Mark Scheme (Results)

Summer 2018

Pearson Edexcel International Advanced Level in Chemistry (WCH04) Paper 01 General Principles of Chemistry I - 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.

Question Number	Answer	Mark
1	**The only correct answer is B** ***A*** *is not correct because this term does not relate to gas chromatography* ***C*** *is not correct because this term is not used* ***D*** *is not correct because this term is not used*	**(1)**

Question Number	Answer	Mark
2	**The only correct answer is D** ***A*** *is not correct because this would not work* ***B*** *is not correct because this would not work* ***C*** *is not correct because this would not work*	**(1)**

Question Number	Answer	Mark
3(a)	**The only correct answer is A** ***B*** *is not correct because UV does not heat chemicals* ***C*** *is not correct because radio waves only affect nuclei* ***D*** *is not correct because UV does not heat chemicals and radio waves only affect nuclei*	**(1)**

Question Number	Answer	Mark
3(b)	**The only correct answer is D** ***A*** *is not correct because IR only makes bonds vibrate/heats up /accelerates reaction* ***B*** *is not correct because microwaves only heat up /accelerates reaction* ***C*** *is not correct because radio waves only affect nuclei*	**(1)**

Question Number	Answer	Mark
4(a)	**The only correct answer is C** ***A*** *is not correct because neither W nor X are methyl ketones* ***B*** *is not correct because Y is not the only molecule which is a methyl ketone* ***D*** *is not correct because Z is not the only molecule which is a methyl ketone*	**(1)**

Question Number	Answer	Mark
4(b)	**The only correct answer is B** ***A*** *is not correct because there are two hydrogen atoms joined to one carbon of the C=C* ***C*** *is not correct because Y is not an alkene* ***D*** *is not correct because X does have geometric isomers*	**(1)**

Question Number	Answer	Mark
4(c)	**The only correct answer is C** ***A*** *is not correct because X also gives a positive result* ***B*** *is not correct because W also gives a positive result* ***D*** *is not correct because neither Y nor Z gives a positive result*	**(1)**

Question Number	Answer	Mark
4(d)	**The only correct answer is B** ***A*** *is not correct because neither molecule W nor X would reduce to pentan-2-ol* ***C*** *is not correct because molecule Z would still have the C=C* ***D*** *is not corrrect because molecule Z would still have the C=C*	**(1)**

Question Number	Answer	Mark
4(e)	**The only correct answer is D** ***A*** *is not correct because a straight-chain is produced* ***B*** *is not correct because a straight-chain is produced* ***C*** *is not correct because molecule Z would also form a branched molecule*	**(1)**

Question Number	Answer	Mark
4(f)	**The only correct answer is D** ***A*** *is not correct because Y has a* CH_3CH_2 *likely to produce a fragment m/e = 29* ***B*** *is not correct because W has a HCO likely to produce a fragment m/e = 29* ***C*** *is not correct because Z would not be expected to produce a fragment m/e = 29*	**(1)**

Question Number	Answer	Mark
5(a)	**The only correct answer is A** ***B*** *is not correct because the concentrations should be squared and not doubled* ***C*** *is not correct because the squared concentrations should be multiplied and not added* ***D*** *is not correct because the concentrations should be squared and not doubled, and multiplied not added.*	**(1)**

Question Number	Answer	Mark
5(b)	**The only correct answer is D** ***A*** *is not correct because dichromate(VI) is not reduced* ***B*** *is not correct because NaOH does not decolorise the solution* ***C*** *is not correct because the equilibrium position shifts to the right*	**(1)**

Question Number	Answer	Mark
6	**The only correct answer is A** ***B*** *is not correct because the units are inverted* ***C*** *is not correct because the decimetres are to the power +3* ***D*** *is not correct because the solids are absent from* K_c	**(1)**

