

Question Number	Answer	Mark
8(a)	**The only correct answer is C** (*E*-octadec-11-enoic acid) ***A*** *is incorrect because C*1 *has to be the carboxylic acid carbon so the double bond is between carbons 11 and 12* ***B*** *is incorrect because C*1 *has to be the carboxylic acid carbon so the double bond is between carbons 11 and 12 and vaccenic acid is an E- isomer* ***D*** *is incorrect because vaccenic acid is an E- isomer*	**(1)**

Question Number	Answer	Mark
8(b)	**The only correct answer is B** ($[COOH]^+$) ***A*** *is incorrect because this has a mass of 43* ***C*** *is incorrect because this has a mass of 40* ***D*** *is incorrect because this has a mass of 45, but cannot easily be formed from vaccenic acid*	**(1)**

Question Number	Answer	Mark
8(c)	**The only correct answer is A** (decolorises misty fumes) ***B*** *is incorrect because the bromine water will decolorise* ***C*** *is incorrect because misty fumes will form with* PCl_5 ***D*** *is incorrect because bromine water will decolorise and misty fumes will form with* PCl_5	**(1)**

Question Number	Answer	Mark
8(d)	**The only correct answer is D** (hydrogen bonds, permanent dipole-dipole forces and London forces) ***A*** *is incorrect because permanent dipole-dipole and London forces are also present* ***B*** *is incorrect because permanent dipole-dipole forces are also present* ***C*** *is incorrect because London forces are also present*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Answer	Additional Guidance	Mark
Penalise incorrect units once only in question 9			
9(a)(i)	• gives expression for calculation of entropy change of the system **(1)** • calculation of entropy change of the system including units **(1)**	Example of calculation = Σ entropy of products - Σ entropy of reactants Allow entropy of products – entropy of reactants Allow substituted values e.g. = (109.2 + (6 × 69.9)) – 343 = (+) 185.6 J K^{-1} mol^{-1} / (+)186 J K^{-1} mol^{-1} / (+) 0.1856 kJ K^{-1} mol^{-1} / (+)0.186 kJ K^{-1} mol^{-1} Ignore SF except 1 SF Correct answer with no working scores 2 Allow TE from incorrect expression	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	An answer that makes reference to one of the following points: • yes because 1 mole of reactant becomes 7 moles of products (and more moles have higher entropy) or yes because a solid becomes (a solid and) a liquid (and liquids have higher entropy than solids)	 Allow yes because the number of moles of products is more than the number of moles of reactants Allow mols/molecules/particles for moles Do not award incorrect numbers of moles Allow TE on (a)(i) for any negative value with 'No because….'	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(b)	• gives expression for calculation of entropy change of the surroundings **(1)** • calculation of entropy change of surroundings including sign and units **(1)**	Example of calculation $= -\frac{\Delta H}{T}$ Allow $= -\frac{88.1}{298}$ or $= -\frac{88\ 100}{298}$ $= -0.29564$ kJ K^{-1} mol^{-1} / -0.296 / -0.30 kJ K^{-1} mol^{-1} or $= -295.64$ J K^{-1} mol^{-1} / -296 / -300 J K^{-1} mol^{-1} Ignore SF except 1 SF Correct answer with no working scores 2	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(c)	An answer that makes reference to the following point: • it is not feasible because ΔS_{total} is negative / the enthalpy change of the surroundings is more negative than the enthalpy change of the system	Allow it is not feasible because $+186 - 296 = -110$ (J K^{-1} mol^{-1}) Allow $\Delta H > T\Delta S$ so ΔG is positive For values in (a)(i) and (b) which give a positive ΔS_{total} only: Allow the reaction is kinetically stable / the reaction rate is very slow	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(d)	• gives the expression for calculation of temperature **(1)** • calculation of temperature that thermal decomposition becomes feasible **(1)**	Example of calculation $T = \frac{\Delta H}{\Delta S_{system}}$ $= \frac{88\ 100}{185.6} = 474.68$ K or $= \frac{88.1}{0.1856} = 474.68$ K Correct answer with no working scores 2 Allow TE throughout this question Ignore SF except 1 and 2 SF	**(2)**

(Total for Question 9 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
10(a)(i)	An answer that makes reference to the following point: • equation	 Allow reversible arrow Do not award HA → H^+ + A^- Ignore state symbols even if incorrect	**(1)**

Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	An answer that makes reference to the following point: • $pH = -\log_{10}[H_3O^+]$	A description in words could take a number of forms Accept $pH = -\lg[H_3O^+]$ Accept $pH = -\log_{10}[H^+]$ Accept $pH = -\log[H^+]$ Accept $pH = -\lg[H^+]$ Award pH is the negative log to the base 10 of oxonium / hydronium / hydroxonium / hydrogen ion concentration	**(1)**

