Mark Scheme (Results)

Summer 2023

Pearson Edexcel GCE
In Chemistry (8CH0)
Paper 02: Core Organic and Physical Chemistry

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Summer 2023
Question Paper Log Number P71927A
Publications Code 8CH0_02_2306_MS

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	Acceptable Answer	Additional Guidance	Mark
1	An answer that makes reference to the following points: • peak height of curve is lower **and** starts at origin **(1)** • to the right of the existing curve **and** approaches x-axis asymptotically **(1)**	Do not award lines which cross over the existing line more than once Ignore any lines indicating activation energy even if incorrect	**(2)**

(Total for Question 1 = 2 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
2(a)	An answer that makes reference to the following points: • saturated means all bonds (between C atoms) are single **(1)** • hydrocarbon contains hydrogen and carbon (only) **(1)**	Allow answers that discuss the absence of double or triple bonds etc, **Or** no more hydrogen can be added without breaking C−C bonds Allow saturated hydrocarbons only undergo substitution reactions **and** not addition reactions	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(b)(i)	• overall equation	Example of equation $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ Ignore state symbols, even if incorrect	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(b)(ii)	• calculation of moles of chlorine molecules **(1)** • calculation of mass (g) of chloromethane produced **(1)**	<u>Example of calculation</u> moles of chlorine molecules = 7.00 ÷ 71 = 0.098592 (mol) Do not award use of 70 for the molar mass of chlorine molecule 1 mole chlorine molecules produces 1 mole CH_3Cl moles of CH_3Cl = 0.098592 (mol) = 0.098592 × 50.5 = 4.9789 (g) = 4.98 / 5.0 / 5 g TE on mol of chlorine Ignore SF including 1 SF Allow TE from equation in (b)(i) Use 35.5 for the molar mass to give 9.96 g scores M2	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(b)(iii)	• termination equation	Example of equation $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$ / $2CH_3\bullet \rightarrow CH_3CH_3$ **Or** $C\mathit{l}\bullet + C\mathit{l}\bullet \rightarrow C\mathit{l}_2$ **Or** $CH_3\bullet + C\mathit{l}\bullet \rightarrow CH_3C\mathit{l}$ Free radical dots are required Ignore state symbols, if shown, even if incorrect	**(1)**

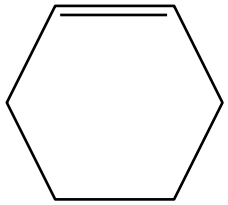
Question Number	Acceptable Answer		Additional Guidance	Mark
2(b)(iv)	• calculation of mol $CH_3C\mathit{l}$	**(1)**	Example of calculation $12.5 \div 50.5 = 0.24752$	**(3)**
	• calculation of mass of $CH_2C\mathit{l}_2$ produced	**(1)**	M_r $CH_2C\mathit{l}_2 = 85$ $0.24752 \times 85 = 21.040$ (g)	
	• conversion of mass to volume of liquid using density **and** answer given to **2 or 3 SF only**	**(1)**	$21.040 \div 1.32 = 15.939$ (cm^3) $= 15.9 / 16$ (cm^3) Allow TE throughout	

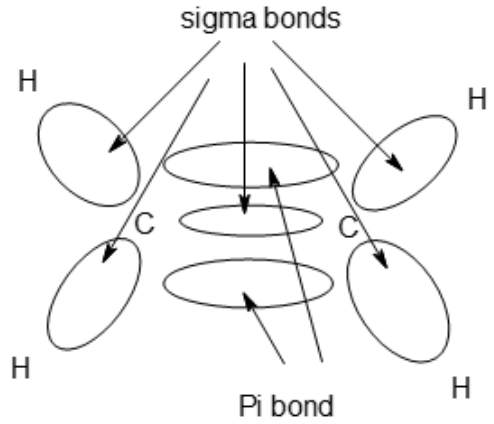
Question Number	Acceptable Answer		Additional Guidance	Mark
2(c)(i)	• calculation of moles of $C_{12}H_{26}$	**(1)**	Example of calculation 1.00 kg = 1000 g $C_{12}H_{26}$ = 170 g mol^{-1} moles $C_{12}H_{26}$ = 1000 ÷ 170 = 5.8824 (mol)	**(4)**
	• calculation of moles CO_2 (from equation)	**(1)**	moles of CO_2 = 5.8824 × 12 = 70.588 (mol)	
	• conversion of temperature to K **and** rearrangement of equation	**(1)**	T = 200 + 273 = 473 K **and** $V = nRT/p$	
	• calculation of volume of CO_2 produced	**(1)**	$V = \frac{70.588 \times 8.31 \times 473}{6 \times 10^6}$ V = 0.046243 (m^3) Ignore SF except 1 SF Allow TE throughout Correct final answer with no working scores (4) 3.85×10^{-3} scores (3) due to omission of M2	

