Mark Scheme (Results)

Summer 2025

Pearson Edexcel GCE A Level
In 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.

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: • energy (required) to remove / lose 1 electron / first electron / last electron from an / each atom (of an element) **(1)** • in 1 mol (e) of gaseous atoms (to form 1 mol of positive ions) **(1)**	Allow $e^{(-)}$ for electron 1 mol(e) must be referenced in either M1 or M2 to score both marks e.g. 'energy to remove 1 mol of electrons from gaseous atoms' scores 2 marks Correct example symbol or generic equation, for first IE, including state symbols scores 1 mark e.g. $X(g) \rightarrow X^{+}(g) + e^{(-)}$ / $X(g) - e^{(-)} \rightarrow X^{+}(g)$ Ignore references to standard conditions / standard states	**(2)**

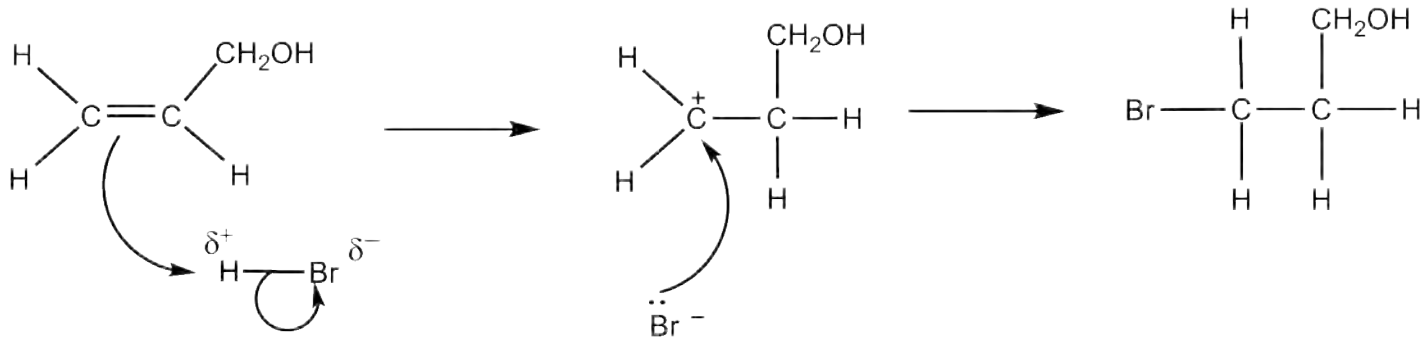
Question Number	Answer	Additional Guidance	Mark
1(b)	An explanation that makes reference to the following points: • as there is a large difference / large increase / (large) jump / in ionisation energy between first and second ionisation energy / after first ionisation energy / before second ionisation energy **(1)** • Group 1 **(1)**	Allow there is a very large increase in 2nd IE Allow alkali metal M2 dependent on M1 Ignore reference to the subshell / orbital of the (outer) electron even if incorrect	**(2)**

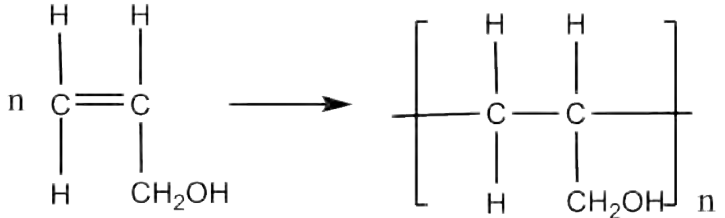
Question Number	Answer	Additional Guidance	Mark
1(c)	An explanation that makes reference to the following points: • element X as it has the lowest (first) ionisation energy **(1)** • as electron removed is furthest from nucleus **(1)** • so there is greater shielding (even though there is an increase in the number of protons) **(1)**	Penalise ionic radius once only Allow X as the (first) ionisation energy decreases down the group Do not award reference to other ionisation energies (unless all are mentioned as being lower) Allow 'outer electron' for 'electron removed' Allow atomic radius is greater Ignore more shells Do not award ionic radius Allow greater repulsion from inner electron shells Allow 1 mark for there is less attraction between the nucleus and the outer electron if neither M2 or M3 is awarded. Allow 1 mark for 'Z, because the nuclear charge / number of protons is the greatest' Ignore effective nuclear charge	**(3)**