Question Number	Answer	Additional Guidance	Mark
10(a)(iii)	An answer that makes reference to the following point: • gives expression for K_a	$K_a = \frac{[H_3O^+][CH_3COO^-]}{[CH_3COOH]}$ Accept $[H^+]$ in place of $[H_3O^+]$ Allow $[CH_3CO_2^-]$ in place of $[CH_3COO^-]$ Allow $[CH_3CO_2H]$ in place of $[CH_3COOH]$ This may be seen in (iv) Do not award HA and A^- unless defined Do not award rounded brackets	**(1)**

Question Number	Answer	Additional Guidance	Mark
10(a)(iv)	An answer that makes reference to the following point: • gives the expression for $[H_3O^+]$	$[H_3O^+] = \sqrt{K_a \times [CH_3COOH]_{(equilibrium)}}$ Accept $[H^+]$ in place of $[H_3O^+]$ Allow $[H_3O^+] = \frac{K_a \times [CH_3COOH]}{[CH_3COO^-]}$	**(1)**

Question Number	Answer	Additional Guidance	Mark
10(a)(v)	• calculation of concentration of $[H_3O^+]$ using expression in (a)(iv) **(1)** • calculation of pH using expression in (a)(ii) **(1)**	Example of calculation $= \sqrt{1.75 \times 10^{-5} \times 0.25}$ $= 0.0020917 / 0.00209 / 2.0917 \times 10^{-3} / 2.09 \times 10^{-3}$ (mol dm^{-3}) $= -\log_{10}[0.0020917]$ $= 2.6795 / 2.68 / 2.7$ Ignore SF except 1SF Correct answer with no working scores (2) TE from M1 or (iv) but do not award a pH ≥7	**(2)**

Question Number	Answer		Additional Guidance	Mark
10(b)	An explanation that makes reference to the following points:			**(4)** **Expert**
	• (because) hydrochloric acid is fully dissociated	**(1)**	Allow ionised for dissociated	
	• a decrease in concentration of hydrochloric acid by a factor of 10 decreases the hydrogen ion concentration by a factor of 10	**(1)**	Allow concentration decreases by a factor of 10 and increases the pH value by 1 Do not award decreases the pH by 1	
	• ethanoic acid is not fully dissociated (so the pH is much higher than the fully dissociated hydrochloric acid)	**(1)**		
	• when diluted the ethanoic acid dissociates more (and so the pH does not change so much)	**(1)**	Ignore increases the pH value by 0.5 If no other mark scored, award one mark for hydrochloric acid is a strong acid but ethanoic acid is a weak acid	

Question Number	Answer	Additional Guidance	Mark
10(c)	An answer that makes reference to the following points: • (sodium citrate) forms a buffer (with citric acid) **(1)** • which maintains an (almost) constant pH **(1)** • to prevent deterioration (to pH change caused by bacteria or fungal activity) **(1)**	Allow reference to tasting sweeter/less sour	**(3)**

(Total for Question 10 = 13 marks)

Question Number	Answer	Additional Guidance	Mark
11(a)	An answer that makes reference to the following point: • two / 2 / 2nd/ second		**(1)**

Question Number	Answer	Additional Guidance	Mark
11(b)(i)	An answer that makes reference to the following point: • so only changes in iodine concentration affect the rate of reaction	Accept so change in concentration of propanone and hydrochloric acid do not affect the rate of reaction Allow so the concentration/amount of propanone and hydrochloric acid remain (almost) constant Ignore references to need for iodine being used up	**(1)**

Question Number	Answer	Additional Guidance	Mark
11(b)(ii)	An explanation that makes reference to the following points: • a graph of volume of thiosulfate/concentration of iodine against time **(1)** • gives a straight line **(1)** or • a graph of the rate (1/time) against the volume of thiosulfate/concentration of iodine **(1)** • gives a horizontal line **(1)**	Allow volume of thiosulfate/concentration of iodine is proportional to time scores 2 Allow rate does not change as thiosulfate/ concentration of iodine changes scores 2 Ignore references to rate equation	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(b)(iii)	An answer that makes reference to the following points: • balanced ionic equation **(1)** • state symbols **(1)**	$HCO_3^-(aq) + H^+(aq) \rightarrow CO_2(g) + H_2O(l)$ or $HCO_3^-(aq) + H_3O^+(aq) \rightarrow CO_2(g) + 2H_2O(l)$ Correct ionic equation with no state symbols scores (1) Non-ionic equation with correct state symbols scores (1)	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(b)(iv)	An answer that makes reference to the following point: • (sodium hydroxide is an alkali) which also catalyses the reaction so the reaction would not stop	Allow alkalis also change the rate of the reaction Allow it will react with iodine/ halogenoalkane Allow forms triiodomethane / iodoform Allow it will result in multiple substitution	**(1)**