Question Number	Answer	Mark
7(a)	**The only correct answer is A** ***B*** *is not correct because total pressure is multiplied by the mole fraction and not moles of chlorine* ***C*** *is not correct because total pressure is multiplied and not divided by the mole fraction* ***D*** *is not correct because total pressure is not divided by the moles of chlorine*	**(1)**

Question Number	Answer	Mark
7(b)	**The only correct answer is B** ***A*** *is not correct because* K_p *has been used as total pressure and the two partial pressures quoted are subtracted from it* ***C*** *is not correct because the two partial pressures have been multiplied by* K_p *instead of dividing by* K_p ***D*** *is not correct because this is the inverse value*	**(1)**

Question Number	Answer	Mark
8(a)	**The only correct answer is B** ***A*** *is not correct because low pressure favours the reactants* ***C*** *is not correct because both high temperature and low pressure favour the reactants* ***D*** *is not correct because high temperature favours the reactants*	**(1)**

Question Number	Answer	Mark
8(b)	**The only correct answer is C** ***A*** *is not correct because the value of* K_c *is a ratio not a quantity of a substance* ***B*** *is not correct because 1 mol of CO cannot form more than 1 mol of methanol* ***D*** *is not correct because this ignores the CO*	**(1)**

Question Number	Answer	Mark
9(a)	**The only correct answer is B** ***A*** *is not correct because the −148 has been omitted* ***C*** *is not correct because the −148 has been omitted and the value has not been halved* ***D*** *is not correct because the enthalpy value has to be halved for one mole of chloride ions*	**(1)**

Question Number	Answer	Mark
9(b)	**The only correct answer is D** ***A*** *is not correct because hydration is from gaseous ions not those in a lattice* ***B*** *is not correct because hydration is nothing to do with the forming of ions* ***C*** *is not correct because potassium ions are larger*	**(1)**

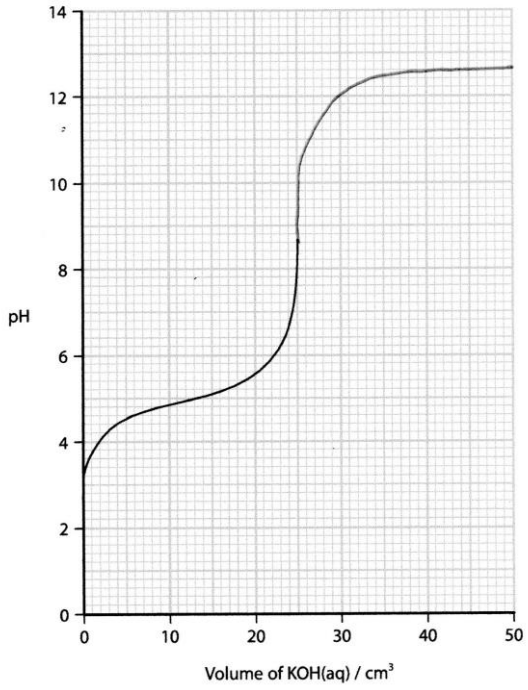
Question Number	Answer	Mark
10	**The only correct answer is C** ***A*** *is not correct because these are the base and its conjugate acid* ***B*** *is not correct because these are not conjugate pairs* ***D*** *is not correct because these are not conjugate pairs*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
11(a)	$[H^+] = \sqrt{(1.34 \times 10^{-5} \times 0.0500)} / = 8.185\ldots \times 10^{-4}$ (1) pH= ($-\log 8.185\ldots \times 10^{-4} = 3.08696$)= 3.09 (1) Correct answer without working scores 2 **Allow** TE from incorrect $[H^+]$ only if pH<7	3 / 3.1 ≥3dp −3.09	**(2)**

Question Number	Acceptable Answers	Reject	Mark
11(b)(i)	pH= (14 – ($-\log 0.04$)=) 12.60206/12.60/12.6 **OR** pH= $-\log (1.0 \times 10^{-14} \div 0.04)$ = 12.60206/12.60/12.6 **IGNORE** SF except 1 or 2	13	**(1)**

Question Number	Acceptable Answers	Reject	Mark
11(b)(ii)	Sketch continues vertical until between 10-11 then plateau at pH~12-12.6 **ALLOW** TE for plateau at answer to (b)(i) Exemplar graph  		**(1)**

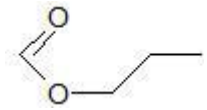
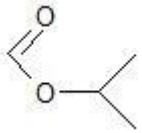
Question Number	Acceptable Answers	Reject	Mark
11(b)(iii)	pH at half equivalence point = pK_a = 4.9 to 5.0 (1) K_a = (inv log −pH= inv log −4.9= 1.26.. x 10^{-5}/0.0000126) or (inv log −pH= inv log −5.0= 1.00 x 10^{-5}/0.0000100) = 1.0 x 10^{-5}/0.000010/ 1.3 x 10^{-5}/0.000013(mol dm^{-3}) (1) Correct final answer scores (2)	Not 2 SF Incorrect units	**(2)**

Question Number	Acceptable Answers	Reject	Mark
11(b)(iv)	Indicator is thymolphthalein **ALLOW** Alizarin yellow R if the pH has been given as 13 in (b)(i) (1) Because the pH range of the indicator must lie within the large / vertical pH change **ALLOW** the pH range overlaps with the vertical part of the sketch / the equivalence point/neutralisation point/end point lies with the pH range of the indicator / pK_{in} value is within the vertical part of the sketch (1) **ALLOW** Max (1) if a weak acid-weak base titration curve given in (b)(ii) and the comment made that no indicator would be suitable because there is no vertical section of the curve Marking point 2 is dependent on marking point 1		**(2)**

Question Number	Acceptable Answers	Reject	Mark
11 (c)	Method 1 **Marking point 1** Initial moles of butanoic acid =0.025 x 0.06=1.5 x10^{-3}(mol) **and** moles of alkali = butanoate= 0.015 x 0.08 =1.2x10^{-3}(mol) (1) **Marking point 2** Equilibrium moles of butanoic acid in buffer = (1.5 x 10^{-3} − 1.2 x 10^{-3}) = 3(.0) x 10^{-4} (mol) (1) **Marking point 3** Concentration of hydrogen ions [H^+] = (K_a x (3 x 10^{-4} ÷ 0.04) ÷ (1.2 x 10^{-3} ÷ 0.04)) = 3.75 x 10^{-6} (mol dm^{-3}) (1) **Marking point 4** pH = (-log 3.75 x 10^{-6})= 5.42597/5.426/5.43/5.4 (1) Method 2 (use of the Henderson-Hasselbalch equation) pH = pK_a + log ([A^-] ÷ [HA]) **Marking point 1** Initial moles of butanoic acid =0.025 x0.06= 1.5 x10^{-3}(mol) **and** moles of alkali = butanoate = 0.015 x 0.08 =1.2 x10^{-3}(mol) (1) **Marking point 2** Equilibrium moles of butanoic acid in buffer = (1.5 x 10^{-3} − 1.2 x 10^{-3}) = 3(.0) x 10^{-4} (mol) (1) **Marking point 3** [butanoic acid] in buffer = (3x10^{-4} ÷ 0.04) = 7.5x10^{-3} (mol dm^{-3}) **and** [butanoate] = (1.2 x 10^{-3} ÷ 0.04) = 0.030 (mol dm^{-3}) **and** pK_a = 4.8239 … (1) **Marking point 4** pH = (4.8239…+ log (0.030 ÷ 7.5 x 10^{-3})) = 5.42597/5.426/5.43/5.4 (1) Correct answer without working scores (4) Ignore SF except 1SF	5 5	**(4)**

Question Number	Acceptable Answers	Reject	Mark
***11(d)**	**Marking point 1** Reference to (large) reservoirs/excess of **both** ethanoic acid and ethanoate ions/sodium ethanoate **ALLOW** Reference to (large) reservoirs/excess of **both** the acid and its conjugate base/salt (1) **Marking point 2** Reference to added OH^- ions reacting with ethanoic acid OR $CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$ **ALLOW** Reference to added OH^- ions reacting with hydrogen ions to form water / $H^+ + OH^- \rightarrow H_2O$ followed by further dissociation of the ethanoic acid (1) **Marking point 3** The concentrations of ethanoic acid and ethanoate ions do not change (significantly and hence the pH doesn't change appreciably) / the ratio of [ethanoic acid]:[ethanoate ion] does not change (significantly and hence the pH doesn't change appreciably) **ALLOW** the ratio of ethanoic acid : ethanoate ion does not change (significantly and hence the pH doesn't change appreciably) (1) **IGNORE** Keeps pH constant	Reservoir of H^+	**(3)**

(Total for Question 11 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
12 (a)(i)	 (1)  (1) **ALLOW** One mark for two correct isomers if drawn with displayed/structural formulae **IGNORE** Other formulae if correct skeletal formulae given Orientation/bond angles		**(2)**

Question Number	Acceptable Answers	Reject	Mark
12(a)(ii)	% C =(((12 x 4) ÷ 88) x 100=) 54.545/54.55/ 54.5/55% **IGNORE** SF except 1	54/ 54.54	**(1)**

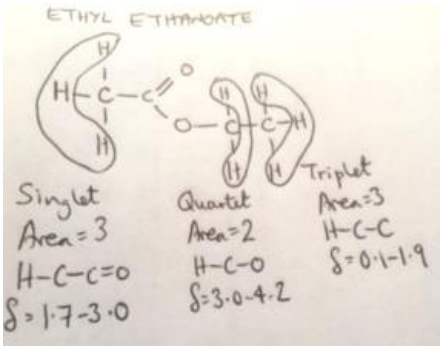
Question Number	Acceptable Answers	Reject	Mark
12(b)	(Reagent) methanol **Allow** methan-1-ol **IGNORE** Strong acid such as sulfuric acid/H_2SO_4 (1) (C_2H_5COOH +) CH_3OH (⇌ $C_2H_5COOCH_3$ +) H_2O (1) **IGNORE** state symbols even if incorrect Mark independently No TE on incorrect reagent	NaOH C_4HO	**(2)**

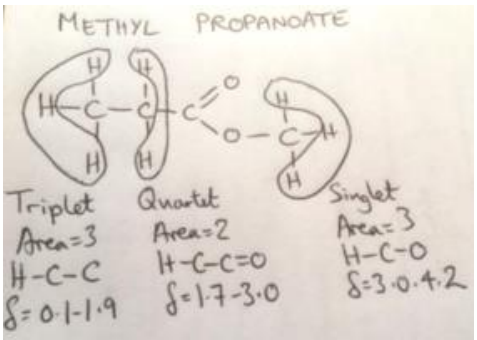
Question Number	Acceptable Answers	Reject	Mark
12 (c)(i)	**Accept** formulae and names in any order (Equation) $CH_3COOC_2H_5 + NaOH \rightarrow CH_3COO^{(-)}Na^{(+)} + C_2H_5OH$ **Allow** ionic equation $CH_3COOC_2H_5 + OH^- \rightarrow CH_3COO^- + C_2H_5OH$ (1) (Names) (Sodium) ethanoate **and** ethanol **Allow** ethan-1-ol (1) **IGNORE** state symbols even if incorrect Mark independently No TE on incorrect ester and its hydrolysis products	$CH_3COO-Na$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
12 (c)(ii)	(It is a catalyst because) alkali speeds up the reaction (compared to water) (1) **IGNORE** comments on activation energy (It is not a catalyst because) the amount of alkali present would decrease/ would be used up / is not regenerated (1) **IGNORE** references to the alkali taking part in the reaction	Reaction goes to completion/ Yield is increased	**(2)**

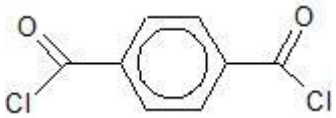
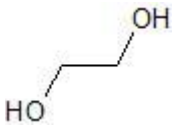
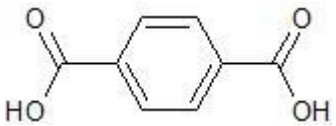
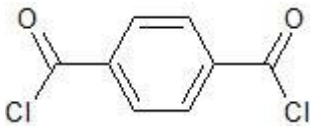
<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>*12 (d)</td><td>
For marking points 1 to 4, use the table below for reference and award 1 mark for each complete row.
<table>
<tr><td></td><td>Ethyl ethanoate</td><td>Methyl propanoate</td></tr>
<tr><td>Similarities (any 2 from)</td><td colspan="2">Both have</td></tr>
<tr><td></td><td colspan="2">3 hydrogen or proton environments</td></tr>
<tr><td></td><td colspan="2">Peak area 3:2:3</td></tr>
<tr><td></td><td colspan="2">Singlet: quartet: triplet (any order)</td></tr>
<tr><td></td><td colspan="2">Triplet at 0.1 – 1.9 / peak area 3 at 0.1 – 1.9</td></tr>
<tr><td></td><td colspan="2">Peaks at δ = 0.1 - 1.9, 1.7 - 3.0 and 3.0 – 4.2</td></tr>
<tr><td>Differences (any 2 from)</td><td></td><td></td></tr>
<tr><td>Quartet peak</td><td>at δ = 3.0 – 4.2</td><td>at δ = 1.7 – 3.0</td></tr>
<tr><td>Singlet peak</td><td>at δ = 1.7 – 3.0</td><td>at δ = 3.0 – 4.2</td></tr>
<tr><td>Peak with area 2</td><td>at δ = 3.0 – 4.2</td><td>at δ = 1.7 – 3.0</td></tr>
<tr><td>(Singlet) peak with area 3</td><td>at δ = 1.7 – 3.0</td><td>at δ = 3.0 – 4.2</td></tr>
<tr><td rowspan="2">Peak at δ = 3.0 – 4.2</td><td>is a quartet</td><td>is a singlet</td></tr>
<tr><td>has area 2</td><td>has area 3</td></tr>
<tr><td rowspan="2">Peak at δ = 1.7 – 3.0</td><td>is a singlet</td><td>is a quartet</td></tr>
<tr><td>has area 3</td><td>has area 2</td></tr>
</table>
Marking point 5
Suitable explanation of one splitting pattern to include reference to (n+1) rule (1)

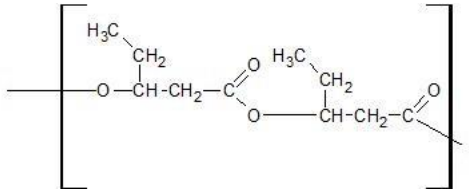
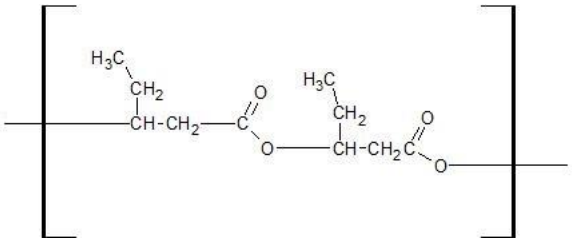
Example of annotated diagrams:



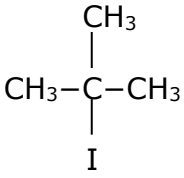


These diagrams provide evidence for marking points 1 to 4 inclusive and would thus score (4)
</td><td></td><td>(5)</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
12 (e)(i)	(monomer structures in any order)  OR  (1)  (1) **ACCEPT** structural, displayed and /or Kekulé formulae, or any combination, such as $HOOC-C_6H_4-COOH$ $ClOC-C_6H_4-COCl$   for the diacid / diacyl chloride **OR** $HOCH_2CH_2OH$ /$(CH_2OH)_2$ for the diol		**(2)**

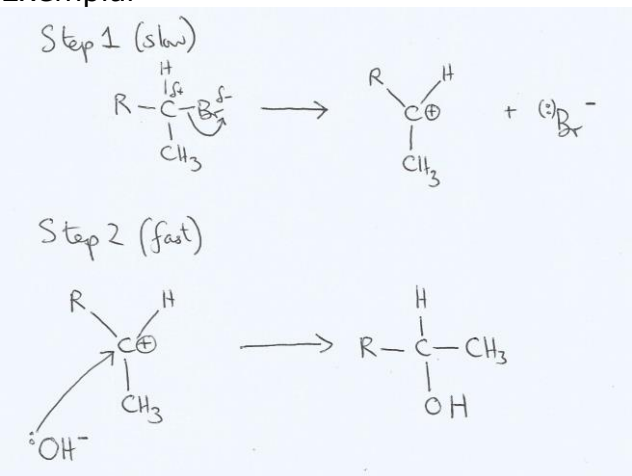
Question Number	Acceptable Answers	Reject	Mark
12(e)(ii)	Suitable diagram, e.g.  Ester link **and** continuation 'bonds' (1) Rest of repeat unit correct (1) **ACCEPT** use of displayed/skeletal formulae **ALLOW** C-O- at either end i.e.  **ALLOW** more than two repeat units **ALLOW** C_2H_5 for CH_3CH_2 **IGNORE** missing brackets or use of 'rounded' brackets	Missing 'H's	**(2)**

(Total for Question 12 = 18 marks)

Question Number	Acceptable Answers	Reject	Mark
13(a)	Any two correct formulae scores 1 All three correct formulae scores 2 Primary – $CH_3(CH_2)_2CH_2I$ / $CH_3CH_2CH_2CH_2I$ / $(CH_3)_2CHCH_2I$ Secondary – $CH_3CHICH_2CH_3$ / $CH_3CHIC_2H_5$ Tertiary – $(CH_3)_3CI$ **COMMENT** Penalise skeletal / displayed formulae once only but **ALLOW** 'semi-structural' e.g. $CH_3-CH_2-CH_2-CH_2-I$ and  **IGNORE** missing brackets i.e. allow $CH_3CI(CH_3)CH_3$ or $CH_3CICH_3CH_3$	$CH_3CH_3CH_3CI$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
13(b)(i)	First order with respect to C_3H_7Br (1) Comparing Expts 2 and 3 the rate doubles as the concentration doubles (and $[OH^-]$ does not change) (1) First order with respect to OH^- (1) Comparing Expts 1 and 2 the rate quadruples as the concentration quadruples (and $[C_3H_7Br]$ does not change) (1) **ALLOW** comparison of Expts 1 and 3 if the order w.r.t. to one reactant has already been found		**(4)**

Question Number	Acceptable Answers	Reject	Mark
13(b)(ii)	They are spectator ions / they do not take part in the reaction **ALLOW** (Sodium and potassium ions) are not involved in the rate determining step IGNORE reference to zero order or taking part in a fast step		**(1)**

Question Number	Acceptable Answers	Reject	Mark
13(c)(i)	Suitable reaction mechanism to include: **Marking point 1** Curly arrow from C–Br bond to/just beyond Br **and** dipole on C–Br bond (1) **Marking point 2** Formation of carbocation **and** bromide ion (1) **ALLOW** bromide ion / NaBr shown as a final product **Marking point 3** Curly arrow from lone pair on hydroxide ion to C+ on carbocation **and** formation of alcohol product (1) Exemplar  **ALLOW** (for a correct S_N2 reaction) **M1** for correct dipole **and** curly arrow showing C-Br bond breaking **M3** for correct curly arrow from a lone pair on the OH^- ion to the δ+ carbon, either in a transition state or not, **and** the alcohol product	Incorrect starting bromoalkane Curly arrow from the charge on OH^-	**(3)**

Question Number	Acceptable Answers	Reject	Mark
13(c)(ii)	Slow step only involves one species / only 2-bromopentane is involved in the rate-determining step / there are two steps, first slow and second fast / OH^- is not involved in the slow step **and** so the reaction is first order (so consistent with the rate equation) / so only 2-bromopentane is in the rate equation	S_N2	**(1)**

Question Number	Acceptable Answers	Reject	Mark
13(c)(iii)	Carbocation is (trigonal) planar about the C+ **ALLOW** Reaction site is (trigonal) planar (1) **EITHER** Attack by nucleophile/OH^- can be (equally) from the top or bottom/either side (of the carbocation) (1) Forming a racemate/racemic mixture/equal number of moles of each optical isomer (1) **OR** The bromide ion obstructs attack by the hydroxide ion (1) Forming mixture of two optical isomers in which one predominates (1) **TE on S_N2 in (c)(i):** Attack by nucleophile is only from one side of the molecule (1) The bromide ion leaves from the other side of the molecule / molecule inverts (1) Forming only one optical isomer (1)	Halogenoalkane is planar	**(3)**

Question Number	Acceptable Answers	Reject	Mark
13(d)	Gradient = (−2.5 ÷ 0.0004 =) −6250 ± 50 (K) (1) Activation Energy = (−(−6250 x 8.31)) = +51937.5/51900/52000 J mol^{-1} OR + 51.9 / 52 kJ mol^{-1} Value in the range 51-53 (1) Sign and units (1) **ALLOW** Max (2) for TE for incorrect slope x −8.31 **IGNORE** SF	K^{-1} Incorrect units Negative value Incorrect units	**(3)**

(Total for Question 13 =17 marks)
Total for Section B = 50 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
14(a)(i)	Any two from: Bubble(s)/fizzing/effervescence (1) (White) Liquid/paste produced **ALLOW** Solution forms (1) Temperature decreases (1) Pungent smell (of ammonia)/pungent gas (1) **IGNORE** Gas produced Chemical test for ammonia and water	Incorrect chemical tests and incorrect observations e.g. white ppte / misty fumes	**(2)**

Question Number	Acceptable Answers	Reject	Mark
14(a)(ii)	(High) positive value is expected because: 3 moles → 13 moles **ALLOW** More moles of product (then reactant) (1) (two) solids → gas and/or liquid (+ one solid) (1) <u>Alternative answer</u> (High) positive value is expected because: Entropy of the surroundings for an endothermic reaction is negative (1) The reaction is feasible with the total entropy being positive (so entropy of the system has to be a large enough positive value for this to be true) (1)	Negative value scores (0) Incorrect numbers of moles quoted Molecules	**(2)**

Allow TE throughout all parts (b)(i)-(iv) even if the calculation results in an incorrect sign

Ignore SF, except 1SF, in (b)(i), (b)(iii) and (b)(iv)

Question Number	Acceptable Answers	Reject	Mark
14 (b)(i)	$\Sigma S^{\ominus}_{(products)}$ = ((2 x 192.3) + (2 x 69.9) + 213.8 =) (+)738.2 J K^{-1} mol^{-1} (1) $\Sigma S^{\ominus}_{(reactants)}$ =((2 x 151.1)+ 99.7 =) (+)401.9 J K^{-1} mol^{-1} (1) $\Delta S^{\ominus}_{system}$ = (738.2 – 401.9 =) **+**336.3 J K^{-1} mol^{-1} (1) Correct answer without working scores (3)		**(3)**

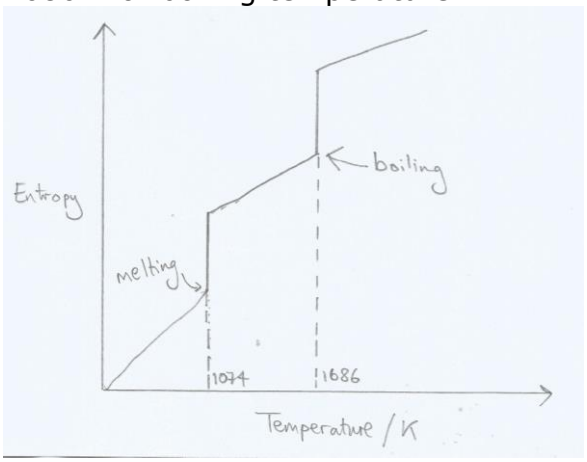
Question Number	Acceptable Answers	Reject	Mark
14(b)(ii)	$\Sigma \Delta H^{\ominus}_{(products)}$ = ((2 x −285.8) + (2 x −46.1)+ −992.1=) −1655.9 (kJ mol^{-1}) **and** $\Sigma \Delta H^{\ominus}_{(reactants)}$ = ((2 x −365.6) + −944.7 =) −1675.9 (kJ mol^{-1}) (1) $\Delta H^{\ominus}_{reaction}$ = (−1655.9 – −1675.9 =) +20 kJ mol^{-1} (1) Correct answer without working scores (2)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
14(b)(iii)	$\Delta S^{\ominus}_{surroundings}$ = (− $\Delta H \div T$) = − $\frac{20\,000 \text{ J mol}^{-1}}{298 \text{ K}}$ (1) = − 67.11409…/−67.1 / −67 J K^{-1} mol^{-1} (1) Correct answer without working scores (2)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
14(b)(iv)	$\Delta S^{\ominus}_{total} = \Delta S^{\ominus}_{system} + \Delta S^{\ominus}_{surroundings}$ $\Delta S^{\ominus}_{total}$ = +336.3 − 67.1 = +269.2 J K^{-1} mol^{-1}		**(1)**

Question Number	Acceptable Answers	Reject	Mark
14 (c) (i)	Molecules of chlorine disperse / diffuse / spread / mix into the top jar **ALLOW** Chlorine/it fills the (new) gas jar (1) Therefore (the system has) greater entropy / greater randomness / greater disorder (1) **M2 is dependent on M1**	Reacts Enthalpy	**(2)**

Question Number	Acceptable Answers	Reject	Mark
14(c)(ii)	<table><tr><th>Molecule A</th><th>Molecule B</th></tr><tr><td>(2</td><td>2</td></tr><tr><td>3</td><td>1)</td></tr><tr><td>1</td><td>3</td></tr><tr><td>4</td><td>0</td></tr><tr><td>0</td><td>4</td></tr></table> The bottom three rows can be completed in any order		**(1)**

Question Number	Acceptable Answers	Reject	Mark
14(d)	General shape of increase from left to right **ALLOW** straight line (1) Two vertical stages for melting and boiling (1) Labelling to include the use of 1074K for melting and 1686K for boiling temperature (1)  	Horizontal sections	**(3)**

Question Number	Acceptable Answers	Reject	Mark
***14 (e)**	Any two from: In the solid / lattice, the ions are fixed (1) But in the solution the ions are mobile /more dispersed / more spread out/ more random (so entropy has increased) (1) (Dissolving results in) an increase in the number of moles of particles **and** from one to two/ $NaCl \rightarrow Na^+ + Cl^-$ (1) The hydrogen bonds between the water molecules are disrupted (1)	Sodium chloride molecules Due to having more energy	**(2)**

TOTAL FOR SECTION C (QUESTION 14) = 20 MARKS

TOTAL FOR PAPER = 90 MARKS

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