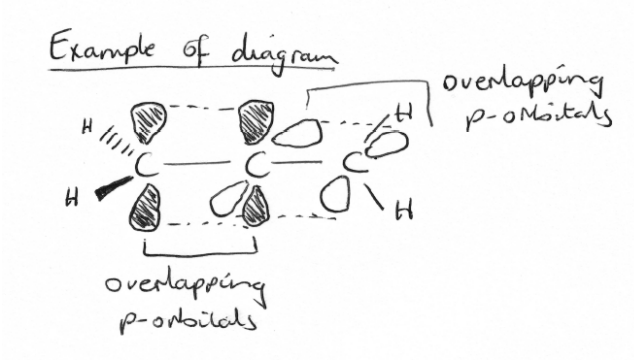
(Total for Question 1 = 7 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	An answer that makes reference to the following points: Test • add bromine water / bromine **(1)** Result • which decolourises / (turns) colourless **(1)** **or** Test • add acidified $KMnO_4$ / acidified potassium manganate(VII) / acidified potassium permanganate **(1)** Result • which decolourises / (turns) colourless **(1)**	Only award M2 if linked to the correct test Allow Br_2 or $Br_2(aq)$ Do not award if Br^- or bromide used Allow if near miss on reagent e.g. Br Allow initial colours of orange, yellow, brown or brown-red Ignore references to heating Do not award incorrect initial colour e.g. red to colourless Do not award clear Allow initial colours of purple or pink If formula is given it must be correct Do not award incorrect initial colour e.g. red to colourless Do not award incorrect initial colour e.g. red to colourless Do not award clear Allow if near miss on reagent e.g. omission of acidified or name / formula recognisable but incorrect Ignore references to heating	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An answer that makes reference to the following points: • dipole on HBr • curly arrow from C=C bond to H $^{(\delta+)}$ • curly arrow from H−Br bond to Br or just beyond • correct intermediate • lone pair and negative charge on Br^- • curly arrow from lone pair (if shown) on Br^- to C+	Do not award partial charge on C=C Allow structural, skeletal or hybrid formulae Penalise half arrows once only Penalise additional arrows once only Penalise use of Br_2 or other incorrect reactant once only All 6 points scores 3 4 or 5 points scores 2 2 or 3 points scores 1	**(3)**



Question Number	Answer	Additional Guidance	Mark
2(b)	An answer that makes reference to the following points: • correct structure of monomer and n on both sides of equation **(1)** • correct structure of repeating unit with extension bonds **(1)**	Allow placement of 'n' anywhere vertically if it is in front of the reactant and after the product  Allow structural or skeletal formulae throughout Do not award molecular formulae Examples n CH_2CHCH_2OH ⟶ ⟊ CH2CHCH2OH ⟋ n  Vertical connectivity must be to C of CH_2OH; penalise once only Ignore conditions / catalysts on the arrow even if incorrect Ignore brackets	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(c)	An explanation that makes reference to the following points: • pi bonds form by sideways overlap of (p) orbitals **(1)** • so two (p) orbitals are at right angles / perpendicular (to each other) / π bonds are at right angles / perpendicular (to each other) **(1)**	Do not award 'head-on' overlap Ignore references to 's' orbitals May be shown on a (labelled) diagram Allow 'one orbital on central C is P_y, the other is P_z' (any pair of x, y and z orbitals will suffice) May be shown on a (labelled) diagram  Ignore repulsion between electrons / bonds etc	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(d)(i)	An answer that makes reference to the following point: • four / 4		**(1)**

Question Number	Answer	Additional Guidance	Mark
2(d)(ii)	An answer that makes reference to the following point: • has two hydrogen (atoms) on (first) **carbon** (atom) of double bond / has same group on (first) **carbon** (atom) of double bond	Allow doesn't have different groups at the **end** of the (one of the) C=C bonds Do not award molecules Allow 'hydrogen groups'	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(d)(iii)	An explanation that makes reference to the following points: • prop-2-en-1-ol is more soluble than bombykol **(1)** • both (have OH / alcohol group that) can form hydrogen bonds (with water) **(1)** • bombykol has a (very) long (hydro)carbon chain **(1)** **or** forms stronger London forces	Allow prop-2-en-1-ol is soluble and bombykol is insoluble Allow as bombykol has a (very) long hydrophobic / non-polar hydrocarbon chain	**(3)**

(Total for Question 2 = 14 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>*3</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 of answer and sustained line 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, which 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>

Question Number	Answer	Additional Guidance	Mark
***3 contd**	**Indicative content:** • **IP1** Carbonate (test) linked to Add HNO_3(aq) / HCl(aq) (to all 3 samples) • **IP2** Carbonate result Solutions that effervesce / bubble / fizz (must be a carbonate) / either $(NH_4)_2CO_3$ or K_2CO_3 • **IP3** Ammonium ion test linked to Add NaOH(aq) gently heat / warm / put in water bath • **IP4** Ammonium ion result (produces a gas) turns (damp) red litmus blue (when held over the mouth of the test tube) proves $(NH_4)_2CO_3$ **IP5 and IP6 on next page.**	Only listed reagents can be used. Ignore tests carried out to identify potassium ions / flame tests Ignore minor slips e.g. missing charges on ions, wrong formulae of reagents, missing state symbols that have been listed in the question. Ignore flame tests Ignore equations even if incorrect For all tests listed the reagent and the ion test and the result must be dependent on the correct reaction except for the limited exceptions that are listed in the additional guidance. Ignore just 'produce a gas' Allow **gas** turns $Ca(OH)_{2(aq)}$ cloudy Ignore gas turns limewater cloudy Do not award subsequent inappropriate gas tests e.g. pop test Do not award Bunsen burner for heating Do not award dip red litmus paper into the solution Do not award bleaches litmus. Allow a near miss for IP4 if the ammonium carbonate solution has been heated without NaOH being added / adding sodium hydroxide without heating Ignore white smoke seen with a glass rod dipped in HCl(aq) and held above the tube	**(6)**

