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Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in Chemistry (8CH0) Paper 02
Core Organic and Physical 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.

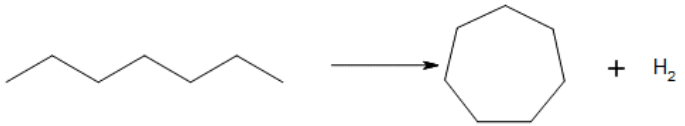
Quality of Written Communication

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.

Question Number	Answer	Mark
1(a)	**B** (2,3-dimethylhexane)	(1)

Question Number	Answer	Mark
1(b)	**A** (3)	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
1(c)	• correct <u>skeletal</u> formulae for heptane and cycloheptane **(1)** • formula for hydrogen **(1)**	Mark independently but max 1 if additional reactants and/or products or more than 1 mole/molecule of hydrogen  Do not allow just structural or displayed formulae for the organic reactant or product, or any combination of formulae, for M1 Ignore additional formulae written as working Ignore shape of heptagon, provided it has 7 sides Ignore any conditions, even if incorrect	(2)

Question Number	Answer	Mark
1(d)(i)	**D** (σ, homolytic)	(1)

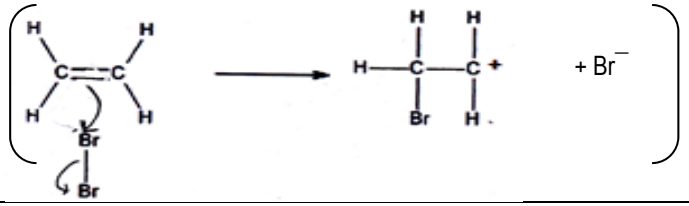
Question Number	Acceptable Answers	Additional Guidance	Mark
1(d)(ii)	• $C_2H_6 + Cl\cdot \rightarrow C_2H_5\cdot + HCl$ **(1)** • $C_2H_5\cdot + Cl_2 \rightarrow C_2H_5Cl + Cl\cdot$ **(1)**	Equations can be in either order Allow correct structural / displayed / skeletal formulae Allow dots / circles anywhere on formula Allow 1 mark for two correct steps but using the incorrect alkane / bromine Allow 1 mark if both propagation steps correct but initiation / termination steps also written and not labelled as such or additional incorrect propagation step(s) Ignore state symbols and curly arrows, even if incorrect Penalise missing dots once only **Comment:** If $C_2H_5^+$ appears in both equations but equations are otherwise correct, allow 1 as TE	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
1(d)(iii)	• (two) ethyl/ $C_2H_5^{(\cdot)}$ radicals react together **or** $C_2H_5\cdot + C_2H_5\cdot \rightarrow C_4H_{10}$	Allow $C_2H_5 + C_2H_5 \rightarrow C_4H_{10}$ Ignore termination Ignore just '(two) radicals react together' Ignore ethane radicals / ethyl groups Do not allow molecules / ions Do not allow incorrect radicals or product Do not allow initiation / propagation / elimination / substitution	**(1)**

(Total for Question 1 = 8 marks)

Question Number	Answer	Mark
2(a)	**D** (*Z*-2-bromo-1-chloroprop-1-ene)	(1)

Question Number	Answer	Mark
2(b)(i)	**A** (electrophilic addition)	(1)

Question Number	Answer	Mark
2(b)(ii)	**C** 	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
2(c)(i)	• (yield) decreases / lower yield	Allow less ethanol is produced Ignore equilibrium shifts to the left but do not allow equilibrium shifts to the right Ignore any reference to Le Chatelier's principle Do not allow high temperature favours the exothermic direction	(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
2(c)(ii)	• (yield) decreases / lower yield	Allow less ethanol is produced Ignore equilibrium shifts to the left but do not allow equilibrium shifts to the right Ignore any reference to Le Chatelier's principle Ignore fewer collisions	**(1)**

Question Number	Answer	Mark
2(c)(iii)	**D** $\left(\frac{[C_2H_5OH(g)]}{[C_2H_4(g)][H_2O(g)]}\right)$	**(1)**

(Total for Question 2 = 6 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
3(a)(i)	• ionic equation	Example of equation: $CH_3CH_2CHBrCH_3 + OH^- \rightarrow CH_3CH_2CHOHCH_3 + Br^-$ Allow $CH_3CH_2CHBrCH_3 + H_2O \rightarrow CH_3CH_2CHOHCH_3 + H^+ + Br^-$ Allow displayed /skeletal formulae or any combination of these formulae provided the correct organic molecules are shown Ignore any working before the final equation, even if not crossed out Ignore equation with molecular formulae Ignore state symbols, even if incorrect Do not allow just an equation with uncancelled K^+ ions	**(1)**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>3(a)*(ii)</td>
<td>This question assesses a 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.

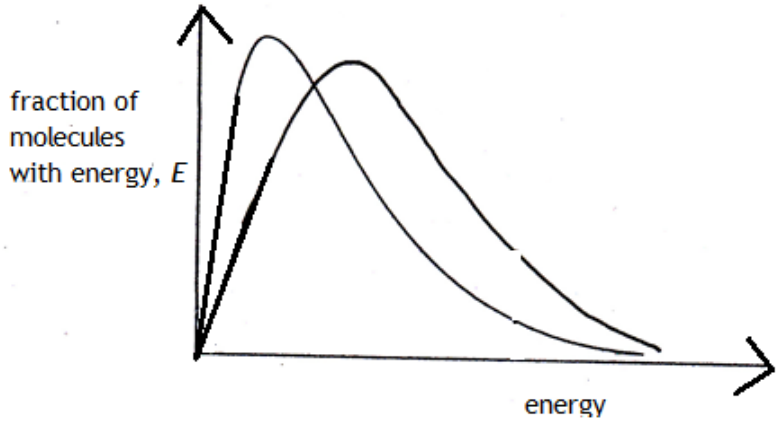
The following table shows how the marks should be awarded for indicative content.

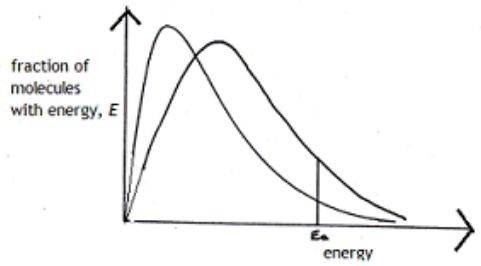
<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning.</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, an answer 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 are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td>(6)</td>
</tr>
</table>

	<table><tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr><tr><td>Answer shows a coherent and 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> **Comment:** Look for the indicative marking points first, then consider the mark for structure of answer and sustained line of reasoning	In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning. If there is any incorrect chemistry, deduct marks from the reasoning mark, for example: If a hydroxide solution is used, deduct 1 mark from reasoning mark If colours of precipitates are incorrect, deduct 1 mark from reasoning mark	

	Indicative content • **Ethanol** – use of ethanol as a solvent (added to each halogenoalkane / liquid in separate containers) • **Fair test** – use of equal volumes/amounts / specified volumes/amounts in each tube **or** warm the tubes in a water bath / specified temperature / room temperature • **Silver nitrate** - silver nitrate (solution) / Ag^+(aq) to each tube (of halogenoalkane) • **Time** - find the time taken for a precipitate to form • **Rate** - expected trend is 2-iodobutane > 2-bromobutane > 2-chlorobutane **or** 2-iodobutane is the fastest and 2-chlorobutane is the slowest • **Bond enthalpy** - bond enthalpy C-I<C-Br<C-Cl / decreases from C-Cl to C-I / C-Cl is the strongest and C-I is the weakest /C-X bond strength decreases down the group (of halogens)	Allow description of experiment from a labelled diagram Ignore nitric acid / HNO_3 Allow find how quickly the precipitates form Allow time taken for 2-iodobutane < 2-bromobutane < 2-chlorobutane Allow I^- forms first, Cl^- forms last Allow the halogenoalkanes get more reactive from chloro to iodo /'down the group' Allow reverse trends Allow 'the bond enthalpy decreases down the group' or a comparison of bond enthalpy in 2-iodobutane and 2-chlorobutane Ignore references to bond length / bond polarity / electronegativity / effective nuclear charge	

Question Number	Acceptable Answers	Additional Guidance	Mark
3(b)(i)	• additional curve added with peak to the right <u>and</u> lower	 Allow curve at start of line Do not allow the additional line to touch or cross the original curve more than once	(1)

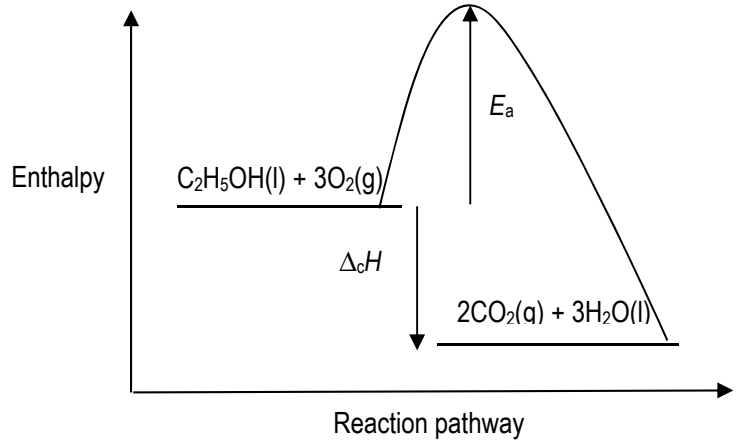
Question Number	Acceptable Answers	Additional Guidance	Mark
3(b)(ii)	An explanation that makes reference to the following points: • (higher temperature gives) molecules / particles more (kinetic) energy (and there is a higher collision frequency) **(1)** • a single activation energy marked on graph **or** more molecules / particles /collisions have energy greater than / equal to the activation energy **or** more molecules / particles / collisions have the activation energy **(1)** • so a greater proportion of the collisions result in a reaction **(1)**	Allow reverse argument for a decrease in temperature Allow collisions have more energy Ignore molecules/particles move faster Do not allow just 'gases/reactants/atoms' once only  Allow more molecules have enough energy to overcome the activation energy Do not allow any indication that the activation energy changes Do not allow any mention that the total area under the curve increases Allow so more collisions are successful Ignore just 'more frequent collisions'	**(3)**

(Total for Question 3 = 11 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
4(a)	• calculation of no. mol of ethanol **(1)** • calculation of no. molecules of ethanol **(1)**	Example of calculation no. mol of ethanol = 55.2 x 1000 / 46 = 1200 no. molecules ethanol = 1200 x 6.02 x 10^{23} = 7.224 x 10^{26} TE on no. of mol of ethanol Correct answer with or without working scores both marks Ignore SF except 1 SF Ignore units **Comment:** common incorrect answers: 7.224 x 10^{23} scores 1 (used 55.2 g) 7.224 x 10^{20} scores 1 (used 0.0552 g)	**(2)**

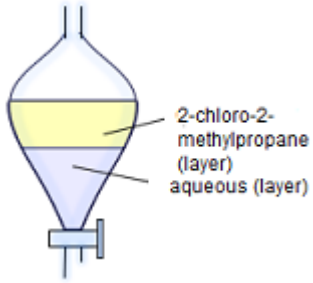
Question Number	Acceptable Answers	Additional Guidance	Mark
4(b)	• balanced equation **(1)** • all state symbols **(1)**	$2C(s, graphite) + 3H_2(g) + ½O_2(g) \rightarrow C_2H_5OH(l)$ Allow C_2H_6O Do not allow multiples Conditional on all species correct Allow C(s) / C(graphite)	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
4(c)(i)	• calculation or working of energy needed to break bonds **(1)** • calculation or working of energy released when bonds made **(1)** • calculation of enthalpy change of combustion with sign **(1)**	<u>Example of calculation</u> energy to break bonds = 347 + (5 x 413) + 358 + 464 + (3 x 498) = 4728 (kJ) energy released in making bonds = (4 x 805) + (6 x 464) = 6004 (kJ) enthalpy change of combustion = 4728 – 6004 = −1276 (kJ mol^{-1}) **or** energy to break bonds = 347 + (5 x 413) + 358 + (3 x 498) = 4264 (kJ) energy released in making bonds = (4 x 805) + (5 x 464) = 5540 (kJ) enthalpy change of combustion = 4464 – 5540 = −1276 (kJ mol^{-1}) TE on energies calculated to break and form bonds Correct answer with sign but no working scores 3 Ignore SF except 1SF Ignore missing units but do not allow incorrect units in M3 e.g. kJ mol^{-}	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
4(c)(ii)	 • products to the right of reactants <u>and</u> at a lower enthalpy <u>and</u> arrow labelled Δ_cH **(1)** • curve and arrow labelled E_a **(1)**	M1 is conditional on exothermic or endothermic value calculated in (c)(i) but if no value is calculated, award mark for exothermic reaction only Allow double headed arrows / lines, but penalise arrows pointing in wrong direction once only Allow 'products'/ unbalanced formulae / missing state symbols as labels for product line Allow $(-)\Delta H/(-)\Delta H_c$/enthalpy change or value calculated in (c)(i) Allow value calculated for energy needed to break bonds in (c)(i) Ignore any transition state Do not allow straight lines instead of Ea curve If no other marks awarded, allow 1 mark for the correct labelled product line <u>and</u> activation energy curve if both arrows missing	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
4(c)(iii)	• standard enthalpy change of combustion refers to ethanol / water as liquid(s) but bond energies are calculated for gases **or** change of state data is not included **or** ethanol / water are not in standard states for bond enthalpy calculation	Ignore bond energies are mean values and the actual values in these compounds/ethanol may be different Ignore any reference to heat loss Ignore any reference to incomplete combustion	**(1)**

(Total for Question 4 = 10 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
5(a)	• diagram of separating funnel **(1)** • aqueous and organic layers labelled as shown **(1)**	Mark independently Allow any shape separating funnel with tap at the bottom (does not need to be labelled), with a narrowing top or vertical sides but do not allow a burette Allow stopper/bung in separating funnel  Allow two layers shown and just one labelled correctly Allow organic layer/ product for top layer / hydrochloric acid for aqueous layer Do not allow 'reactant' for top layer	**(2)**

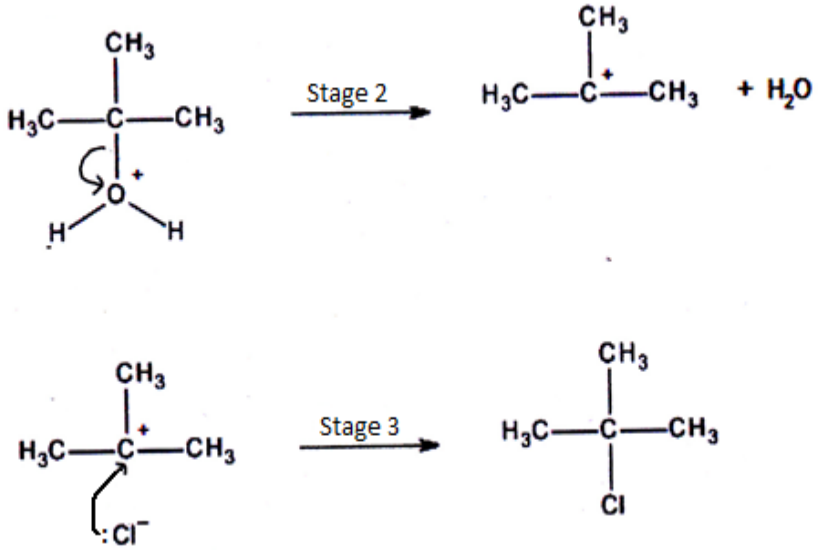
Question Number	Acceptable Answers	Additional Guidance	Mark
5(b)	• to react with/ neutralise any (unreacted/ excess hydrochloric) acid **(1)** • to release the carbon dioxide produced **or** to relieve the build-up of pressure **(1)**	Mark independently Allow to remove the (hydrochloric) acid Allow to neutralise the organic layer/ solution Allow to release gases Ignore just 'pressure builds up' Do not allow incorrect gases e.g. hydrogen	**(2)**

Question Number	Answer	Mark
5(c)	**D** (sodium sulfate)	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
5(d)(i)	A description that makes reference to the following points: • the (bulb of the) thermometer should be opposite the opening to the condenser **(1)** • the water in and out of the condenser should be reversed **(1)** • put a vent after the condenser **or** leave a gap between the condenser and the receiver **or** conical flask must be open **(1)**	Allow these changes if shown on the diagram Allow thermometer should be higher up / above the liquid / should measure the temperature of the vapour / out of the mixture/liquid Allow water should enter the bottom (of the condenser) Ignore just 'vent' / the apparatus should not be completely sealed Ignore references to using a fume cupboard	**(3)**

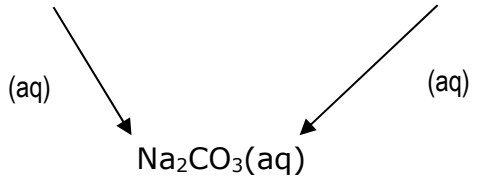
Question Number	Acceptable Answers	Additional Guidance	Mark
5(d)(ii)	• 50-52^{o}C	Allow any range between 49 and 53^{o}C, <u>provided</u> it includes 51^{o}C Do not allow just 51^{o}C	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
5(e)	• calculation of moles of alcohol used **(1)** • calculation of theoretical volume of 2-chloro-2-methylpropane made **or** calculation of actual moles of 2-chloro-2-methylpropane **or** calculation of actual mass of 2-chloro-2-methylpropane **(1)** • calculation of percentage yield **(1)**	<u>Example of calculation</u> mass of alcohol used = 15.0 x 0.79 = 11.85 (g) moles of alcohol used = 11.85/74.0 = 0.16014 theoretical mass of chloro compound = 0.16014 x 92.5 = 14.8125 (g) theoretical volume = 14.8125/0.84 = 17.634 (cm^3) **or** actual moles of chloro compound = 6.9 x 0.84 / 92.5 = 0.062659 **or** actual mass of chloro compound = 0.062659 x 92.5 = 5.796 (g) % yield = (6.9/17.634) x 100 = 39.1% **or** = (0.062659/0.16014) x 100 = 39.1% **or** = (5.796/14.8125) x 100 = 39.1% TE on M1 and M2 Ignore SF except 1 SF Correct answer without working scores 3	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
5(f)	• curly arrow from C–O bond to O **(1)** • curly arrow from <u>lone pair</u> on Cl^- to C^+ **(1)**	 Do not allow single-headed arrows Do not allow additional, incorrect arrows	**(2)**

(Total for Question 5 = 14 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
6(a)	• calculation or working of heat evolved during reaction **(1)** • calculation or working of mol Na_2CO_3 used **(1)** • calculation of enthalpy change of solution **(1)** • negative sign and answer to 2 or 3 SF **(1)**	<u>Example of calculation</u> heat evolved = 50 x 4.18 x 5.4 = 1128.6 J or 1.1286 kJ Ignore any sign mol Na_2CO_3 used = 5.09/106 = 0.04802 enthalpy of solution = 1.1286/0.04802 = 23.5 TE on heat evolved and mol Na_2CO_3 $-23.5/-24$ (kJ mol^{-1}) TE on enthalpy change in M3 Correct answer with − sign but no working scores 4 Ignore missing units but penalise incorrect units once only in (a) or (b)	**(4)**

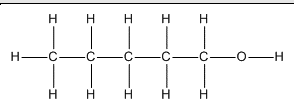
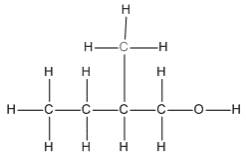
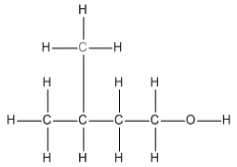
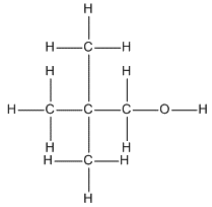
Question Number	Acceptable Answers	Additional Guidance	Mark
6(b)	• both arrows in correct direction and $Na_2CO_3(aq)$ (+ $10H_2O(l)$) / $2Na^+(aq) + CO_3^{2-}(aq)$ (+ $10H_2O(l)$) **(1)** • answer to (a) − 53.7 with correct sign **(1)**	$Na_2CO_3(s) + 10H_2O(l) \rightarrow Na_2CO_3.10H_2O(s)$  Allow aq omitted from arrows Allow both arrows pointing upwards provided labelled as opposite signs <u>Example of calculation</u> −23.5 − 53.7 = −77.2 (kJ mol^{-1}) TE on answers to (a) but not on incorrect cycle Allow −77200 **J mol^{-1}** Ignore SF except 1SF Ignore missing units but penalise incorrect units	**(2)**

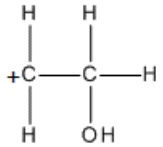
Question Number	Acceptable Answers	Additional Guidance	Mark
6(c)	An explanation that makes reference to the following points: • enthalpy change of solution will be lower/ less endothermic / less positive (than data book value) **(1)** • because anhydrous sodium carbonate releases energy/reacts exothermically with water **or** because less energy is needed to separate the (fewer) water molecules from the ions (in the crystal structure) **(1)**	Allow smaller / requires less energy Allow more exothermic / negative Conditional on M1 Allow because there is (less water so) more Na_2CO_3 (in the sample) Allow because less energy is needed to break the bonds between water and sodium carbonate	**(2)**

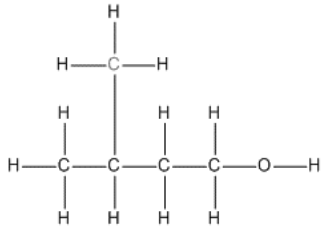
(Total for Question 6 = 8 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
7(a)	• calculation of empirical formula **(1)** • uses molecular ion to prove molecular formula **(1)** **or** • calculation of percentage of each element in compound all 3 correct scores **(2)** any 2 correct scores **(1)** **or** • calculation of the number of atoms of each element directly all 3 correct scores **(2)** any 2 correct scores **(1)**	Example of calculation C : H : O 68.2 / 12 : 13.6 / 1 : 18.2 / 16 = 5.68 : 13.6 : 1.14 = 5 : 12 : 1 Use of 88 to show molecular formula is $C_5H_{12}O$ e.g. M_r is (5x12) + (12x1) + 16 = 88 or states that M_r of empirical formula is 88 **or** % C = $\frac{5 \times 12 \times 100}{88} = 68.2$ % H = $\frac{12 \times 1 \times 100}{88} = 13.6$ % O = $\frac{1 \times 16 \times 100}{88} = 18.2$ **or** C atoms = $\frac{68.2 \times 88}{100 \times 12} = 5$ H atoms = $\frac{13.6 \times 88}{100 \times 1} = 12$ O atoms = $\frac{18.2 \times 88}{100 \times 16} = 1$	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(i)	• (**X** is a) primary/ 1° (alcohol)		**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(ii)	    • 4 correct **(3)** • 3 correct **(2)** • 2 correct **(1)**	Allow alcohols in any order Allow CH_3 / OH Allow slip of 1 H missing from 1 alcohol / 1 C-C bond missing Ignore names, even if incorrect Penalise O-H-C- / -C-H-O at end of molecule once only If no other mark is given, allow (2) for 4 correct skeletal / structural formulae or any combination of these or (1) for 3 correct Allow (2) for displayed formulae of pentan-2-ol, pentan-3-ol and 3-methylbutan-2-ol if secondary alcohol in (b)(i), or (1) for any two of those If no other mark awarded and if (b)(i) is blank or incorrect, allow (2) for any 4 different alcohols with formula $C_5H_{12}O$, (1) for 3 alcohols	**(3)**

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(iii)	• 	Allow structural formula or any combination of displayed and structural formula Allow + anywhere on structure or outside of a formula in a bracket Do not allow $C_2H_5O^+$/$C_2H_4OH^+$ Do not allow missing charge Allow CH_3C^+HOH if secondary alcohol identified in (b)(i)	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(iv)	•  **(1)** • because this is the **only** alcohol with a branched chain and forms $CH_2OHCH_2^+$ / $C_2H_4OH^+$ / peak at 45 / fragment identified in (b)(iii) **(1)**	Allow any type of identification, including name 3-methylbutan-1-ol Ignore incorrect name with correct structure Conditional on correct identification Ignore missing charge on fragment Allow reasons why the others are not correct e.g. not pentan-1-ol as it is not branched and not 2-methylbutan-1-ol or 2,2-dimethylpropan-1-ol as they do not form $CH_2OHCH_2^+$ If secondary alcohol identified in (b)(i): Allow 3-methylbutan-2-ol (1) as it is the only alcohol with a branched chain that forms CH_3C^+HOH (1)	**(2)**

(Total for Question 7 = 9 marks)

Question Number	Acceptable Answers	Additional Guidance	Mark
8(a)	• potassium dichromate((VI))/$K_2Cr_2O_7$ <u>and</u> sulfuric acid/H_2SO_4 **or** sodium dichromate((VI))/$Na_2Cr_2O_7$ <u>and</u> (dilute) sulfuric acid/H_2SO_4 **(1)** • heat/reflux **(1)**	Allow $Cr_2O_7^{2-}$ <u>and</u> H^+ / acidified (potassium / sodium) dichromate((VI)) If name and formula given, both must be correct Ignore concentration of acid Do not allow hydrochloric acid / HCl / nitric acid / HNO_3 Conditional on correct reagents or near miss, provided dichromate or (per)manganate((VII)) is mentioned Allow a specified temperature in the range 60 – 150^oC Ignore distillation / warm Allow answers written on either dotted line	**(2)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(b)(i)	A description that makes reference to the following points: • **Flask** - use of a volumetric / graduated flask **(1)** • **Weighing** - weigh the ethanedioic acid (in a weighed container and record the exact mass) **(1)** • **Dissolve, transfer and washings** – allow these in any order depending on the method used **(1)** • **Mark and mix** - make up to the mark / 250 cm^3 <u>and</u> then mix **(1)**	Ignore heat Do not allow just 'flask' / conical flask Ignore just 'put 1 /1.0 /1.09 g solid in beaker' Distilled / deionised water must be mentioned once in M3 or M4 Allow pure water Allow any indication of mixing eg swirl / invert the flask	**(4)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(b)(ii)	• (From) colourless (to) pink	Allow (to) red Do not allow purple / pink/purple Do not allow clear	**(1)**

Question Number	Acceptable Answers	Additional Guidance	Mark
8(b)(iii)		Correct answer of 2.2582/2.258/2.26/2.3 without working scores 5 Final answer of 2, with working, resulting from a number between 2.2 and 2.3, scores 5 If no other mark is scored, an answer of just 2 scores 1	**(5)**
	• calculation of moles of NaOH **(1)**	<u>Example of calculation</u> moles NaOH = 16.2 x 0.103/1000 = 1.6686×10^{-3}	
	• calculation of moles of $H_2C_2O_4$ in 25 cm^3 **(1)**	moles $H_2C_2O_4$ in 25 cm^3 = $1.6686 \times 10^{-3}/2 = 8.343 \times 10^{-4}$ TE on mole NaOH	
	• calculation of moles of $H_2C_2O_4$ in 250 cm^3 **(1)**	moles $H_2C_2O_4$ in 250 cm^3 = $8.343 \times 10^{-4} \times 10 = 8.343 \times 10^{-3}$ TE on moles $H_2C_2O_4$ in 25 cm^3	
	• calculation of M_r of crystals **(1)**	M_r of crystals = $1.09/8.343 \times 10^{-3}$ = 130.648 /130.65 / 130.6 TE on moles $H_2C_2O_4$ in 250 cm^3	
		For first 4 marking points ignore SF except 1 SF	
	• calculation of value of n **(1)**	130.65 = (2 + (2x12) + (4x16)) + 18n n = 2.2582/ 2.258/2.26/2.3/2 TE on M_r of crystals, provided n is positive	
	Alternative method for M4 and M5 • calculation of moles of H_2O **(1)**	mass $H_2C_2O_4$ = 8.343×10^{-3} x 90 = 0.75087 (g) mass H_2O = 1.09 − 0.75087 = 0.3391 (g) moles H_2O = 0.3391/18 = 0.01884	
	• calculation of value of n **(1)**	mole ratio $H_2C_2O_4$: H_2O = 1 : $0.01884/8.343 \times 10^{-3}$ = 1 : 2.2582/ 2.258/2.26/2.3/2	

Question Number	Acceptable Answers	Additional Guidance	Mark
8(b)(iv)	An explanation that makes reference to the following points: • (damp crystals will have more water so) lower mass / moles / concentration of $H_2C_2O_4$ **(1)** • so titre will be lower and the value of n will be higher **(1)**		**(2)**

(Total for Question 8 = 14 marks)

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