Question Number	Answer	Additional Guidance	Mark
11(c)	A description that makes reference to the following points: • change the concentration of chloride ions **(1)** • compare the two results/rates (to show they are the same) **(1)** OR • use an alternative (strong) acid **(1)** • compare the two results/rates (to show they are the same) **(1)**	Allow any soluble neutral ionic chloride, e.g. NaCl M2 dependent on M1 or near miss	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(d)(i)	An explanation that makes reference to the following points: • Step 3 contains iodine **(1)** • which does not appear in the rate equation **(1)** or • Step 1 and Step 2 contain propanone / hydrogen ions **(1)** • which appear in the rate equation **(1)**	Do not award iodide ion	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(d)(ii)	An answer that makes reference to the following point: • (Step 2) involves the breaking of a (strong) bond/ has a high activation energy / requires a lot of energy (so it is the rate determining step)		**(1)**

(Total for Question 11 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
12(a)	An answer that makes reference to the following point: • 1-hydroxy-4-methylpentan-2-one	Allow 4-methyl-1-hydroxy-pentan-2-one Ignore lack of dashes and use of commas Allow hydroxyl for hydroxy	**(1)**

Question Number	Answer	Additional Guidance	Mark
12(b)	An explanation that makes reference to two of the following points: • both have 5 peaks **(1)** • both have the same number of carbon environments **(1)** • the chemical shift ranges are the same **(1)** • they have the same functional groups / both molecules contains a ketone (C=O) and an alcohol (C−OH) group **(1)**	Allow same number of peaks	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>12(c)(i)</td><td>• two or three correct (1)
• all four correct (1)</td><td>
<table>
<tr><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td>1.3</td><td>2.2</td><td>2.6</td><td>3.8</td></tr>
<tr><td>singlet</td><td>singlet</td><td>singlet</td><td>singlet</td></tr>
<tr><td>6</td><td>3</td><td>2</td><td>1</td></tr>
</table>
</td><td>(2)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>12(c)(ii)</td>
<td>

chemical shift (1)
two or three correct multiplicities (1)
all four correct multiplicities (1)

</td>
<td>
<table>
<tr><td>V</td><td>W</td><td>X</td><td>Y</td><td>Z</td></tr>
<tr><td>0.95</td><td>2.2</td><td>2.3</td><td>1.8 – 4.2</td><td>3.2</td></tr>
<tr><td>doublet</td><td>multiplet</td><td>doublet</td><td>singlet</td><td>singlet</td></tr>
<tr><td>6</td><td>1</td><td>2</td><td>2</td><td>1</td></tr>
</table>
Allow for Y any single value within the range

Allow split into 2 for doublet
Allow no splitting for singlet
</td>
<td>(3)</td>
</tr>
</table>

(Total for Question 12 = 8 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*13(a)</td>
<td>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.
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5-4</td><td>3</td></tr>
<tr><td>3-2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td>
<td>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).

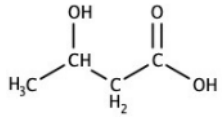
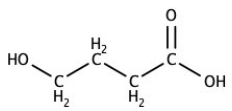
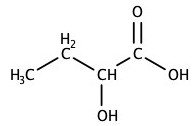
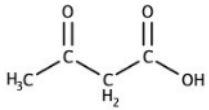
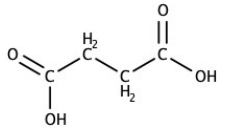
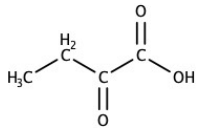
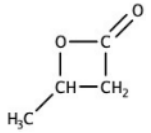
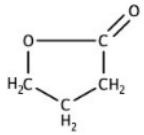
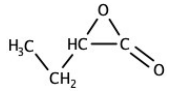
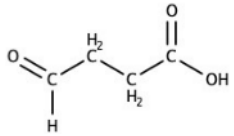
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).

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
Ignore deductions about the final structures</td>
<td>(6)</td>
</tr>
</table>

	Indicative content **IP1** S and T contain carboxylic acid functional groups as they react with sodium hydrogencarbonate solution (releasing bubbles of CO_2) **IP2** S and T contain alcohols they are oxidisable/ give a colour change with (acidified potassium) dichromate(VI) solution **IP3** W and X are (cyclic) esters (so S and T must contain a carboxylic acid and an alcohol) **IP4** S contains a methyl secondary alcohol group / CH_3CHOH as it reacts with iodine in sodium hydroxide solution (but T does not) **IP5** U contains a methyl ketone as it reacts with iodine in sodium hydroxide solution (but V does not) **IP6** V has an aldehyde/ ethyl ketone / (di) carboxylic acid group as it is an oxidation product (and gives no positive iodoform)	Allow structural diagrams of the functional group in place of descriptions / names throughout Ignore aldehydes If only one of S and T are given in IP1/2 award one IP In IP4 and 5 iodoform justification needs mentioning once only	