***3 contd**	**Indicative content:** • **IP5** Sulfate ion test (linked to) Add $BaCl_2$ and HCl / HNO_3 (in either order) • **IP6** Sulfate ion result Formation of white ppt / solid confirms it is K_2SO_4	Do not award H_2SO_4 Allow if acid is missing from IP5 Do not award if $BaCl_2$ is missing Allow goes milky / cloudy	

(Total for Question 3 = 6 marks)

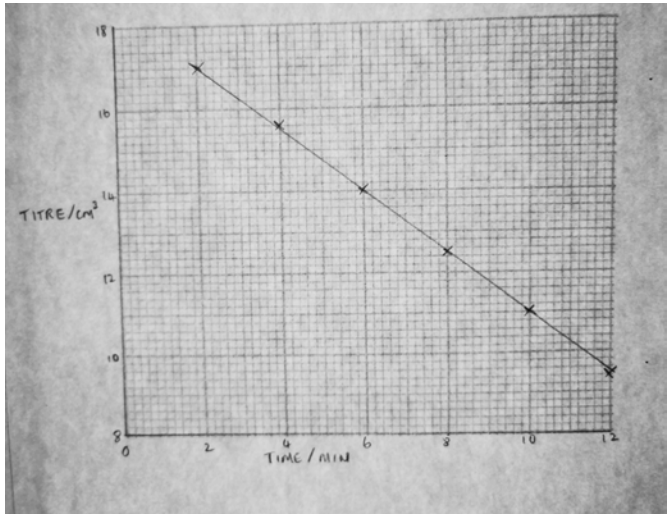
Question Number	Answer		Additional Guidance	Mark
4(a)	A description that makes reference to the following points: • (remove colourless solution by) rinsing with sulfuric acid (of concentration 2.00 mol dm^{-3}) • in order to prevent dilution (of acid sample) / keep acid concentration the same	**(1)** **(1)**	Allow rinse with deionised / distilled water followed by (2.00 mol dm^{-3}) sulfuric acid Allow other substances left in the **pipette** might **react** (with any of the other reactants or products) M2 dependent on M1	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An explanation that makes reference to the following points: • stopping the reaction **(1)** in order to ensure there is no (further) change in concentration (before the titration is carried out) / **(1)**	Allow slowing down the reaction / freezing the reaction Ignore references to stopping / freezing an equilibrium Ignore to ensure the titration is accurate Ignore references to stopping an equilibrium	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An answer that makes reference to the following points: • sodium hydrogencarbonate (solution) / $NaHCO_3$ / potassium hydrogen carbonate / $KHCO_3$ **(1)** • correct equation to match compound **(1)**	Accept sodium / potassium carbonate (solution) / Na_2CO_3 / K_2CO_3 Ignore state symbols even if incorrect If both name and formula are given, they must match e.g. $2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$ / $2KHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$ / $NaHCO_3 + H^+ \rightarrow CO_2 + H_2O + Na^+$ / $KHCO_3 + H^+ \rightarrow CO_2 + H_2O + K^+$ / $KHCO_3 + H^+ \rightarrow CO_2 + H_2O + K^+$ / $HCO_3^- + H^+ \rightarrow CO_2 + H_2O$ / $HCO_3^- + H^+ \rightarrow H_2CO_3$ / $Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + CO_2 + H_2O$ / $K_2CO_3 + H_2SO_4 \rightarrow K_2SO_4 + CO_2 + H_2O$ / $CO_3^{2-} + 2H^+ \rightarrow CO_2 + H_2O$ / $H_2SO_4 + CO_3^{2-} \rightarrow SO_4^{2-} + H_2O + CO_2$	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to two of the following points: • risk depends on **both** hazard and amount of a substance **(1)** • (only a) small amount of it / iodopropanone is formed **(1)** • (most of) it / iodopropanone remains in solution **(1)**	Allow as reaction runs for only a short amount of time Allow it / iodopropanone is not a gas / is a liquid / has a high boiling point / not volatile Ignore harmful fumes Ignore iodopropanone is a solid	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(d)	An answer that makes reference to the following points: • calculation of moles of iodine **(1)** • calculation of moles of propanone **(1)** show moles propanone are much greater than iodine / propanone is in great excess **and** so there is a negligible / very small change in the concentration of propanone **(1)** • change in rate is due only to the changing concentration of iodine **(1)**	<u>Example of calculation</u> (Moles of I_2) = (0.0500 × 0.0200) = 1.00×10^{-3} Ignore SF (Moles of propanone) = 0.0250 × 2.00 = 0.0500 (mol) Ignore SF $0.0500 \gg 1.00 \times 10^{-3}$ (so order is wrt I_2) Ignore just propanone is in excess Allow iodine is a limiting factor Ignore the sulfuric acid throughout	**(4)**