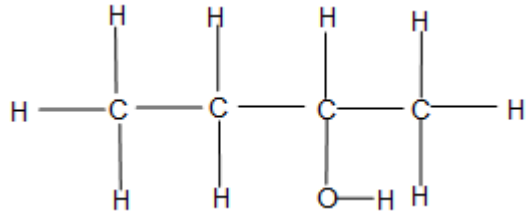
Question Number	Acceptable Answer	Additional Guidance	Mark
2(c)(ii)	An answer that makes reference to the following point: • one reason for increasing use of biodiesel	<u>Examples of acceptable answer</u> Renewable / sustainable resource (derived from plant matter) Cleaner burning (because it contains oxygen in the molecule) Better lubricant (than petrodiesel) Uses up waste (cooking) oils Plants grown locally so less dependent on imports Allow references to carbon neutrality only if an explanation is provided Do not award if incorrect statements made such as biodiesel is biodegradable are included with correct reasons such as sustainability	**(1)**

(Total for Question 2 = 14 mark

Question Number	Acceptable Answer	Additional Guidance	Mark
3(a)	An answer that makes reference to the following points: • general formula for an alkene and/or cycloalkane **and** general formula of an alkane **(1)** • alkenes have a double bond (with two less hydrogens) **(1)** • cycloalkanes have carbons in a ring (resulting in two less hydrogens) **(1)**	General formula of alkenes and/or cycloalkanes = C_nH_{2n} General formula of alkanes = C_nH_{2n+2}	**(3)**

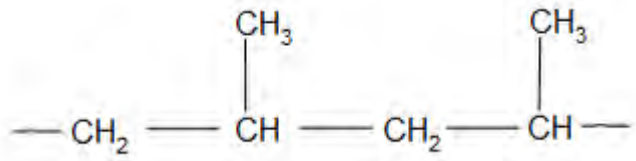
Question Number	Acceptable Answer	Additional Guidance	Mark
3(b)	• skeletal formula of cyclohexene	<u>Example of skeletal formula</u>  Ignore bond lengths and bond angles Ignore position of C=C Do not award any other type of formula	**(1)**

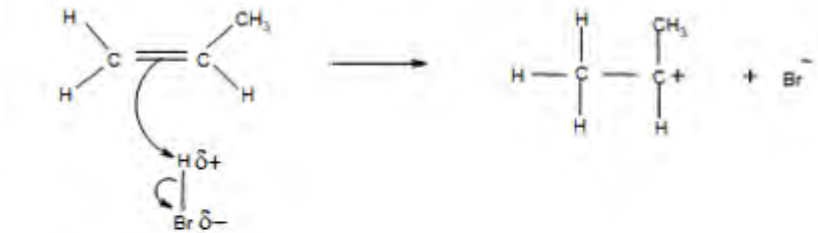
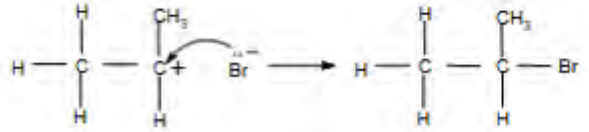
Question Number	Acceptable Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to the following points: • σ/sigma bond drawn and identified between both C atoms **(1)** • (labelled) diagram identifying π/pi bond above **and** below σ/sigma bond between C atoms **(1)** • C−H bonds drawn and at least one identified as a σ bond **(1)**	<u>Example of diagram</u>  σ and π bonds may be shown as overlap of individual orbitals Allow π bonds shown as banana shaped and σ bonds shown as lozenge-shaped If a double bond is drawn between the two carbon atoms then M1 is lost but M2 can still be scored from appropriate pi bond labelled drawing Rescue mark - If no other mark is awarded and lines are shown instead of shapes, allow (1) for identification of σ and π bonds	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(d)(i)	• fully displayed formula of isomer **B** (butan-2-ol)	Example of displayed formula  Allow O−H shown as OH and ignore connectivity unless shown horizontally as −HO Do not award methyl and ethyl groups to be shown as CH_3 and C_2H_5	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
3(d)(ii)	• structural formula of butane-1,2-diol	Example of structural formula $CH_3CH_2CH(OH)CH_2OH$ Allow partially displayed formula eg $CH_3CH_2CH\ CH_2$ $\quad\quad\quad\quad\quad\quad\ \ \vert\quad\vert$ $\quad\quad\quad\quad\quad\quad OH\ OH$ Allow C_2H_5 Ignore connectivity of vertical OH groups	(1)