Question Number	Answer	Additional Guidance	Mark
13(b)	• any 1 correct **(1)** • any further 2 correct **(1)** • any further 3 correct **(1)**	<table><tr><td></td><td>Option 1</td><td rowspan="4">OR</td><td>Option 2</td></tr><tr><td>  S</td><td>  T</td><td>  T</td></tr><tr><td>  U</td><td>  V</td><td>  V</td></tr><tr><td>  W</td><td>  X</td><td>  X</td></tr></table> Allow  as an alternative to V in Option 1 Allow any formula (except molecular formula) including mixed types Allow TE on incorrect number of carbons in S and T	**(3)**

(Total for Question 13 = 9 marks)

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Answer	Additional Guidance	Mark
14(a)(i)	An answer that makes reference to the following points: • the concentrations / amounts of the reactants and products remain constant **(1)** • (because) the rates of the forward and backward reactions are equal **(1)**	Do not award concentrations of reactant/products are equal	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(a)(ii)	An answer that makes reference to the following points: • decrease in moles from three to two **(1)** • high pressure would shift the equilibrium to the right **(1)** • but the value of K_c is large / equilibrium is far to the right/ reaction is near complete **(1)** • so the (increased) pressure would only give a small increase in yield **(1)**	Allow fewer moles/mols/molecules on RHS Allow increase yield / favour the products Allow high pressure has little effect (on yield) Allow (so) increased pressure is not needed Allow K_c is not affected by (changes in) pressure Ignore references to catalyst, safety	**(4)**

Question Number	Answer	Additional Guidance	Mark
14(a)(iii)	An answer that makes reference to the following points: • there is no effect (by the catalysts on the value of K_c) **(1)** • because (both) catalysts speed up both the forward and backward reaction rates equally **(1)**	Allow (because) K_c only changes with temperature	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(b)	• calculation of the number of moles **(1)** • calculation of mole fraction **(1)** • calculation of partial pressure **(1)** • calculation of K_p **and** justification **(1)**	<u>Example of calculation</u> SO_3 | SO_2 | O_2 1.20 | 2.00 – 1.20 = 0.80 (mol) | 1.00 – 0.60 = 0.40 (mol) $\frac{1.20}{2.40} = 0.500$ | $\frac{0.80}{2.40} = 0.333$ | $\frac{0.40}{2.40} = 0.167$ $0.500 \times 3.00 = 1.50$ | $0.333 \times 3 = 1.00$ | $0.167 \times 3.0 = 0.500$ $= \frac{1.50^2}{1.00^2 \times 0.50} = 4.5$ (atm^{-1}) which is not equal to 35.2 (atm^{-1}) (so not at equilibrium)	**(4)**

Question Number	Answer	Additional Guidance	Mark
14(c)(i)	An answer that makes reference to two of the following points: (decreasing value of K_p means) • the partial pressure of products decreases **(1)** • the partial pressure of reactants increases **(1)** • so the equilibrium moves to the left (at higher temperature) **(1)**	Allow / SO_3 decreases Allow the numerator decreases Allow SO_2 and O_2 rises Allow the denominator increases	**(2)**

Question Number	Answer	Additional Guidance	Mark
14(c)(ii)	An answer that makes reference to the following points: • $\Delta_r H$ is negative as (as increasing temperature moves the equilibrium to the left) **(1)** Either • so $\Delta S_{surroundings}$ is positive / becomes less positive as T increases **(1)** **(1)** • ΔS_{total} has decreased / become less positive Or • $\Delta S_{total} = R \ln K$ **(1)** • so as K has decreased $\ln K$ / $R \ln K$ / ΔS_{total} has decreased / becomes less positive **(1)**	Allow reaction is exothermic Do not award entropy change is negative	**(3)**

Question Number	Answer	Additional Guidance	Mark
14(d)(i)	An answer that makes reference to the following point: • equation for K_c	 $K_c = [CO_2]$ Ignore (g) but penalise incorrect state symbols Do not award use of rounded brackets	**(1)**

Question Number	Answer		Additional Guidance	Mark
14(d)(ii)	• calculates K_c	**(1)**	Example of calculation $= 1.48 \times (8.2053 \times 10^{-2} \times 450)^{-1}$ $= 0.040082 / 4.0082 \times 10^{-2} / 4.008 \times 10^{-2} / 4.01 \times 10^{-2}$	**(2)**
	• units	**(1)**	mol dm^{-3} Ignore SF	

(Total for Question 14 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS