Pearson Edexcel

Mark Scheme (Results)

Summer 2024

Pearson Edexcel GCE
Chemistry (9CH0) Paper 03
General and Practical Principles in 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	Additional Guidance	Mark
1(a)	An answer that makes reference to the following points: • (the relative isotopic mass is) the mass of an atom (of an isotope) **(1)** • relative to 1/12 of the mass of a carbon-12 atom **or** relative to a carbon-12 atom which has a mass of (exactly) 12 **(1)**	Allow weight for mass Do not award reference to average/mean mass Accept divided by 1/12 of the mass of a carbon-12 atom Allow reference to moles such as The mass of one mole of atoms of an isotope relative to 1/12 of the mass of one mole of carbon-12 atoms	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that makes reference to the following point: • five / 5		**(1)**

(Total for Question 1 = 3 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)	An explanation that makes reference to the following points: (Setting up of the dipole) • (random) movement of **electrons** / (temporary) uneven distribution of **electrons** / Fluctuation of **electrons** **(1)** (Type of dipole) • (this results in an) instantaneous/temporary dipole (in the first molecule) **(1)** (Induction of a second dipole) • (which) causes/induces a (second) dipole in a neighbouring/adjacent molecule **(1)**	Allow reference to atoms throughout but for M3 a second/different atoms should be clear Allow reference to **electron** density Allow oscillating dipole Do not award reference to **permanent** dipole Allow in/on another molecule for adjacent Do not award reference to **permanent** dipole M3 is consequential on M2 or a near miss Allow a **labelled** diagram for evidence of these marks Ignore any reference to attraction stated thereafter Penalise reference to electronegativity once only	**(3)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to the following points: • compound A as London forces increase as branching decreases or compound A is unbranched and has greater/more London forces **(1)** • so surface area/points of contact (of molecules) increases **(1)**	Allow van der Waals'/dispersion forces/ induced dipole – dipole forces for London forces Allow 'least branching'/ 'longer chain' for unbranched Allow reference to packing of molecules more closely/closer together Allow compound for molecule Ignore A molecules are more compact Do not award 'more electrons' Do not award M2 if clear reference to covalent bonds being broken/decomposition Accept reverse argument e.g. • compound A, as the other compounds have less London forces as branching increases • so surface area/points of contact (of molecules) decreases	**(2)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>2(c)</td><td>An explanation that makes reference to the following points:

• effect on the stream of liquid by CCl_4, $CHCl_3$ and C_6H_{14} (1)

• (because of) bond polarity in CCl_4, $CHCl_3$ and C_6H_{14} (1)

• (resulting in) molecular non-polar /polarity due to shape (1)</td><td>Allow differences in electronegativities for references to polar/non-polar bonds

<table><tr><td></td><td>CCl_4,</td><td>$CHCl_3$</td><td>C_6H_{14}</td></tr><tr><td>Deflection</td><td>X</td><td>✓</td><td>X</td></tr><tr><td>Bond polarity</td><td>✓</td><td>✓</td><td>*X</td></tr><tr><td>Molecular polarity</td><td>X
because
symmetrical</td><td>✓
because
non-symmetrical</td><td>*(X)</td></tr></table>Score either rows or columns, awarding the higher score

* For hexane only, allow reference to non-polar bonds to imply non-polar molecule but not vice versa

Allow no dipole moment/vectors cancel for symmetry
Allow reference to dipoles cancel for symmetry</td><td>(3)</td></tr>
</table>

(Total for Question 2 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)	• (crystals will be small enough) to get through (pores in) the filter paper	Ignore references to just not being filtered Do not award references to crystals being 'stuck' on the filter paper or dissolving	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to the following points: • to remove (excess) $BaCl_2(aq)$ / MCl(aq) **(1)** • which would otherwise crystallise / add to mass (of sulfate) **(1)**	Allow to remove remaining solution Allow reference to removing filtrate Ignore reference to residue Allow reference to 'change the mass' Do not award a decrease in mass If no other mark awarded then allow (1) for to remove (soluble) impurities Do not award removal of solid impurities	**(2)**

Question Number	Answer		Additional Guidance	Mark
3(c)	• calculation of moles of $BaSO_4$	**(1)**	$1.02 \div 233.4 = 4.3702 \times 10^{-3}$ / 0.0043702 (mol)	**(3)**
	• calculation of RFM of M_2SO_4	**(1)**	$0.48 \div 4.3702 \times 10^{-3} = 109.84$ / 110 (g mol^{-1}) Ignore SF except 1 SF for M1 and M2	
	• deduction of identity of M	**(1)**	(109.84 – (32.1 + 64) = 13.74 hence A_r of M = 6.87 / 6.9) so M = Li Allow Li^+ Ignore SF for M3 Allow TE from M1 to M2 Allow TE from M2 to M3 provided value is positive and linked to an appropriate metal that can form a +1 ion Correct answer without working scores (1)	

Question Number	Answer	Additional Guidance	Mark
3(d)(i)	An explanation that makes reference to the following points: • (some of) M_2SO_4 (solution) would be lost (from the beaker) **(1)** • so (calculated) **moles**/**amount** (of M_2SO_4) would be less **and** (calculated) formula mass would be more/higher **(1)**	Allow just some of the solution would be lost Allow reference to moles of $BaSO_4$ for M_2SO_4 Ignore less mass of $BaSO_4$ Allow M2 for answers that show understanding of the negligible change (of RFM) M2 dependent upon M1 attempt Allow M2 for a TE such as the moles of M_2SO_4 would be more which results in a lower RFM provided the answer states that the mass has increased	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(d)(ii)	• rinse glass rod with deionised/distilled water into the beaker	Allow wash for rinse Allow 'to the solution' for "into the beaker" Do not award rinsings go down the sink References to the use of a magnetic stirrer can score if rinsing is mentioned of the 'flea'	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(e)(i)	An explanation that makes reference to the following points: • heat causes electrons to be promoted / excited / move to a higher energy level **(1)** • light is emitted when electrons fall back (to lower level / ground state) **(1)**	Electrons need to be mentioned once in M1 or M2 Allow just 'energy (from flame) causes electrons to be promoted/excited' Accept reference to photons for light Allow released/ given out for emitted Ignore reference to just energy Do not award reference to complementary colours/absorption colour Do not award reference to reflected/transmitted	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(e)(ii)	An answer that makes reference to the following points: • Advantage – simpler (process) / quicker (process) **(1)** • Disadvantage – flame colours are subjective (by eye) / some metal (ions) produce very similar flame colours (by eye) / often more than one colour may be seen (due to contamination) **(1)**	Allow just 'easier' Ignore just 'cheaper' Ignore references to more accurate Allow several metal (ions) produce red flames / not all metal (ions) produce a flame colour (in the visible range) If metals are named then their colours must be correct	**(2)**

(Total for Question 3 = 13 marks)

Question Number	Answer		Additional Guidance	Mark
4(a)(i)			Example of calculation	(5)
	• calculation of $\Delta S^{\ominus}_{system}$	(1)	$((2 \times 70.4) + (4 \times 240.0) + 205.0) - (2 \times 213.8) = 878.2$ ($J\ K^{-1}\ mol^{-1}$)	
	• calculation of $\Delta S^{\ominus}_{surroundings}$	(1)	$(-1010 \times 1000) \div 298 = -3389.26 / 3389.3$ ($J\ K^{-1}\ mol^{-1}$) or $(-1010 \div 298) = -3.38926 / 3.3893$ ($kJ\ K^{-1}\ mol^{-1}$)	
	• consistent units for $\Delta S^{\ominus}_{system}$ and $\Delta S^{\ominus}_{surroundings}$	(1)	$\Delta S^{\ominus}_{surroundings}$ converted to $J\ K^{-1}\ mol^{-1}$ or $\Delta S^{\ominus}_{system}$ converted to $kJ\ K^{-1}mol^{-1}$ M3 could be subsumed as part of either M1 or M2	
	• calculation of $\Delta S^{\ominus}_{total}$	(1)	$= 878.2 + (-3389.3)$ $= -2511.1$ ($J\ K^{-1}\ mol^{-1}$) or -2.5111 ($kJ\ K^{-1}\ mol^{-1}$) Penalise incorrect units for M4 only	
	• comment on thermal stability at 298 K	(1)	Negative value, so reaction is not feasible /compound thermally stable (at 298 K) Standalone mark Do not award on positive values for $\Delta S^{\ominus}_{total}$ Ignore SF except 1 SF Allow TE from M1 to M4 provided M4 is negative	
			A negative value for $\Delta S^{\ominus}_{system}$ loses M3 to M4 so can only score M2 and M5 $\Delta S^{\ominus}_{total} = +874.8$ scores (2) for M1 and M2 but the failure to convert to consistent units means a positive $\Delta S^{\ominus}_{total}$ is obtained that does not match the question	

	Alternative method using ΔG • calculation of $\Delta S^{\ominus}_{system}$ **(1)** • calculation of $T\Delta S^{\ominus}_{system}$ **(1)** • consistent units for $T\Delta S^{\ominus}_{system}$ and $\Delta H^{\ominus}$ **(1)** • calculation of ΔG **(1)** • reason why thermally stable at 298 K **(1)**		<u>Example of calculation</u> $((2 \times 70.4) + (4 \times 240.0) + 205.0) - (2 \times 213.8) = (+) 878.2$ (J K^{-1} mol^{-1}) $298 \times 878.2 = 261703.6$ (J mol^{-1}) M2 could be subsumed as part of either M3 or M4 $\Delta H^{\ominus}$ converted to J mol^{-1} OR $T\Delta S^{\ominus}_{system}$ converted to kJ mol^{-1} M3 could be subsumed as part M4 ($\Delta G = \Delta H - T\,\Delta S_{system}$) = (+) 1010 000 − 261703.6 = (+) 748296.4 (J mol^{-1}) = (+) 748.296 (kJ mol^{-1}) Penalise incorrect units for M4 only Ignore SF except 1 SF Allow TE from M1 to M4 provided M4 is positive ΔG positive / > 0 so reaction is not feasible/ compound is stable (at 298 K) Standalone mark but Do not award on negative values for $\Delta G^{\ominus}$ A negative value for $\Delta S^{\ominus}_{system}$ loses M3 to M4 so can only score M2 and M5 ΔG = − 260693.6 scores (2) for M1 and M2 but the failure to convert to consistent units means a negative ΔG is obtained that does not match the question	

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	• rearrangement of ΔG expression **(1)** • calculation of T **(1)** • conversion to °C to 2/3 SF **(1)**	<u>Example of calculation</u> $T = \Delta H/\Delta S_{system}$ *(*T = (1010 × 1000) / 878.2) = 1150.1 (K) M2 subsumes M1 so the numerical value scores (2) = 877 (°C) / 880 (°C) Allow 878 (°C) Do not award an answer below 25°C for M3	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that makes reference to the following points: (calcium nitrate is less thermally stable because) • (both ions have the same charge but) the calcium **ion** is smaller / has a greater charge density **(1)** • so polarises (the anion) to a greater extent **(1)** • and so weaken the N−O bond / bond(s) within the nitrate ion **(1)**	Allow reverse arguments Ignore 'calcium atom is smaller' Do not award references to electronegativity Do not award reference to electron density Allow so more likely to polarise (the nitrate (ion) / calcium ion has more polarising power Allow reference to polarisation of the bond Allow a description of polarisation such as the distortion of the anion electron cloud to a greater extent Do not award reference to breaking of/polarising the ionic bond between the calcium and the nitrate	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	An answer that makes reference to the following point: • $8Al + \mathbf{3}NO_3^- + \mathbf{5}OH^- + \mathbf{18}H_2O \rightarrow \mathbf{8}Al(OH)_4^- + \mathbf{3}NH_3$		**(1)**

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	An answer that makes reference to the following point: • (ammonia turns damp red) litmus paper blue	Allow (ammonia turns damp) UI paper blue Do not award if litmus paper bleached after turning blue Allow (ammonia produces) white smoke with HCl (gas) Do not award white fumes/misty fumes If two tests given then both must be correct to score	**(1)**

(Total for Question 4 = 13 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*5</td>
<td>
This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.
<table>
<tr><td>Number of indicative marking points seen in answer</td><td>Number of marks awarded for indicative marking points</td></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>

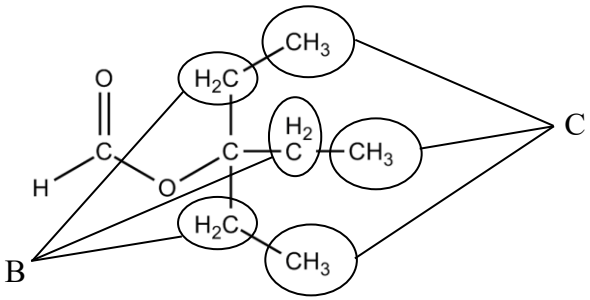
The following table shows how the marks should be awarded for structure and lines of reasoning
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained lines of reasoning</td></tr>
<tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td>
<td>
Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, a response with four indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).
</td>
<td>(6)</td>
</tr>
</table>

	Indicative content **Similarity** • **IP1 both** reactions involve attack by an electrophile **Differences** • **IP2** benzene reaction is a substitution, cyclohexene reaction is an addition • **IP3** benzene forms 2 products, cyclohexene forms 1 product • **IP4** so benzene reaction requires a catalyst of $FeBr_3$ (to induce dipole in bromine) • **IP5** cyclohexene reacts at room temperature / with bromine water • **IP6** benzene is less reactive / more stable as (pi) **electrons** are **delocalised** (across the ring)	Benzene forms bromobenzene + HBr and cyclohexene forms just 1,2-dibromocyclohexane Allow equations for evidence of IP3 but not IP2 Ignore names if correct structures drawn Allow Fe/$AlBr_3$ as catalyst/halogen carrier Allow $AlCl_3$ Allow this shown by equation e.g. $FeBr_3 + Br_2 \rightarrow FeBr_4^- + Br^+$ Ignore reference to heat/reflux/room temperature Accept cyclohexene is more reactive due to high **electron** density of double bond / localised pi electrons Ignore just 'does not need a catalyst' Ignore just 'no special conditions'	

(Total for Question 5 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)	(method 1) • (**M1**) calculation of moles of carbon dioxide **(1)** • (**M2**) calculation of moles of **Q** based on 100% yield **(1)** (method 2) • (**M1**) calculation of volume at 100% yield **(1)** • (**M2**) calculation of moles at 100% yield **(1)** (method 1 and method 2) • (**M3**) show how to calculate M_r of **Q** **(1)**	<u>Example of calculation</u> n (CO_2) = 269 ÷ 24000 = 0.011208 / 1.1208 × 10^{-2} (mol) n (ester) = 0.011208 × (100 ÷ 78) = 0.014370 / 1.4370 × 10^{-2} (mol) V (CO_2) = 269 × (100 ÷ 78) = 344.87 (cm^3) n (CO_2) = 344.87 ÷ 24000 = 0.01437 / 1.437 × 10^{-2} (mol) = n (ester) M_r of ester = 2.07 ÷ 0.014370 = 144.05 / 144 or Justification 2.07 ÷ 144 = 1.4375 × 10^{-2} which is ca. 1.4370 × 10^{-2} Accept calculation variations which involve the 78% conversion, the molar volume of gas and the starting mass of 2.07 Ignore SF except 1 SF in M1 and M2 Ignore intermediate units even if incorrect Note: Use of the formula pV=nRT with T =298 and P =1 × 10^5 gives a RMM=148 and scores (3)	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An explanation that makes reference to the following points: • (peak due to A) is a singlet **(1)** • as there are no adjacent carbon atoms with hydrogen atoms/ as the carbon is (only) bonded to oxygen atoms **(1)**	Ignore any comments about chemical shifts Allow no splitting Use of n+1 rule Do not award if it is clear that the methanoate carbon is being referred to as the adjacent carbon	**(2)**

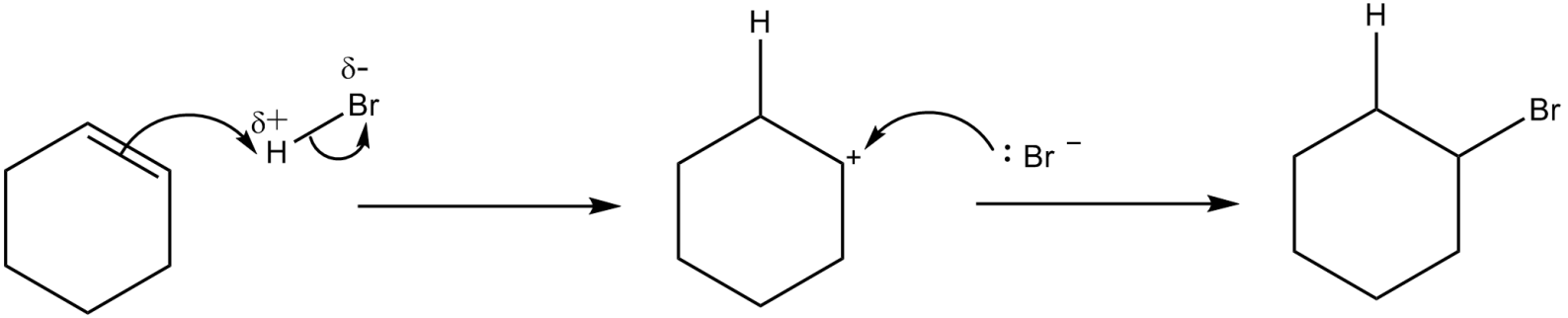
Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An answer that makes reference to the following points:  	Accept any clear means of labelling of the two different hydrogen environments Ignore labelling of just one CH_3 and one CH_2 unless it is clearly stated that the other groups (of each sort) are equivalent	**(1)**

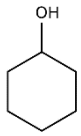
<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>6(b)(iii)</td><td>
• chemical shifts (1)
• splitting patterns (1)
• relative peak areas (1)
</td><td>
<table>
<tr><th></th><th>Chemical shift (∂) / ppm</th><th>Splitting pattern of peak</th><th>Relative peak area</th></tr>
<tr><td>B</td><td>0 − 1.9</td><td>quartet</td><td>6
Allow 2</td></tr>
<tr><td>C</td><td>0 − 1.9</td><td>triplet</td><td>9
Allow 3</td></tr>
</table>
Allow any single chemical shift value or range within the MS range
Allow four splits for quartet and three splits for triplet
Ignore reference to proton environment A
Additional proton environments max 1 for chemical shifts

If no other mark awarded then allow (1) for either B or C given correctly for chemical shift and splitting and peak area (row)
</td><td>(3)</td></tr>
</table>

(Total for Question 6 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following points: • curly arrow from C=C to ∂+ H in HBr • dipole on HBr • curly arrow from H-Br bond to, or just beyond, $Br^{\partial-}$ • structure of carbocation • lone pair on Br^- • curly arrow (from lone pair on) Br^- to C^+	Penalise use of half arrows once only in points 1, 3 and 6 Ignore drawing of hydrogen atoms on carbocation unless the number of hydrogen atoms is too many 6 points scores (4) 5 points scores (3) 3 or 4 points scores (2) 2 points scores (1) 1 point scores (0)	**(4)**



Question Number	Answer	Additional Guidance	Mark
7(b)	An answer that makes reference to the following points: • (reaction of) bromocyclohexane with KOH**(aq)** /NaOH**(aq)** **(1)** • (nucleophilic) substitution **(1)** • structure of **A** (cyclohexanol) **(1)** • reflux / heat with sulfuric acid and sodium dichromate ((VI)) **(1)** • oxidation **(1)**	Each mark is standalone Accept aqueous ethanolic for **(aq)** or **aqueous** Ignore reference to reflux / heating Do not award just ethanolic KOH/ NaOH Accept hydrolysis  Accept displayed formula Ignore name of A, even if incorrect Allow acidified dichromate ((VI)) / H^+ and $Cr_2O_7^{2-}$ Accept $K_2Cr_2O_7$ for $Na_2Cr_2O_7$ Ignore concentration Allow distillation/distil for reflux/heat Do not award HCl for sulfuric acid Allow reference to oxidising agent/oxidised Ignore redox	**(5)**

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	• (dry) ether / ethoxyethane	Accept diethyl ether Ignore any formulae, even if incorrect Do not award if given with any additional substance	**(1)**

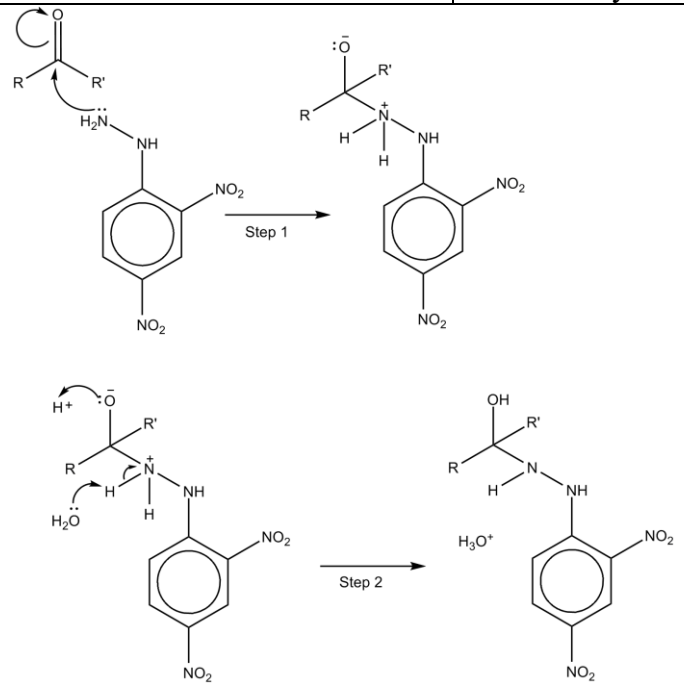
Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	An explanation that makes reference to the following points: • to prevent moist air entering **(1)** • as Grignard reagent will not form in presence of water **(1)**	Allow to keep the reactants dry Allow reference to absorbing water Ignore just drying agent Do not award to remove water from the solution or coming out from the solution Allow 'to ensure Grignard Reagent doesn't break down (to an alkane)' / Grignard reagents react with water / avoid hydrolysis of Grignard reagents Allow reference to ethane/alkane forming Ignore reference to just reacting with the reactants	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(c)(iii)	An answer that makes reference to the following point: • to ensure efficient cooling / prevent air bubbles forming in condenser	Allow to fill the condenser with water	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(d)(i)	An answer that makes reference to the following point: • orange / yellow	 Allow red Allow any combination of these 3 colours Ignore any shades	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(d)(ii)	An answer that makes reference to the following points: • arrow from C=O bond to O **(1)** • arrow from lone pair on O− to H+ **(1)** • arrow from lone pair in O in H_2O to H in NH_2 **(1)** • arrow from N−H bond to N+ **(1)**	Accept arrow to either of the two hydrogen atoms Allow M2 to M4 to be drawn on the product of Step 1 if not drawn in Step 2 Ignore any dipoles added, even if incorrect Penalise any additional incorrect curly arrows over four	**(4)**

Exemplar diagram



Question Number	Answer	Additional Guidance	Mark
7(d)(iii)	An answer that makes reference to the following points: • solid dissolved in **minimum** amount of **hot** solvent **(1)** • (hot filtration then) solution allowed to cool and (re)crystallise/precipitate **(1)** • solid filtered under reduced pressure **(1)** • rinsed with (cold) solvent **and** dried between (sheets of) filter paper **(1)**	Allow any named solvents M2 dependent on M1 or near miss Allow solid for crystal/ppt Allow 'Buchner filtration' / suction filtration Cooling and recrystalising follows M1 so M2 dependent M3 and M4 must apply to crystals/solid being present however derived Filtering and drying of dissolved solid is nonsense so M3 and M4 would both be lost Allow desiccator / warm oven as alternative for (sheets of) filter paper Allow drying with paper towels	**(4)**

(Total for Question 7 = 22 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)(i)	An explanation that makes reference to the following points: • as the weak acid (is being titrated with) a weak base **(1)** • as no rapid change in pH (to find volume at end-point) **(1)** • so end-point cannot be determined **(1)**	Accept pH changes gradually around the end point Allow there is no vertical section in the titration curve so a sharp colour change cannot be observed Allow phenolphthalein would not change colour/ pK_{In} is too high	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	• (replace ammonia with) a strong base such as NaOH / KOH	Allow name or formula of strong base Allow use of a pH probe/pH meter Do not award change of indicator	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(a)(iii)	An answer that makes reference to the following points: (method 1) • K_a expression for ethanoic acid **(1)** • statement that at half-neutralisation concentration of anion and acid are equal **(1)** • $K_a = [H^+]$ $(=10^{-pH})$ **(1)** (method 2) • Henderson-Hasselbalch expression **(1)** • statement that at half-neutralisation concentration of anion and acid are equal **(1)** • $pK_a = pH$ (so $K_a = [H^+] = 10^{-pH}$) **(1)**	$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ or $K_a = \frac{[A^-][H^+]}{[HA]}$ $[CH_3COOH] = [CH_3COO^-]$ or $[HA] = [A^-]$ Allow $pK_a = pH$ $(= -\log [H^+] = -\log K_a)$ Standalone mark Do not award $K_a = pK_a$ Penalise omission of square brackets once only Penalise use of () throughout for [] once only $pH = pK_a + \log \frac{[A^-]}{[HA]}$ or $pH = pK_a + \log \frac{[salt]}{[acid]}$ or $pK_a = pH - \log \frac{[A^-]}{[HA]}$	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(b)	A calculation that makes reference to the following points: • (**M1**) calculation of $[H^+]$ **(1)** • (**M2**) rearrangement of K_a expression **(1)** • (**M3**) calculation of $[CH_3COONa]$ in buffer **(1)** OR Use of Henderson Hasselbalch for M1 to M3 • (**M1**) rearrangement of H−H expression **(1)** • (**M2**) calculation of $[CH_3COONa] \div [CH_3COOH]$ **(1)** • (**M3**) calculation of $[CH_3COONa]$ **(1)** --- • (**M4**) calculation of M_r of CH_3COONa **(1)** • (**M5**) calculate the mass of CH_3COONa needed **(1)**	<u>Example of calculation</u> $10^{-4.48} = 3.3113 \times 10^{-5}$ (mol dm^{-3}) $K_a = ([H^+][CH_3COONa]) \div [CH_3COOH]$ $[CH_3COONa] = K_a \times [CH_3COOH] \div [H^+]$ $[CH_3COONa] = (1.74 \times 10^{-5} \times 0.52) \div 3.3113 \times 10^{-5}$ $= 0.27325$ (mol dm^{-3}) log $([CH_3COONa] \div [CH_3COOH]) = 4.48 - 4.75945 = -0.27945$ $[CH_3COONa] \div [CH_3COOH] = 10^{-0.27945} = 0.52547$ $[CH_3COONa] = 0.52547 \times 0.52 = 0.27325$ (mol dm^{-3}) 82 $= (0.27325 \div 4 \times 82) = 5.6015$ (g) / 5.6 (g) Allow TE but not from an incorrect rearrangement for M3 Ignore SF except 1 SF Allow CH_3COO^- for CH_3COONa in M2 and M3 Correct answer with or without working scores (5)	**(5)**

Question Number	Answer	Additional Guidance	Mark
8(c)	A calculation that makes reference to the following points: • calculate amount of $H^+(aq)$ in mol **(1)** • calculate amount of $OH^-(aq)$ in mol **(1)** • calculate amount of excess $OH^-(aq)$ in mol **(1)** • calculate $[OH^-]$ in resultant solution **(1)** • calculate pH of resultant solution **(1)**	<u>Example of calculation</u> $= (20 \div 1000) \times 0.400 \times 2 = 0.016$ (mol) $= (50.0 \div 1000) \times 0.900 = 0.045$ (mol) $= 0.045 - 0.016 = 0.029$ (mol) $= 0.029 \div (70 \div 1000) = 0.41429$ (mol dm^{-3}) pH = 14 – (– log(0.41429) = 13.617 / 13.6 or pH = – log ($1 \times 10^{-14} \div 0.41429$) = 13.617 / 13.6 Do not award M5 for a pH less than 7 Ignore SF except 1 SF Ignore intermediate units even if incorrect Allow TE throughout	**(5)**

(Total for Question 8 = 17 marks)

Question Number	Answer	Additional Guidance	Mark
9(a)(i)	An answer that makes reference to the following points: • carry out in a fume cupboard **(1)** • SO_2 is toxic / poisonous **(1)**	 Allow in a well-ventilated laboratory Ignore references to handling safely etc Allow SO_2 is corrosive Allow reference to SO_2 issues for breathing difficulties e.g. asthma Allow reference to gases/fumes for SO_2 Ignore acidic/harmful/irritant	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	An explanation that makes reference to the following points: • SO_2 form acids when dissolved **(1)** • so the titre value would be greater (than expected) / results would (appear to) show more (tartaric) acid (than was present in the wine) **(1)**	 Allow SO_2 is acidic Allow SO_2 reacts with the NaOH Ignore CO_2 M2 is dependent upon M1 or a near miss such as the titre value is increased because of greater acidity or the reaction of dissolved gases with NaOH	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(a)(iii)	A calculation that makes reference to the following points: • calculation of amount of NaOH **and** amount of tartaric acid **(1)** • calculation of amount of tartaric acid in mol dm^{-3} **(1)** • calculation of amount of tartaric acid in g dm^{-3} **(1)**	$(20.6 \div 1000) \times 0.100 = 2.06 \times 10^{-3}$ (mol) $= 2.06 \times 10^{-3} \div 2 = 1.03 \times 10^{-3}$ (mol) $1.03 \times 10^{-3} \div (20 \div 1000) = 0.0515$ (mol dm^{-3}) $= 0.0515 \times 150 = 7.725$ (g dm^{-3}) Accept step 3 carried out before step 2 Ignore intermediate units even if incorrect Ignore SF except 1SF TE throughout	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(a)(iv)	An explanation that makes reference to the following points: • the titre value includes the volume of the air bubble (as well as sodium hydroxide solution) **(1)** • so the titre value would be greater (than expected) **(1)**	Allow some alkali/solution is used to fill the air bubble/ burette tip/burette jet M2 is dependent upon M1 or a near miss	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	An explanation that makes reference to the following points:		(4)
	• calculation of amount of iodine **(1)**	$(11.80 \div 1000) \times 0.01 = 1.18 \times 10^{-4}$ / 0.000118 (mol)	
	• calculation of concentration of SO_2 in mol dm^{-3} **(1)**	$1.18 \times 10^{-4} \div (50 \div 1000) = 2.36 \times 10^{-3}$ / 0.00236 (mol dm^{-3})	
	• calculation of concentration of SO_2 in g dm^{-3} **(1)**	$2.36 \times 10^{-3} \times 64.1 = 0.15128$ (g dm^{-3})	
	• calculation of concentration of SO_2 in mg dm^{-3} **and** comment regarding allowable level **(1)**	$= 0.15128 \times 1000 = 151$ (mg dm^{-3}) so below maximum permitted level Allow just 'so ok/suitable' or $151 < 200$ for comment	
		Accept calculations in steps 2 to 4 in any order Accept calculation carried out in reverse order, i.e. from permitted mass to moles	
		Ignore intermediate units	
		Final answer without working scores (4)	
		Allow use of 64 for M_r of SO_2 Allow final answer in g dm^{-3} if permitted maximum converted to g dm^{-3} Ignore SF except 1SF	
		TE throughout provided that the numbers are carried forward	

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An explanation that makes reference to the following points: • to produce CO_2 **(1)** • which forms a blanket / layer (on surface of solution) **(1)**	Allow CO_2 is denser / heavier than air (so stops escape of SO_2) Allow SO_2 cannot get past the (blanket of) CO_2	**(2)**

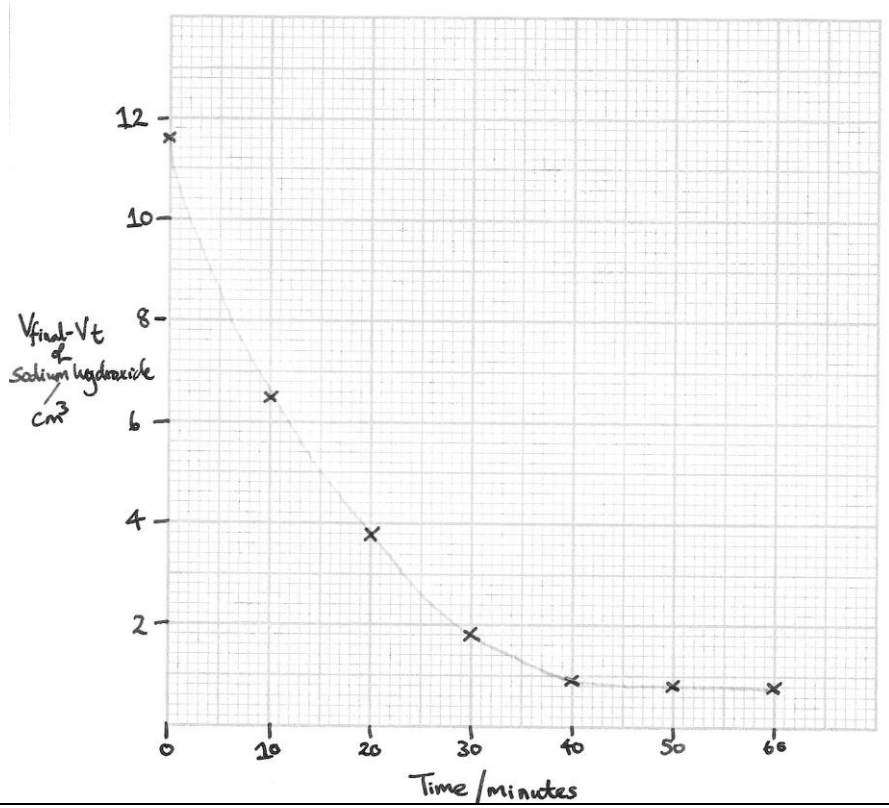
(Total for Question 9 = 15 marks)

Question Number	Answer	Additional Guidance	Mark
10(a)(i)	An explanation that makes reference to the following points: • to stop / freeze / quench the reaction **(1)** • to allow time for the titration to be carried out **(1)**	 Allow to prevent further hydrolysis/negligible reaction Ignore reference to cooling the reaction Ignore prevention of evaporation Ignore just slow the reaction Accept to prevent change/negligible change in concentration of reactants / products Allow so the concentration can be found at that time	**(2)**

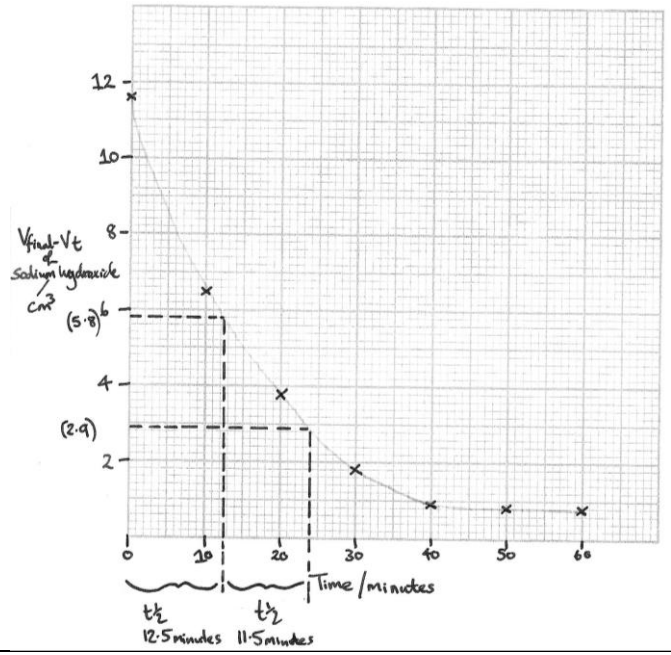
Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	An explanation that makes reference to the following points: • to ensure the hydrolysis / reaction reaches equilibrium **(1)** • so the maximum amount of carboxylic acid (formed) can be determined **(1)**	 Allow hydrolysis reaction goes to completion Do not award reference to oxidation Allow reference to final equilibrium/at the end for maximum	**(2)**

Question Number	Answer	Additional Guidance	Mark
10(b)(i)	• both axes labelled with units with time on horizontal axis **(1)** • suitable scale where points cover at least half the available space horizontally and vertically **(1)** • all points plotted correctly and line of best fit shown **(1)**	Line of best fit to be with +/− 2 small square of plotted points Do not award a line that goes up by 1 small square after 60 minutes	**(3)**

Exemplar graph



Question Number	Answer	Additional Guidance	Mark
10(b)(ii)	An explanation that makes reference to any two of the following points: • V_{final} is proportional to concentration of / amount of ester initially plus the acid catalyst **(1)** • $V_{final} - V_t$ is proportional to concentration of / amount of ester at each time / at t **(1)** • the concentration (of NaOH) does not change (so the graph would be a straight line) **(1)**		**(2)**

Question Number	Answer	Additional Guidance	Mark
10(b)(iii)	An answer that makes reference to the following points • first half-life correctly shown on graph and value determined **(1)** • second half-life correctly shown on graph and value determined **(1)**	**Check the graph that 6 and 3 are not used** Allow values between 11 and 13 (mins)	**(2)**
Exemplar graph 		Penalise lack of working on graph once only	

Question Number	Answer	Additional Guidance	Mark
10(b)(iv)	An answer that makes reference to the following point: • first order **and** (as) half-lives are constant	Standalone mark No TE from half life values	**(1)**

Question Number	Answer	Additional Guidance	Mark
10(c)	An answer that makes reference to the following points: • Rate = k $[CH_3CO_2CH_2CH_3][OH^-]$ **(1)** • as slow step involves 1 (mol) of ethyl ethanoate and 1 (mol) of OH^- ions **(1)**	Allow name or any correct structure of ester in rate equation Allow $C_4H_8O_2$ for ethyl ethanoate Allow any suitable alkali such as NaOH Allow r for rate Allow only 1 mol of each reactant in the rate determining step Ignore just that step 1 is the rate determining step Ignore just that they are both first order No TE on incorrect rate equation M2 dependent on M1 or near miss	**(2)**

(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 120 MARKS