Mark Scheme (Results)

Summer 2017

Pearson Edexcel GCE
in Chemistry (6CH04) Paper 01
General Principles of Chemistry I -
Rate, 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.
- 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	Answer	Mark
1	**1. The only correct answer is C** ***A*** *is not correct because colour increases as bromine is formed* ***B*** *is not correct because colour increases as bromine is formed and conductivity increases as ions are removed* ***D*** *is not correct because conductivity increases as ions are removed*	**(1)**

Question Number	Answer	Mark
2	**2. The only correct answer is D** ***A*** *is not correct because this would be for 1 half-life* ***B*** *is not correct because this is 1/3 but incorrect for 3 half-lives* ***C*** *is not correct because this would be for 2 half-lives*	**(1)**

Question Number	Answer	Mark
3(a)	**3(a). The only correct answer is A** ***B*** *is not correct because the rate constant does not change with a change in concentration* ***C*** *is not correct because the rate constant does not change with a change in concentration* ***D*** *is not correct because the rate constant does not change with a change in concentration*	**(1)**

Question Number	Answer	Mark
3(b)	**3(b). The only correct answer is D** ***A*** *is not correct because there are not 2 molecules of NO_2 in the slow step* ***B*** *is not correct because there are additional species in the slow step that are not in the rate equation* ***C*** *is not correct because there are not 2 molecules of NO_2 in the slow step*	**(1)**

Question Number	Answer	Mark
4	**4. The only correct answer is B** ***A*** *is not correct because a high rate constant would give a fast reaction* ***C*** *is not correct because a low activation energy would give a fast reaction* ***D*** *is not correct because a low activation energy would give a fast reaction and a low activation energy would give a fast reaction*	**(1)**

Question Number	Answer	Mark
5	**5. The only correct answer is C** ***A*** *is not correct because change from solid to gas so increase in entropy* ***B*** *is not correct because change from solid to gas so increase in entropy* ***D*** *is not correct because change from solid to gas so increase in entropy*	**(1)**

Question Number	Answer	Mark
6	**6. The only correct answer is B** ***A*** *is not correct because high pressure decreases the yield* ***C*** *is not correct because low temperature and high pressure decrease the yield* ***D*** *is not correct because low temperature decreases the yield*	**(1)**

Question Number	Answer	Mark
7	**7. The only correct answer is A** ***B*** *is not correct because* the conjugate base is incorrect ***C*** *is not correct because ethanoic acid is a weaker acid than methanoic acid so is not the acid in this reaction* ***D*** *is not correct because ethanoic acid is a weaker acid than methanoic acid so is not the acid in this reaction*	**(1)**

Question Number	Answer	Mark
8	**8. The only correct answer is A** ***B*** *is not correct because this is the pH at 298 K* ***C*** *is not correct because this is incorrect as there are more* H^+ *ions at higher temperature so pH is lower than 7* ***D*** *is not correct because* this is pK_w	**(1)**

Question Number	Answer	Mark
9	**9. The only correct answer is B** ***A*** *is not correct because this is pH of 1.0 mol* dm^{-3} *solution* ***C*** *is not correct because this is* pK_a ***D*** *is not correct because this is the answer when square root is not taken to calculate* $[H^+]$	**(1)**

Question Number	Answer	Mark
10(a)	**10(a). The only correct answer is B** ***A*** *is not correct because this is the pH of the weak acid* ***C*** *is not correct because this is the neutral pH* ***D*** *is not correct because this is the pH with excess NaOH*	**(1)**

Question Number	Answer	Mark
10(b)	**10(b). The only correct answer is B** ***A*** *is not correct because this assumes a 1:2 mole ratio* ***C*** *is not correct because this has not used 20* cm^3 *from the graph and assumed equal volumes* ***D*** *is not correct because this has mixed up the two volumes*	**(1)**

Question Number	Answer	Mark
10(c)	**10(c). The only correct answer is D** ***A*** *is not correct because changes at too low pH range* ***B*** *is not correct because changes at too low pH range* ***C*** *is not correct because not the best as complete range of pH change is not in the vertical region of the graph*	**(1)**

Question Number	Answer	Mark
10(d)	**10(d). The only correct answer is B** ***A*** *is not correct because this is too low, the best buffer solution is formed when the weak acid is half-neutralised* ***C*** *is not correct because this is the volume to reach the end point* ***D*** *is not correct because this is when there is excess alkali present*	**(1)**

Question Number	Answer	Mark
11	**11. The only correct answer is D** ***A*** *is not correct because low boiling point as no hydrogen bonding* ***B*** *is not correct because - low boiling point as no hydrogen bonding* ***C*** *is not correct because higher boiling point than A or B as hydrogen bonding but fewer hydrogen bonds than D*	**(1)**

Question Number	Answer	Mark
12	**12. The only correct answer is A** ***B*** *is not correct because does not have* CH_3CO *in structure* ***C*** *is not correct because does not have* CH_3CO *in structure* ***D*** *is not correct because does not have* CH_3CO *in structure*	**(1)**

Question Number	Answer	Mark
13	**13. The only correct answer is C** ***A*** *is not correct because* alkanes are not oxidised to carboxylic acids ***B*** *is not correct because ketones are not oxidised to carboxylic acids* ***D*** *is not correct because this would give butanoic acid*	**(1)**

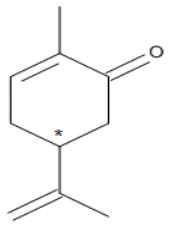
Question Number	Answer	Mark
14(a)	**14(a). The only correct answer is A** ***B*** *is not correct because does not reduce carboxylic acids to alcohols* ***C*** *is not correct because does not reduce carboxylic acids to alcohols* ***D*** *is not correct because does not reduce carboxylic acids to alcohols*	**(1)**

Question Number	Answer	Mark
14(b)	**14(b). The only correct answer is C** ***A*** *is not correct because does not react with a carboxylic acid to form an acyl chloride* ***B*** *is not correct because does not react with a carboxylic acid to form an acyl chloride* ***D*** *is not correct because does not react with a carboxylic acid to form an acyl chloride*	**(1)**

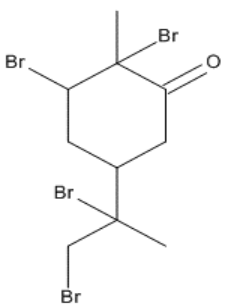
Question Number	Answer	Mark
14(c)	**14(c). The only correct answer is C** ***A*** *is not correct because will not produce a secondary amide* ***B*** *is not correct because will not produce a secondary amide* ***D*** *is not correct because will not produce a secondary amide*	**(1)**

TOTAL FOR SECTION A = 20 MARKS

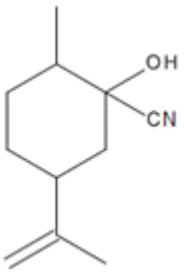
Section B

Question Number	Acceptable Answers	Reject	Mark
15(a)(i)	 ALLOW Any way of identifying the chiral carbon, including a circle, provided that it does not include any other carbon atoms	Any additional carbon atoms indicated	**(1)**

Question Number	Acceptable Answers	Reject	Mark
15(a)(ii)	$C_{10}H_{14}O$ ALLOW Atoms in any order, i.e $C_{10}OH_{14}$ / $H_{14}C_{10}O$ / $H_{14}OC_{10}$ / $OC_{10}H_{14}$ / $OH_{14}C_{10}$ IGNORE Any other formulae as working	Superscripts e.g. $C^{10}H^{14}O$	**(1)**

Question Number	Acceptable Answers	Reject	Mark
15(a)(iii)	 2 bromines added across 1 double bond **(1)** 2 bromines added across other double bond **(1)** ALLOW cis or trans isomer in ring IGNORE bond angles		**(2)**

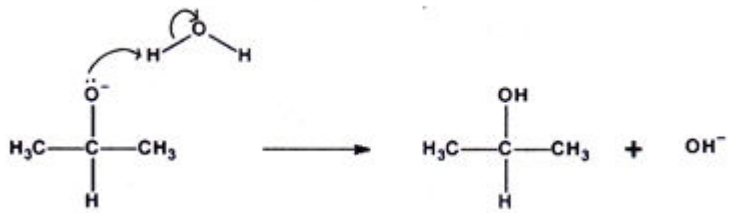
Question Number	Acceptable Answers	Reject	Mark
15(b)(i)	There are two hydrogen atoms attached to one of the carbon atoms in C=C ALLOW not a carbon in C=C with two different groups attached ALLOW there is CH2 at one end of C=C IGNORE restricted rotation	There are not four different groups attached to C=C	**(1)**

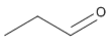
Question Number	Acceptable Answers	Reject	Mark
15(b)(ii)	 ACCEPT C≡N /-≡N for CN O-H for OH IGNORE Bond angles	C=N Incorrect connectivity of OH / CN	**(1)**

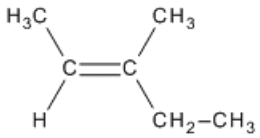
Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	8 / eight (proton environments)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
15(b)(iv)	C=O ((alkyl) ketone) **and** 1700 – 1680 / 1680 -1700 (cm^{-1}) OR C=C **and** 1669 – 1645 / 1700 – 1680 (cm^{-1})	C=O aryl ketone	**(1)**

Question Number	Acceptable Answers	Reject	Mark
15(c)(i)	 Dipole **and** curly arrow from C=O **bond** to O **(1)** Lone pair on H^- **and** curly arrow from H^- to C of C=O **(1)** If no mark is scored, allow (1) for both curly arrows		**(2)**

Question Number	Acceptable Answers	Reject	Mark
15(c)(ii)	 Lone pair on O^- / H_2O **and** curly arrow from O^- to H **and** curly arrow from H-O **bond** to O in H_2O Penalise once only if curly arrow does not start from lone pair in (i) and (ii) Penalise missing lone pairs once only in (i) and (ii)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
15(d)(i)	But-1-ene will produce CH_3CH_2CHO / C_2H_5CHO /  **and** HCHO / CH_2O **(1)** (Whereas) but-2-ene will (only) produce CH_3CHO /  **(1)** If no other mark awarded: ALLOW 1 mark for but-1-ene produces propanal and methanal and but-2-ene produces ethanal		**(2)**

Question Number	Acceptable Answers	Reject	Mark
15(d)(ii)	 ALLOW Any unambiguous structure e.g. displayed, skeletal or structural formula or any combination of these ALLOW *E* or *Z* isomer		**(1)**

(Total for Question 15 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	Second (order) **(1)** The (initial) rate is (directly) proportional to $[HI]^2$ / rate $\propto [HI]^2$ ALLOW because the graph is a straight line, provided M1 has been awarded ALLOW There is a positive correlation, provided M1 has been awarded **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	(Rate =) $k[HI]^2$ ALLOW R/r for rate TE from (a)(i)		**(1)**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	Correct answer with or without working scores (2) ALLOW 2nd stage as TE on 1st stage. **EITHER** Moles/min = 0.00620 x 60 = 0.372 **(1)** Molecules/min = $6.02 \times 10^{23} \times 0.372$ $= 2.2394 \times 10^{23}$ $= 2.24 \times 10^{23}$ **(1)** **OR** Molecules/s = $0.00620 \times 6.02 \times 10^{23}$ $= 3.7324 \times 10^{21}$ **(1)** Molecules/min = $3.7324 \times 10^{21} \times 60$ $= 2.2394 \times 10^{23}$ $= 2.24 \times 10^{23}$ **(1)** IGNORE SF except 1SF		**(2)**

Question Number	Acceptable Answers	Reject	Mark
***16(b)**	Correct answer, to 3SF with or without working, scores (5) **Method 1** **Calculation of A** (2 marks) $A = \ln 2.32 \times 10^{-3} + (\frac{184000}{8.31} \times \frac{1}{700})$ Or $A = \ln 2.32 \times 10^{-3} + (\frac{184}{0.00831} \times \frac{1}{700})$ **(1)** $A = -6.066 + 31.631$ $= 25.565$ **(1)** **Calculation of k (3 marks)** $\ln k = -(\frac{184000}{8.31} \times \frac{1}{800}) + 25.565$ Or $\ln k = -(\frac{184}{0.00831} \times \frac{1}{800}) + 25.565$ **(1)** TE on value for A $\ln k = -27.677 + 25.565$ $= -2.112$ **(1)** TE on value for A $k = 0.121$ $(dm^3\ mol^{-1}\ s^{-1})$ **(1)** TE on value for A and $\ln k$ Final answer must be to 3 SF **Method 2** $\ln k_2 - \ln k_1 = \frac{E_a}{R}(\frac{1}{T_1} - \frac{1}{T_2})$ **(1)** $\ln k_2 - \ln 2.32 \times 10^{-3} = \frac{184000}{8.31}(\frac{1}{700} - \frac{1}{800})$ Or $\ln k_2 - \ln 2.32 \times 10^{-3} = \frac{184}{0.00831}(\frac{1}{700} - \frac{1}{800})$ **(1)** $\ln k_2 + 6.006 = 22142 \times 1.757 \times 10^{-4}$ **(1)** $\ln k_2 = (22142 \times 1.757 \times 10^{-4}) - 6.006$ $= -2.1157$ **(1)** $k_2 = 0.121$ $(dm^3\ mol^{-1}\ s^{-1})$ **(1)** TE on value for $\ln k_2$ Final answer must be to 3 SF	Incorrect unit Incorrect unit	**(5)**

Question Number	Acceptable Answers	Reject	Mark
16(c)(i)	(K_c =) $\frac{[H_2(g)][I_2(g)]}{[HI(g)]^2}$ IGNORE Missing/incorrect state symbols	Round brackets $[2HI(g)]^2$ on denominator	**(1)**

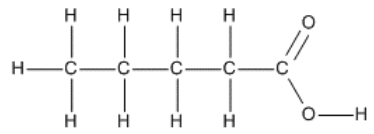
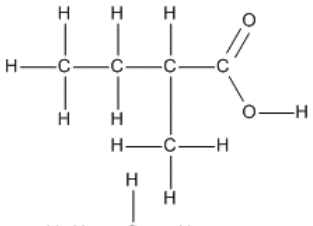
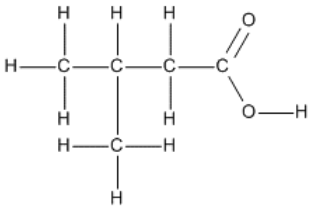
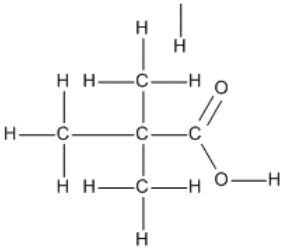
Question Number	Acceptable Answers	Reject	Mark
16(c)(ii)	Units cancel OR Same number of moles /molecules each side ALLOW Volume / V cancels IGNORE Concentrations cancel / products and reactants cancel / same number of products as reactants	Concentrations are the same	**(1)**

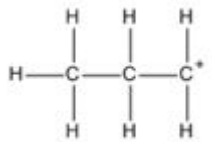
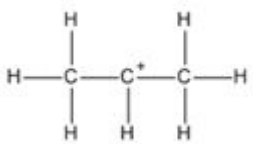
Question Number	Acceptable Answers	Reject	Mark
16(c)(iii)	Correct answer, with or without working, scores 4 Initial mol HI = 0.192/127.9 = 0.0015012 **(1)** Eqm mol H_2 = 0.00019 = mol I_2 **(1)** Eqm mol HI = 0.0015012 – (0.00019 x 2) = 0.0011212 **(1)** (Since V = 1dm^3) $K_c = \frac{0.00019 \times 0.00019}{0.0011212^2}$ = 0.028719/0.02872/0.0287/0.029 **(1)** ALLOW TE on eqm moles IGNORE SF except 1SF		**(4)**

Question Number	Acceptable Answers	Reject	Mark
***16(c)(iv)**	**First mark** $\Delta S_{surroundings} = -\frac{\Delta H}{T}$ **(**and ΔH is positive) ALLOW a description or conclusion of this expression e.g. the reaction is endothermic so $\Delta S_{surroundings}$ is negative **(1)** **Second mark** So $\Delta S_{surroundings}$ becomes less negative **(1)** IGNORE smaller / more positive **Third mark** – conditional on some explanation (ΔS_{total} increases) and hence K_c increases OR ($\Delta S_{total} = R\ln K$)and hence K_c increases **(1)**		**(3)**

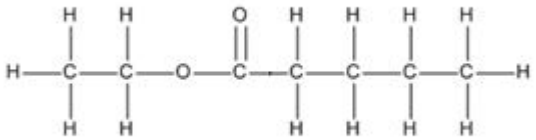
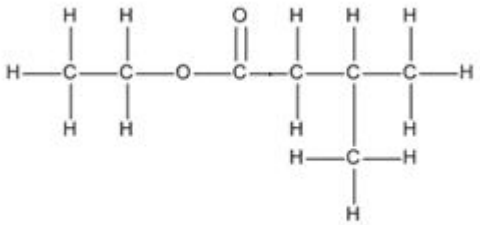
(Total for Question 16 = 19 marks)

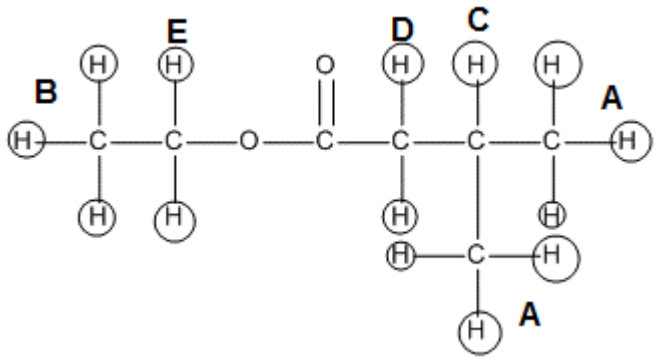
Question Number	Acceptable Answers	Reject	Mark
17(a)	**Working must be shown** **EITHER** % of oxygen = 31.4% **and** C : H : O mol $\frac{58.8}{12}$: $\frac{9.8}{1}$: $\frac{31.4}{16}$ = 4.9 : 9.8 : 1.96 **(1)** ratio 2.5 : 5 : 1 = 5 : 10 : 2 **(1)** IGNORE SF in mol and ratio Use of 102 to show molecular formula is $C_5H_{10}O_2$ eg M_r is (5 x 12) + (10 x 1) + (2 x 16) = 102 **(1)** **OR** % of C in $C_5H_{10}O_2$ = $\frac{60}{102}$ x 100 = 58.8% **(1)** % of H in $C_5H_{10}O_2$ = $\frac{10}{102}$ x 100 = 9.8% **(1)** % of O in $C_5H_{10}O_2$ = $\frac{32}{102}$ x 100 = 31.4% **(1)** **OR** No. C atoms = $\frac{58.8 \times 102}{100 \times 12}$ = 5 **(1)** No. H atoms = $\frac{9.8 \times 102}{100 \times 1}$ = 10 **(1)** No. O atoms = $\frac{31.4 \times 102}{100 \times 16}$ = 2 **(1)**		**(3)**

Question Number	Acceptable Answers	Mark
17(b)	    Carboxylic acids can be in any order ALLOW CH_3, C_2H_5, OH All four correct scores **(2)** Two or three correct scores **(1)** IGNORE one missing H or C-C bond in one structure	**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(c)	 ALLOW $CH_3CH_2CH_2^+$ ALLOW structure in brackets with charge outside **(1)**  ALLOW $CH_3CH^+CH_3$ ALLOW structure in brackets with charge outside **(1)** If no structures are given, allow 1 mark for $C_3H_7^+$ Penalise missing + charge once only		**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(d)	pentanoic acid **and** 3-methylbutanoic acid **OR** Structures **OR** Identified from numbers in (b)		**(1)**

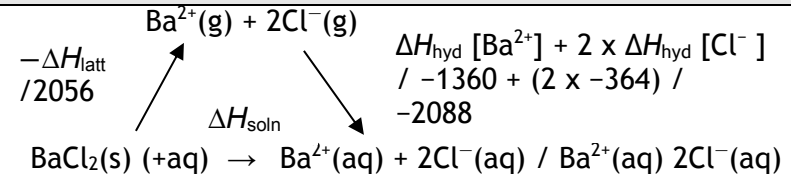
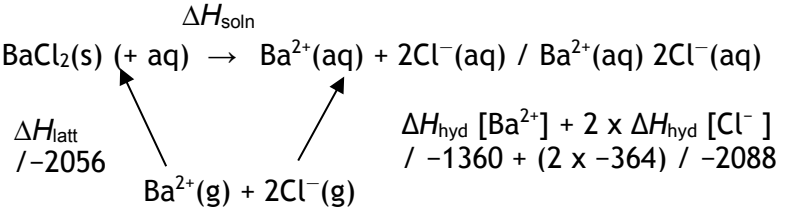
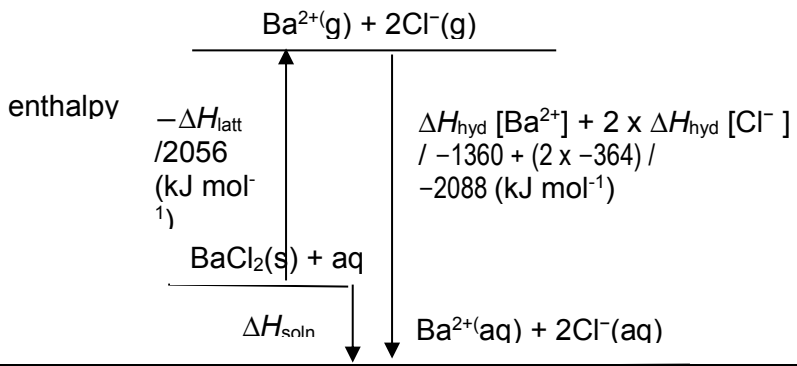
Question Number	Acceptable Answers	Reject	Mark
17(e)	 **(1)**  **(1)** ALLOW Any unambiguous structures e.g. displayed, skeletal, structural or any combination of these TE from (d) If no other mark awarded, allow one mark for a correct ethyl group **and** ester linkage	C_4H_9 Structures with more than one H missing from a bond	**(2)**

Question Number	Acceptable Answers	Mark
17(f)	**Mark 1 – structure** Correct structure **(1)**  **Marks 2 to 4 – labelled protons** Protons can be just labelled or circles and labelled Five proton environments correct scores **(3)** Three of four proton environments correct scores **(2)** One or two proton environments correct scores **(1)** If a structure for **Q** is shown from one of the other $C_5H_{10}O_2$ carboxylic acids, allow 1 mark for Identification of proton environments for peaks B and E **Mark 5 – splitting** Peak B is a triplet as there are two protons on the adjacent carbon atom (and it is split into 2 + 1) **(1)**	**(5)**

(Total for Question 17 = 15 marks)

TOTAL FOR SECTION B = 48 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	 OR  **First mark** All correct species including state symbols **(1)**	$BaCl_2(aq)$	**(4)**
	Second mark Both arrows in correct directions ALLOW Arrows in opposite directions if labelling is correct for that direction **(1)**		
	Third mark Arrows labelled with enthalpy change or values ALLOW LE for lattice energy and HE for hydration enthalpy ALLOW any unambiguous labels **(1)**		
	Fourth mark Enthalpy change of solution = −1360 + (2 x −364) − (−2056) = −32 (kJ mol^{-1}) **(1)**	Incorrect unit	
	ALLOW Other correct cycles ALLOW energy level diagram 		

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	Calcium (ions**)**/ Ca^{2+} have a smaller (ionic) radius / are smaller (than barium ions/Ba^{2+}) ALLOW higher charge density ALLOW calcium (ions) have a smaller atomic radius **(1)** So enthalpy of hydration is more exothermic / more negative **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	Its concentration / it is constant / does not change	Solids do not have a concentration	**(1)**

Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	**Correct answer with or without working scores 3 marks** $[Ba^{2+}(aq)] = [SO_4^{2-}(aq)]$ So $[Ba^{2+}(aq)] = \sqrt{K_s} = \sqrt{1.00 \times 10^{-10}}$ $= 1.00 \times 10^{-5}$ (mol dm^{-3}) **(1)** **EITHER** Conc $BaSO_4 = 1.00 \times 10^{-5} \times 233.4$ $= 2.334 \times 10^{-3}$ (g dm^{-3}) **(1)** TE on $[Ba^{2+}(aq)]$ Mass $BaSO_4$ in 50.0 cm^3 $= 2.334 \times 10^{-3} \times \frac{50.0}{1000}$ $= 1.167 \times 10^{-4}$ / 1.17×10^{-4} / 1.2×10^{-4} / 0.0001167 / 0.000117 / 0.00012(g) TE on conc $BaSO_4$ in g dm^{-3} **(1)** **OR** Mol $BaSO_4$ in 50.0 cm^3 $= 1.00 \times 10^{-5} \times \frac{50.0}{1000}$ $= 5.00 \times 10^{-7}$ **(1)** TE on $[Ba^{2+}(aq)]$ Mass $BaSO_4$ in 50.0 cm^3 $= 5.00 \times 10^{-7} \times 233.4$ $= 1.167 \times 10^{-4}$ / 1.17×10^{-4} / 1.2×10^{-4} / 0.0001167 / 0.000117 / 0.00012(g) TE on mol $BaSO_4$ in 50.0 cm^3 **(1)** IGNORE SF except 1 SF		**(3)**

Question Number	Acceptable Answers			Reject	Mark
18(c)(i)		$BaCl_2(s)$	$H_2O(l)$		**(2)**
	$\Delta H^{\ominus}_f$ /kJ mol^{-1}	−858.6	−285.8		
	$S^{\ominus}$ /J mol^{-1} K^{-1}	123.7	69.9		
	All 4 correct **(2)** Any 2 or 3 correct **(1)**				

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	**Correct answer with or without working scores 2 marks** [(2 x −46.1) + (−858.6) + (10 x −285.8)] − [−3345 + (2 x −314.4)] **(1)** = (+)165 (kJ mol^{-1}) ALLOW Answer converted to J mol-1 TE from incorrect data in table in (a)(i) **(1)** ALLOW 1 mark for cycle wrong way round −165 (kJ mol^{-1}) ALLOW 1 mark for using correct values but not multiplied by balancing numbers (+)2468.9 /(+)2469 (kJ mol^{-1}) IGNORE SF except 1SF	Incorrect unit	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(c)(iii)	**Correct answer with or without working scores 2 marks** [(2 x 192.3) + 123.7 + (10 x 69.9)] − [427 + (2 x 94.6)] **(1)** = (+)591.1 /(+)591 (J mol^{-1} K^{-1}) ALLOW Answer converted to kJ mol^{-1} K^{-1} ALLOW TE from incorrect data in table in (a)(i) **(1)** ALLOW 1 mark for cycle wrong way round −591.1 / −591 (J mol^{-1} K^{-1}) ALLOW 1 mark for using correct values but not multiplied by balancing numbers −135.7 / −136 (J mol^{-1} K^{-1}) IGNORE SF except 1SF		**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(c)(iv)	**Correct answer with or without working scores 3 marks** ΔS_{surr} at 298 K = $-\Delta H/T$ = − (165 x 1000) /298 **(1)** = −553.69 J mol^{-1} K^{-1} ALLOW answer as −0.55369 kJ mol^{-1} K^{-1} ALLOW M2 if M1 not used x 1000 **(1)** $\Delta S_{tot} = \Delta S_{surr} + \Delta S_{sys}$ = −553.69 + 591.1 = (+)37.41 J mol^{-1} K^{-1} **OR** = −0.55369 + 0.5911 = (+)0.03741 kJ mol^{-1} K^{-1} ALLOW TE from (c)(iii) and ΔS_{surr} **(1)** IGNORE SF except 1 SF		**(3)**

Question Number	Acceptable Answers	Reject	Mark
***18(c)(v)**	($S^{\ominus}$ for hydrated barium chloride will be greater than for anhydrous barium chloride as it is more complex) so this will increase ΔS_{sys} **(1)** 8 water molecules are formed instead of 10 ALLOW fewer moles of products and this will decrease ΔS_{sys} **(1)** as we do not know the extent of each change, we cannot predict the overall change on ΔS_{tot} OR No information about the effect on $\Delta S_{surroundings}$ / ΔH ALLOW provided $\Delta S_{surroundings}$ does not change **(1)**		**(3)**

TOTAL FOR SECTION C = 22 MARKS

TOTAL FOR PAPER = 90 MARKS

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