Question Number	Answer	Mark
3(e)	**The only correct answer is B (nickel)** **A** *is not correct because iron is used in the Haber process* **C** *is not correct because a heterogeneous catalyst is needed for this reaction* **D** *is not correct because a heterogeneous catalyst is needed for this reaction*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(f)	• poly(propene) showing two repeat units	Example of suitable diagram  Allow diagram with square or round brackets Allow diagram with n or n/2 Allow isotactic or syndiotactic structures Allow displayed formula	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(g)(i)	• curly arrow from double bond to H of HBr **and** dipole on HBr **(1)** • curly arrow from H−Br bond to Br (or just beyond Br) **(1)** • intermediate **(1)** • lone pair on Br− **and** curly arrow from lone pair to C+ **(1)**	Example of mechanism   Formatıon of 1-bromopropane can score M1, M2 and M4	**(4)**

Question Number	Answer	Mark
3(g)(ii)	**The only correct answer is A (electrophilic addition)** **B** *is not correct because this is an addition reaction not a substitution* **C** *is not correct because this is electrophilic not nucleophilic* **D** *is not correct because this is electrophilic not nucleophilic and addition not substitution*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(h)(i)	An answer that makes reference to the following point: • scrubbing with alkali / pass through any alkaline solution eg NaOH(aq) /over solid base e.g. CaO	 Allow reference just to passing over an alkali Ignore neutralisation without some specified alkali Ignore reference to dissolving in water	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(h)(ii)	• any one reason	<u>Possible reasons</u> Polymer degrades during heating (for recycling) Heavy pigmentation/ colour of plastic to be recycled Thermoset / 3D polymers cannot be recycled (because of their structure) It's difficult to separate polymers into types Do not award reference to breaking of the long polymer chains COMMENT Allow reference to difficulty to break down because of the strong bonds	**(1)**

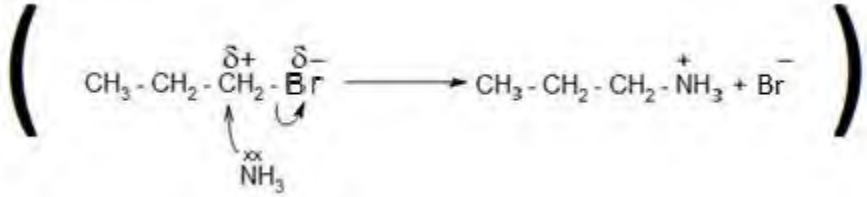
(Total for Question 3 = 18 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
4(a)(i)	An answer that makes reference to the following points: • ethanol / ethanol & water mixture is used to ensure all reactants mix efficiently / are in same phase **(1)** • same volumes (of each reactant) ensures a fair test **(1)** • warm water bath used to speed up reaction **Or** water bath ensures all reactions carried out at same temperature (fair test) **(1)**	Allow ethanol enables halogenoalkane to be soluble Allow use the same volume of silver nitrate Allow use the same volume of halogenoalkane Allow alternative wording to 'fair test' such as improves reliability Allow because the hydrolysis / reaction of chloroalkanes / some halogenoalkanes is (very) slow	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(a)(ii)	An explanation that makes reference any two of the following three points: • (hydrolysis by water) releases halide ions **(1)** • halide ions react with silver (ions) **(1)** • to give an insoluble silver halide/ product / ppt **(1)**	Allow a correct equation with / without states Example of equation $R{-}X + H_2O \rightarrow R{-}OH + X^- + H^+$ If shown, states must be correct but allow ethanol as solvent Do not award use of halogen for halide A correct equation with states to score (2) Example of equation $X^-(aq) + Ag^+(aq) \rightarrow AgX(s)$	**(2)**

Question Number	Answer	Mark
4(a)(iii)	**The only correct answer is A (X, Y, Z)** **B** *is not correct because* ***Z*** *hydrolyses faster than* ***Y*** **C** *is not correct because* ***X*** *is the slowest to hydrolyse* **D** *is not correct because* ***Z*** *is the fastest to hydrolyse /* ***X*** *is the slowest to hydrolyse and this is in order of* ***decreasing*** *rate*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(b)	An answer that makes reference to the following point: • tertiary bromoalkanes react fastest **OR** primary bromoalkanes react slowest	Allow names as identifiers in explaining reason e.g. Allow answers in terms of bond strength, ie C-Br bond is weakest in 2-bromo-2-methylpropane **OR** strongest in 1-bromobutane Allow primary bromoalkanes are more stable Ignore reference to secondary bromoalkane	**(1)**

Question Number	Answer	Mark
4(c)(i)	The only correct answer is B  **A** *is not correct because the nitrogen in the intermediate should be positively charged with three hydrogens and the other product should be the bromide ion* **C** *is not correct because there is a hydrogen atom missing on the N of* NH_2 *in the product cation* **D** *is not correct because the charges on the intermediate must be shown*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(c)(ii)	• $NH_4^{(+)}Br^{(-)}$	Ignore HBr Ignore ammonium bromide	(1)

Question Number	Answer	Mark
4(c)(iii)	**The only correct answer is A (absorption P)** **B** *is not correct because this is an alkane absorption* **C** *is not correct because this is the C=O of an amide absorption* **D** *is not correct because this is an unassigned peak that happens to appear in the IR spectrum*	(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
4(d)(i)	An answer that makes reference to two of the following points: • many organic reactions are equilibria (with a significant equilibrium constant) **(1)** • side reactions may also take place **(1)** • a specific handling loss **(1)**	Allow reverse reactions lower yield Allow eqm not achieved, takes too long / slow reaction / high activation energy Reaction stopped before eqm achieved Allow reactions are incomplete e.g. substitution v elimination Allow reference to by-products/minor products e.g. loss of liquid during transfer between containers, volatility	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(d)(ii)	An answer that makes reference to the following points: Reagent: • KCN / potassium cyanide **(1)** Conditions: • aqueous ethanolic / ethanolic solution **(1)**	Allow NaCN / sodium cyanide Do not award just 'cyanide' Do not allow nitrile in place of cyanide If the name and formula are given, both must be correct Allow just ethanol/alcohol Ignore heat Mark independently	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4(d)(iii)	An answer that makes reference to the following points: Reagent: • (concentrated) potassium hydroxide / KOH **(1)** Condition: • alcoholic / ethanolic solution **(1)**	Accept (conc.) sodium hydroxide / NaOH Do not award contradictory reagents, e.g. acidified KOH Allow just ethanol/alcohol Ignore heat Mark independently	**(2)**

(Total for Question 4 = 16 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)(i)	• calculation of ΔT **and** use of mcΔT **(1)** • calculation of mass of alcohol burnt **and** calculation of energy produced, g^{-1} **(1)** • final answer, in kJ g^{-1}, including sign **(1)**	<u>Example of calculation:</u> ΔT = 28.7 − 17.8 = 10.9 (K / ºC) Accept ΔT included in the mcΔT calculation mcΔT = 500 × 4.18 × 10.9 = 22781 (J) / 22.781 (kJ) Allow M1 if this number is seen 20.24 – 19.48 = 0.76 g 22781 ÷ 0.76 = 29975 (J g^{-1}) / 29.975 (kJ g^{-1}) = 30000 (J g^{-1}) −30 / −30.0 (kJ g^{-1}) Ignore SF TE throughout Correct final answer (inc. sign) with no working scores 3 marks	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)(ii)	An explanation that makes reference to the following points: • magnitude / size will be reduced / less negative **(1)** • because fewer bonds are made (in forming CO_2) **(1)**	Do not award change of sign of $\Delta_c H$ [alcohol] Do not award becomes more positive If a decrease in enthalpy is linked to less energy being released then allow M1 but do not award just for decrease in enthalpy Allow (carbon is the product of) incomplete combustion	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)	An answer that makes reference to the following points: Theoretical reason: • molar mass is unknown **Or** the data book values must be converted to kJ g^{-1} **(1)** Practical reason: • experiment is (very) inaccurate **(1)**	the enthalpy change of combustion in kJ mol^{-1} cannot be determined (for comparison with a data book listing $\Delta_c H$ in kJ mol^{-1}) Allow reference to unknown number of moles Accept this mark for any valid, specified source of heat loss in the procedure: heat loss from walls of container heat loss from surface of water heat loss to container heat loss to burner heat loss from flame to air alcohol loss by evaporation Allow heat loss to the surroundings Allow reference to incomplete combustion Ignore scaffolding and award marks wherever the answer is written	**(2)**

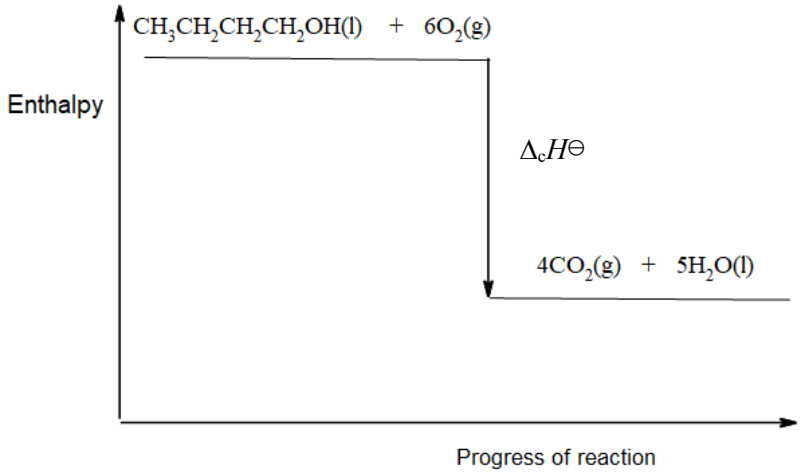
Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)	An explanation that makes reference to the following points: **Either** • presence of a peak at 29 **(1)** • which is due to $C_2H_5^+$ / $CH_3CH_2^+$ **(1)** **Or** • presence of a peak at 31 **(1)** • which is due to CH_2OH^+ **(1)**	Do not award peak at 15 due to CH_3^+ Do not award peak at 17 / 43 due to OH^+ or $C_3H_7^+$ Do not award peak at 59 due to $C_3H_7O^+$	**(2)**

(Total for Question 5 = 9 marks)

Question Number	Answer	Mark
6	**The only correct answer is C ($[NH_3]^2[CO_2]$)** **A** *is not correct because the equation shows 2 mol NH_3 so the term $[NH_3]$ must be squared, and ammonium carbamate is a solid so it does not appear in the equilibrium expression* **B** *is not correct because the equation shows 2 mol NH_3 so the term $[NH_3]$ must be squared not doubled , and ammonium carbamate is a solid so it does not appear in the equilibrium expression* **D** *is not correct because ammonium carbamate is a solid so it should not be included in the equilibrium expression*	**(1)**

(Total for Question 6 = 1 mark)

Question Number	Answer	Mark
7(a)	**The only correct answer is C (**hydrogen bonding, permanent dipole-dipole forces and London forces) **A** *is not correct because although hydrogen bonding is the strongest intermolecular force, permanent dipole-dipole interactions and London forces are also present* **B** *is not correct because London forces are always present between molecules in the liquid state* **D** *is not correct because London forces are the weakest of the intermolecular forces, and other intermolecular forces are also present between butan-1-ol molecules*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(b)	• reactants above products **(1)** • downwards pointing arrow from reactants to products **and** label on down arrow **(1)**	Example of enthalpy level diagram  Allow 'reactants' & 'products' OR chemical formulae correctly balanced (with/without states) on levels Arrow label = Δ_rH / Δ_cH / -2675.6 kJ mol^{-1} Allow label of just 'enthalpy change' / ΔH / ΔH_c Arrow must go from level to level without any gap(s) Ignore activation energy 'hump' if reaction profile diagram drawn Do not award double headed arrow for downwards pointing arrow	**(2)**

Question Number	Answer	Mark
7(c)(i)	**The only correct answer is B (phosphorus(V) chloride PCl_5(s) steamy fumes)** **A** *is not correct because hydrogen chloride is not white smoke* **C** *is not correct because carbonates only react with acids and CO_2 cannot be observed* **D** *is not correct because carbonates only react with acids*	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(c)(ii)	An answer that makes reference to the following point: • set equipment for distillation (rather than reflux) / distil out the aldehyde as soon as it is formed	Allow just 'distillation'/'distil' Allow (use) stoichiometric quantities (for partial oxidation) Allow a form of words to mean the same as stoichiometric	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(c)(iii)	An answer that makes reference to the following points: • (react with) Benedict's / Fehling's solution **(1)** **and** heat / warm • butanal gives a red/brown ppt (butan-1-ol does not react) **(1)**	Allow Tollens' reagent (M1) **and** heat / warm Aldehyde gives a silver mirror (M2) Allow solid for ppt Ignore 'starting' colour even if incorrect Allow Schiff's reagent test (M1) aldehydes give a magenta/red/pink colouration (M2) Ignore use of 2,4-DNPH (aldehydes give yellow/red/orange ppt) Check for missing 'heat/warm' and 'ppt'	**(2)**

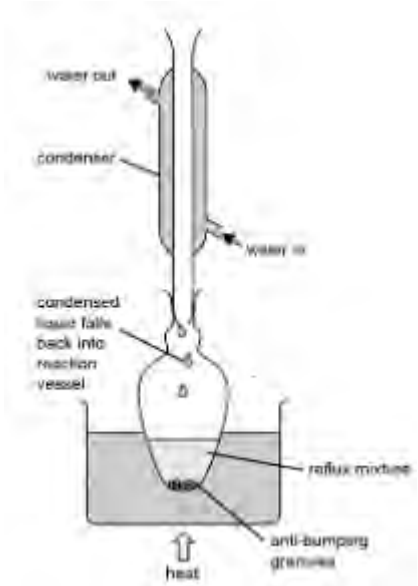
<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*7(c)(iv)</td>
<td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative 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.
<table>
<tr><th></th><th>Number of marks awarded for structure and sustained lines of reasoning</th></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>
</td>
<td>Guidance on how the mark scheme should be applied:

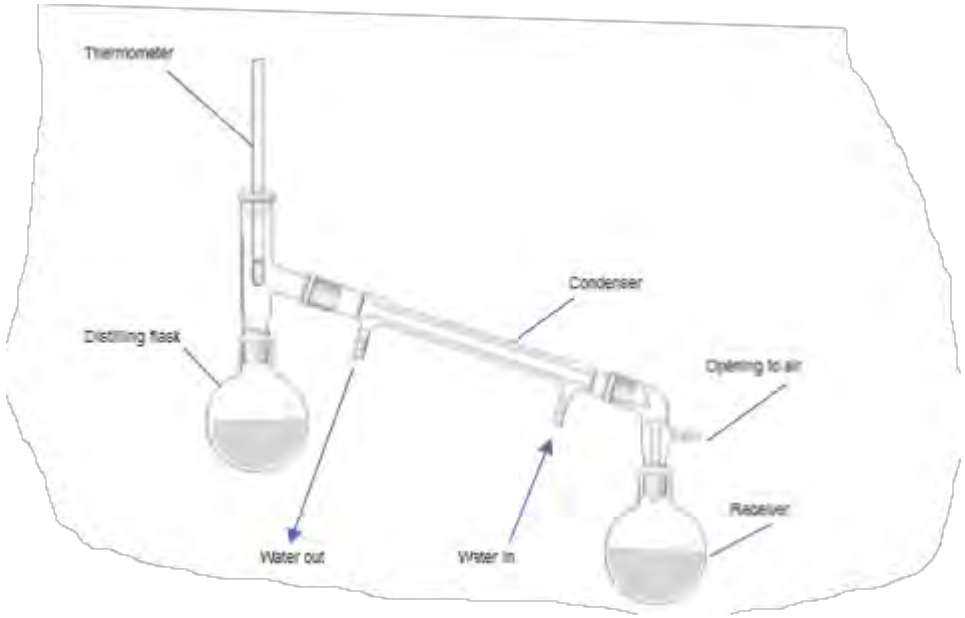
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some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

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.

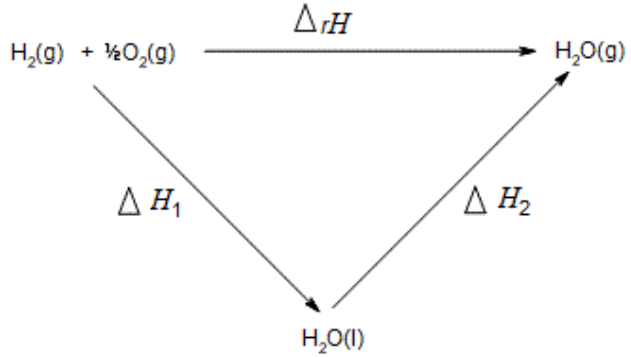
If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s).</td>
<td>(6)</td>
</tr>
</table>

	Indicative content: **IP1** mention of refluxing (and excess oxidising agent) **IP2** diagram of reflux equipment with vertical condenser and correct water flow **IP3** anti-bumping granules and suitable method of heating	Do not award reference to reflux of butanoic acid Accept diagram of workable reflux arrangement even if not fully labelled. Allow direct/indirect heating  Ignore method of adding the alcohol, e.g. butan-1-ol may be added down reflux condenser Allow direct heating with Bunsen burner or electrical heater/ Isomantle/thermomantle etc. Allow just an arrow labelled heat as shown in the diagram above	

	IP4 mention of distillation at suitable temperature **IP5** diagram of distillation apparatus with sloping condenser and collecting vessel **IP6** inclusion of thermometer (pocket) on left-hand side (in this diagram) **and** opening for gaseous escape on right-hand side (in this diagram)	Any range or value between 120 ºC and the maximum temperature of 170 ºC for distillation of butanoic acid Do not award distillation of the butan-1-ol  Penalise incorrect water flow/unlabelled water flow in condenser once only in IP2 or IP5 Penalise gaps in joints between the equipment once only in IP2 or IP5 If initial oxidation under reflux is not mentioned then only IP4 and IP6 are obtainable	

(Total for Question 7 = 13 marks)

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)	An answer that refers to the following points: • pressure = 1 atm / 100 kPa / 100000 Pa / 1000000 N m^{-2} / 1 bar **(1)** • stated temperature **(1)**	Allow 101 kPa / 101000 Pa Allow any stated temperature in K or °C 273−298 K / 0−25°C inclusive Ignore room temperature	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(b)(i)	An answer that makes reference to the following points: • correct species and states at each corner of the triangle **(1)** • all arrows labelled and pointing in the correct direction **(1)**	<u>Example of Hess's Law diagram</u>  Allow ΔH_1, ΔH_2 **or** figures ($\Delta H_1 = -285.8$ kJ mol^{-1}, $\Delta H_2 = +2.261$ kJ g^{-1}) with correct sign Allow reversed arrows **provided** the ΔH_1, ΔH_2 or figures also have reversed signs	**(2)**

Question Number	Acceptable Answer		Additional Guidance	Mark
8(b)(ii)	• convert energy change for $H_2O(l) \rightarrow H_2O(g)$ from kJ g^{-1} to J mol^{-1} / kJ mol^{-1} **OR** conversion of −285.8 kJ mol^{-1} to J g^{-1}/kJ g^{-1}	**(1)**	Example of calculation 2.261 × 18.0 → (+)40698 (J mol^{-1}) = (+)40.698 (kJ mol^{-1}) −285.8 ÷ 18.0 → −15.878 kJ g^{-1}/ −15878 J g^{-1}	**(3)**
	• correct use of Hess's Law	**(1)**	$\Delta_r H = \Delta H_1 + \Delta H_2$ COMMENT An incorrect Hess cycle in (b)(i) cannot score this mark	
	• calculate numerical value of energy change ($\Delta_r H$)	**(1)**	−285.8 + (+40.698) = −245.10 / −245.1 / −245 (kJ mol^{-1}) Accept final answer in kJ mol^{-1}, J mol^{-1} (−245102), kJ g^{-1} (−13.617) or J g^{-1} (−13617) Ignore SF except 1 SF Correct answer with no working scores 3 marks Allow TE throughout (b)(ii) Ignore units even if incorrect If the Hess cycle is repeated in (b)(ii) or only seen (b)(ii) then it can be credited for part (b)(i)	

(Total for Question 8 = 7 marks)

(Total for Paper = 80 marks)