Question Number	Answer	Additional Guidance	Mark
4(e)(i)	An answer that makes reference to the following points: • axes labelled including units **and** suitable scale, where points cover at least half the available space **(1)** • points plotted correctly (allow ± a square**)** **and** straight line of best fit **(1)**	Allow volume or vol for titre <u>Example of graph</u>  	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(e)(ii)	An answer that makes reference to the following point: • as the titre / volume (of sodium thiosulfate solution) is (directly) proportional to the concentration (of iodine)		**(1)**

Question Number	Answer	Additional Guidance	Mark
4(e)(iii)	An answer that makes reference to the following points: • order with respect iodine = 0 **(1)** • gradient remains constant **(1)**	Allow straight line / linear (with a negative gradient) / the gradient is independent of the concentration M2 dependent on M1	**(2)**

(Total for Question 4 = 17 marks)

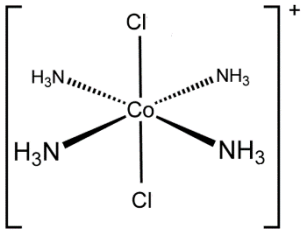
<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>5(a)(i)</td>
<td>An answer that makes reference to the following points:

• calculate moles of each element (1)

• show ratio by division by smallest number (1)
and
show RFM of $CoN_4H_{12}Cl_3$ is 233.4</td>
<td>
<table>
<tr><td></td><td>Co</td><td>N</td><td>H</td><td>Cl</td></tr>
<tr><td>mol</td><td>1.26 ÷ 58.9 = 0.0214</td><td>1.20 ÷ 14.0 = 0.0857</td><td>0.257 ÷ 1.0 = 0.257</td><td>2.28 ÷ 35.5 = 0.0642</td></tr>
<tr><td>ratio</td><td>0.0214 / 0.0214 = 1</td><td>0.0857 / 0.0214 = 4</td><td>0.257 / 0.0214 = 12</td><td>0.0642 / 0.0214 = 3</td></tr>
</table>
(58.9 + (4 × 14) + 12 + (3 × 35.5) = 233.4 (so molecular formula = $CoN_4H_{12}Cl_3$)

M1 % of each element by mass in sample of 4.997 g
M2 % of each element by comparing ΣA_r to M_r
</td>
<td>(2)</td>
</tr>
</table>

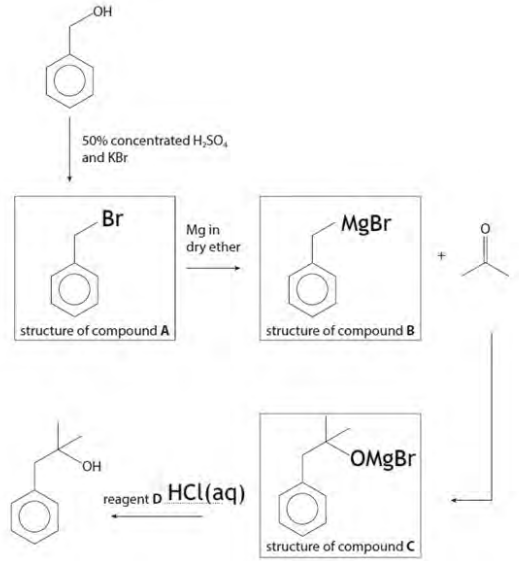
Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	EITHER • calculation of moles of AgCl / Cl^- **(1)** • calculation of moles of R **(1)** **and** show ratio is 1:1 (so one mole of R releases 1 mol of chloride ions) **OR** • calculation of moles of R **(1)** • calculation of moles of AgCl /Cl^- **(1)** **and** show ratio is 1:1 (so one mole of R releases 1 mol of chloride ions)	<u>Example of calculation</u> moles of AgCl = $0.614 \div 143.4 = 4.2817 \times 10^{-3}$ mol moles of R = $1.00 \div 233.4 = 4.2845 \times 10^{-3}$ mol 4.2845×10^{-3} mol : 4.2817×10^{-3} mol ≈ 1:1, (so 1 mol of R releases 1 mol of chloride ions) Do not award $3Cl^-$ ions moles of R = $1.00 \div 233.4 = 4.2845 \times 10^{-3}$ mol moles of AgCl = $0.614 \div 143.4 = 4.2817 \times 10^{-3}$ mol 4.2845×10^{-3} mol : 4.2817×10^{-3} mol ≈ 1:1, (so 1 mol of R releases 1 mol of chloride ions) Do not award $3Cl^-$ ions Ignore SF except 1 SF	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(a)(iii)	An answer that makes reference to the following points: • octahedral shape (around cobalt) using wedges **(1)** • correct number and type of ligand **(1)** • correct overall charge **(1)**	 Allow dashed line for dashed wedges Allow '+' on cobalt Allow correct calculation of charge from incorrect ligands Ignore position of Cl ligands relative to NH_3 ligands Ignore connectivity Ignore omission of square brackets Ignore additional chloride ion (to form R) Arrows if drawn must be pointing towards the cobalt	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	An answer that makes reference to the following points: • forward and backward reactions proceed at the same rate **(1)** • concentration of reactants and products remain constant / remain the same **(1)**	Do not award rates of forward and backward reactions are constant Accept resulting in no observable change in the system	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	An explanation that makes reference to the following points: • (The most stable is) $[Co(EDTA)]^{2-}(aq)$ as it has the larger (log) K_c / eqm lies furthest to RHS **(1)** • 2 moles (of ions) forms 7 moles (of product in EDTA equation) **(1)** • (greater) increase in entropy (change of the system) / ΔS_{sys} is positive **(1)**	Ignore calculated K_c values Allow more moles of product than reactant Allow species Do not award 'molecules' Do not award increase in entropy if clear that it is referring to the EDTA (complex) and not the reaction	**(3)**

(Total for Question 5 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)	An answer that makes reference to the following points: • structure of compound A **(1)** • structure of compound B **(1)** • structure of compound C **(1)** • identify reagent D **(1)**	 Allow Kekulé structures Allow O^- for OMgBr Allow any dilute (aq) strong acid for reagent D Ignore H^+, H_3O^+ Ignore partial charges on Mg and Br even if incorrect Penalise missing delocalised ring once only. Do not award full charges on Mg and Br	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(b)	An answer that makes reference to the following points: • all 12 correct scores 5 marks • 10-11 correct scores 4 marks • 7-9 correct scores 3 marks • 4-6 correct scores 2 marks • 2-3 correct scores 1 mark • 0-1 correct scores 0	See table below	**(5)**

	Chemical shift / ppm	Area under curve	Splitting pattern
Environment **J**	6.8 – 8.2	5	complex
Environment **K**	**1.6−3(.0)**	**2**	**singlet**
Environment **L**	**−0.2 – 2(.0)**	**6**	**singlet**
Environment **M**	**2.8 – 4.4**	**2**	**quartet / quadruplet**
Environment **N**	**−0.2 – 2(.0)**	**3**	**triplet**

For chemical shifts allow any single value or range within the stated range
Allow ranges reversed (e.g. 1.9-0.0)
Do not award quaternary
Ignore splitting patterns even if incorrect (e.g .1,2,1)
Penalise numbers for the splitting pattern (e.g. for K, 1, for L, 1, for M, 4 and for N, 3) up to a maximum of 2 points
Ignore ‘no splitting’ for singlet

(Total for Question 6 = 9 marks)

Question Number	Answer		Additional Guidance	Mark
7(a)	An explanation that makes reference to two of the following points:			**(2)**
	• (warmth) to allow for (all) the ethanol to evaporate	**(1)**	Ignore to speed the reaction up Ignore activation energy Do not award to evaporate the acidified dichromate(VI)	
	• (24 hr) to allow (time for) the ethanol to fully react / fully oxidise	**(1)**	Allow the reaction goes to completion Allow all of ethanol reacts	
	• (To allow full oxidation of the ethanol) **to ethanoic acid**	**(1)**	Allow to ensure there is no ethanol / ethanal left 'To allow time for all the ethanol to react to form ethanoic acid', scores P2 and P3	

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	• calculation of moles of thiosulfate **(1)** • deduction of moles of iodine **(1)** • deduction of moles of acidified dichromate(VI) that reacted to form iodine **(1)** • calculation of moles of acidified dichromate(VI) that reacted with ethanol **(1)** • deduction of moles of ethanol in 5 cm^3 sample **(1)**	<u>Example of calculation</u> $(32.70 \div 1000) \times 0.0220 = 7.194 \times 10^{-4}$ (mol) $7.194 \times 10^{-4} \div 2 = 3.597 \times 10^{-4}$ $3.597 \times 10^{-4} \div 3 = 1.199 \times 10^{-4}$ (mol) $[(10.0 \div 1000) \times 0.078] = 7.80 \times 10^{-4}$ $7.80 \times 10^{-4} - 1.199 \times 10^{-4} = 6.601 \times 10^{-4}$ (mol) $6.601 \times 10^{-4} \times (3 \div 2)$ $= 9.9015 \times 10^{-4} / 9.90 \times 10^{-4}$ (mol) Allow TE throughout Ignore SF except 1SF Correct answer without working scores 5	**(5)**

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	• calculation of moles of ethanol in 250 cm^3 of diluted drink **(1)** • calculation of concentration of alcoholic drink in mol dm^{-3} **(1)** • calculation of concentration of alcoholic drink in g dm^{-3} **(1)**	Example of calculation $9.9015 \times 10^{-4} \times (250 \div 5) = 0.049508$ (mol) $0.049508 \div (20 \div 1000) = 2.4754$ (mol dm^{-3}) $2.4754 \times 46 = 113.87 / 114$ (g dm^{-3}) Allow TE throughout including from part bi Ignore SF except 1SF Correct answer without working scores 3	**(3)**

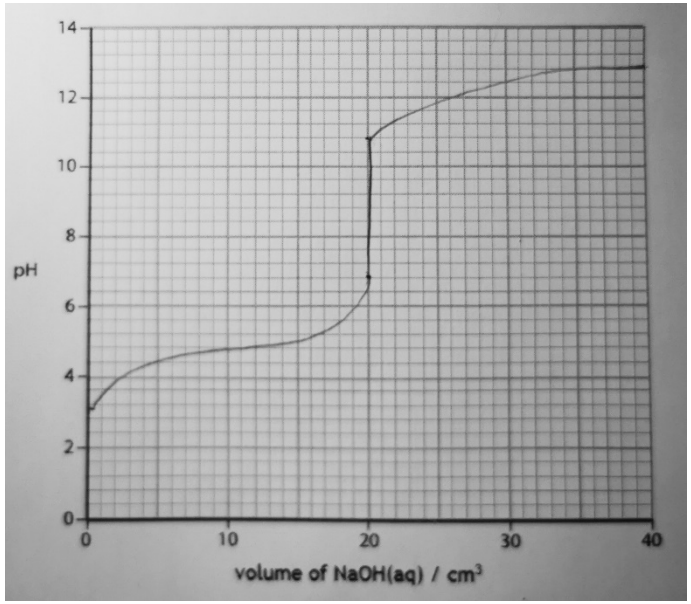
Question Number	Answer	Additional Guidance	Mark
7(c)	An answer that makes reference to the following points: • repeat the whole experiment / set up more than one version of the experiment and run concurrently **(1)** • take more than one sample / smaller samples (so more than one titration can be carried out) **(1)**	Do not allow just repeat the titration If no other mark is scored allow repeat the titration and calculate a mean / repeat the titration until concordant results are obtained Ignore starch / indicator	**(2)**

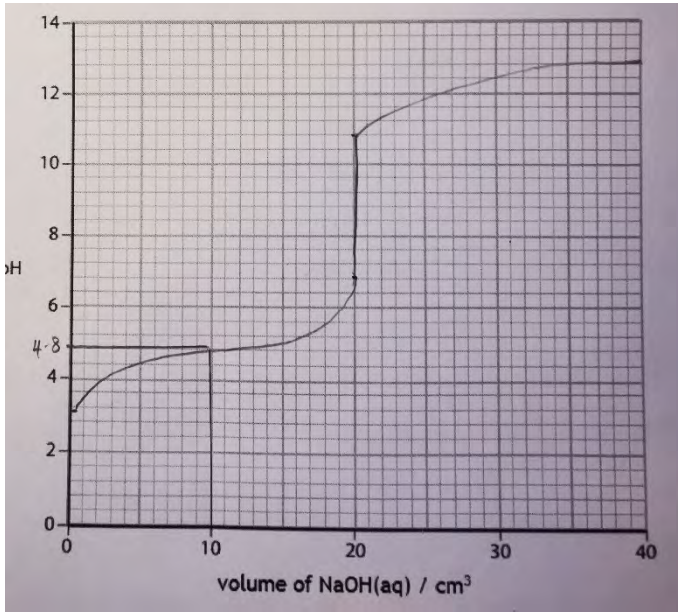
Question Number	Answer	Additional Guidance	Mark
7(d)	An answer that makes reference to the following points: M1 reason to support change • heating under reflux will speed up the reaction **(1)** **or** • less chance of incomplete reaction with heating under reflux M2 reason to remain unchanged • might be other (less volatile substances) that could also be oxidised by the dichromate(VI) **(1)** **or** • greater risk of uncontrolled reaction associated with heating under reflux **or** • greater risk of some of the ethanol evaporating with reflux	Ignore the ethanol and the ethanoic acid produced might react to form an ester Ignore greater risk of flammability Allow some ethanol may escape from the reflux condenser before it is oxidised	**(2)**

(Total for Question 7 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)	• calculation of concentration of hydrogen ions **(1)** • calculation of K_a **(1)**	Example of calculation $([H^+] =) 10^{-3.25} = 5.6234 \times 10^{-4}$ (mol dm^{-3}) $(5.6234 \times 10^{-4})^2 \div 0.0712 = 4.4414 \times 10^{-6}$ (mol dm^{-3}) Allow TE from M1 Final answer with no working scores 2 Ignore SF except 1SF If they round their answer to M1 to 5.6×10^{-4} they get an answer of 4.4045×10^{-6} (mol dm^{-3})	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	• calculation of pH	Example of calculation $[H^+] = 1.00 \times 10^{-14} \div [OH^-]$ $= 1.00 \times 10^{-14} \div 0.05$ $= 2.00 \times 10^{-13}$ (mol dm^{-3}) $-\log (2.00 \times 10^{-13}) = 12.7$ Do not award answers with more than 1 decimal place (e.g. 12:70 scores 0) Correct answer with no or incorrect working scores 1	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An answer that makes reference to the following points: • starting pH between 2.8 and 3.4 **and** pH at 40 cm^3 between 12 and 12.8 **(1)** no TE on answer to bi • vertical section at 20 cm^3 **(1)** **and** range of vertical section between 6-11, but must include 7-10 **(1)** • curved shape including steep rise at the start (as example) between 0 and approx. 5 cm^3	<u>Example of graph</u>  	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	An answer that makes reference to the following points: • working shown, and value of pH at 10 cm^3 consistent with graph in 8b(ii) Allow tolerance of ± 0.5 square	<u>Example of working on graph</u>  e.g. pH = 4.8	**(1)**

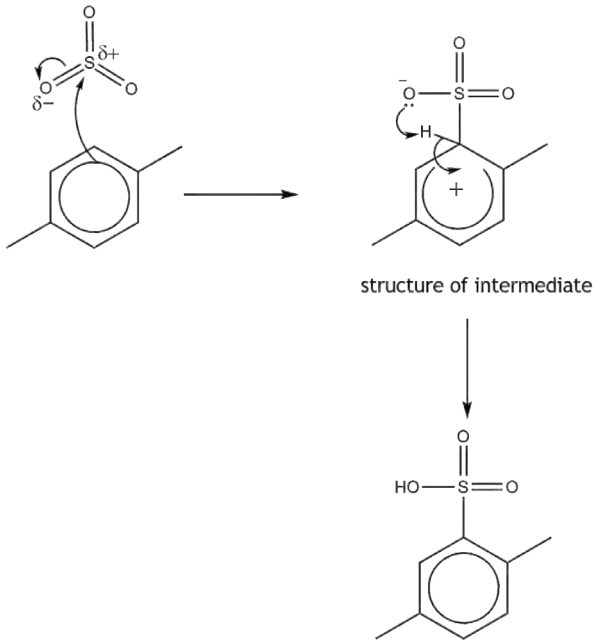
Question Number	Answer	Additional Guidance	Mark
8(b)(iv)	An answer that makes reference to the following points: • *K*a expression for ethanoic acid **(1)** **or** at half–neutralisation $[CH_3COOH] = [CH_3COO^-]$ / $[HA] = [A^-]$ • $[H^+] = K_a$ **(1)** **or** $pH = pK_a$ • Value of K_a **(1)**	$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ or $K_a = \frac{[A^-][H^+]}{[HA]}$ e.g. $K_a = 10^{-4.8} = 1.585 \times 10^{-5}$ (mol dm^{-3}) Allow TE from 8biii	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(c)	An answer that makes reference to three of the following points: Data logger likely to give most valid outcomes as • time period / volume between readings is (much) smaller / greater resolution / more data points / more frequent data-points **(1)** • (percentage) errors in using measuring equipment reduced / **(1)** • data collection is faster **(1)** • produces continuous data / graph / processed data can be seen in real time **(1)** • automatic collection of data means less chance of human error / parallax error reduced **(1)** • data can be transferred (easily) to other software (e.g. spreadsheets) / stored **(1)**	Allow reverse arguments Ignore a general comment about accuracy e.g. more accurate	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(d)(i)	• calculation of $[H^+]$ **(1)** • calculation of concentration of salt **(1)** • rearrangement of K_a to find $[CH_3CH_2COOH]$ **(1)** • calculation of $[CH_3CH_2COOH]$ **(1)**	<u>Example of calculation</u> $10^{-4.2} = 6.3096 \times 10^{-5}$ (mol dm^{-3}) $(2.30 \div 96) \times 10 = 0.23958$ (mol dm^{-3}) $[CH_3CH_2COOH] = ([H^+] \times [CH_3CH_2COONa]) \div K_a$ $(6.3096 \times 10^{-5} \times 0.23958) \div 1.34 \times 10^{-5}$ $= 1.128 / 1.13 / 1.1$ (mol dm^{-3}) Ignore SF except 1 SF Allow TE throughout Correct answer without working scores 4 Do not award 1.12 (incorrectly rounded) Allow use of Henderson-Hasselbalch equation $pH = pK_a + \log_{10} \frac{[A^-]}{[HA]}$ M1: Rearrangement of HH equation $\log_{10} \frac{[A^-]}{[HA]} = 4.2 - 4.873 = -0.673$ M2 : Calculation of $\frac{[CH_3CH_2CO_2Na]}{[CH_3CH_2COOH]} = 10^{-0.673} = 0.2123$ M3: $[CH_3CH_2COONa] = (2.3 \div 96) \div 0.1 = 0.2396$ (mol dm^{-3}) M4: $[CH_3CH_2COOH] = 0.2396 \div 0.2123 =$ $1.128 / = 1.128 / 1.13 / 1.1$ (mol dm^{-3}) TE at all stages	**(4)**

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	An explanation that makes reference to the following points: • (large) reservoir of sodium propanoate / propanoate ions (and propanoic acid) **(1)** • (large reservoir of) propanoate ions accept protons from / react with HCl **(1)** • (small changes in [acid] and [salt] are negligible) so **ratio** of acid: salt remains (nearly) constant (and pH depends on this ratio) **(1)**	Allow a large amount / high concentration Accept (acid) eqm moves to left (forming CH_3CH_2COOH) $CH_3CH_2CO_2^- + H^+ \rightarrow CH_3CH_2COOH$ $NaCH_3CH_2CO_2 + HCl \rightarrow$ $CH_3CH_2COOH + NaCl$ Do not award the H^+ ions **neutralise** the propanoate	**(3)**

(Total for Question 8 = 20 marks)

Question Number	Answer	Additional Guidance	Mark
9(a)	An answer that makes reference to the following points: • arrow from **inside** the hexagon to sulfur atom • partial charges on S and O • basic structure of intermediate, including both methyl groups, and broken circle covering at least three carbons, facing the tetrahedral carbon, and containing (some part of) positive charge • lone pair **and** negative charge on O of intermediate • arrow from (lone pair on) oxygen to H on ring • return of C−H bond pair towards/ inside (broken) ring	 structure of intermediate In point 2 allow δ− on all O atoms In point 5 allow arrow from lone pair on O to H^+, or hydrogen on H_2O, H_3O^+, or H_2SO_4 6 points scores 3 marks 4 or 5 points scores 2 marks 2 or 3 points scores 1 mark 0 or 1 point scores 0 marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	An explanation that makes reference to the following points: • both 2,5-dimethylbenzenesulfonic acid and (soluble) impurities dissolve in hot water / hot solvent **(1)** • impurities are soluble in **cold** solvent **or** 2,5-dimethylbenzenesulfonic acid is (much) less soluble / insoluble in **cold** solvent **(1)** • so impurities remain in solution (as the solvent cools) / impurities remain in the filtrate **and** 2,5-dimethylbenzenesulfonic acid recrystallises / solid remains (on filter paper) **(1)**	Allow impurities are present in small amounts (and so do not crystallise in cold solvent) Do not award the ice-cold water (in step 4) dissolves the soluble impurities Allow the ice-cold water washes off any surface impurities	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	A description that makes reference to the following points: • filter when still hot / filter funnel and / or paper are heated **(1)** • (filtration) carried out **after** step 1 / **before s**tep 2 (to remove insoluble impurities) **(1)**	Allow redissolve in a different solvent If no other credit awarded, allow 1 mark for decant (off from the impurities) whilst still hot	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(c)(i)	A description that makes reference to the following points: • (add the solution formed) to a 100 cm^3 volumetric flask **(1)** • (rinse remaining solution from conical flask) with distilled / deionised water and add washings to volumetric flask **(1)** • add distilled / deionised water **(1)** • make up to the line / mark **(1)** **and** • (add stopper) then invert / mix (to ensure solution is homogenous)	Ignore starting with just the acid and omitting the alkali Do not award shake	**(4)**

Question Number	Answer	Additional Guidance	Mark
9(c)(ii)	• calculation of moles of HCl(aq) **(1)** • calculation of moles of NaOH in in small conical flask **(1)** • calculation of moles of 2,5-dimethylbenzenesulfonic acid **(1)** • calculation of M_r of 2,5-dimethylbenzenesulfonic acid **(1)** • deduction of value for n (must be an integer) **(1)**	<u>Example of calculation</u> $(22.4/1000) \times 0.0250 = 5.6 \times 10^{-4}$ (mol) $5.6 \times 10^{-4} \times 5 = 2.8 \times 10^{-3}$ (mol) $(10/1000) - 2.8 \times 10^{-3} = 7.2 \times 10^{-3}$ $1.60 / 7.2 \times 10^{-3} = 222.2$ (g mol^{-1}) 222.2 – 186.1 = 36.1 so n = 2 Allow TE throughout Correct answer with **no** working scores M5 only If you see 222.2 for the M_r this will score M1-M4 as the other steps will have been carried out correctly. Do not award negative value of n	**(5)**

Question Number	Answer	Additional Guidance	Mark
9(d)(i)	An answer that makes reference to the following point: • lower burette so pouring in acid below eye-level / place stand in sink / on (stable) stool / on floor	Allow alternative methods of height reduction Ignore just an observation that the top of the burette is too high Ignore just lower the burette / stand Do not award student raises themselves e.g. standing on a stool	**(1)**

Question Number	Answer		Additional Guidance	Mark
9(d)(ii)	An explanation that makes reference to the following points: • reduce the value of the titre • smaller (calculated) value of excess NaOH / greater (calculated) moles of 2,5-dimethylsulfonic acid that reacted • so smaller M_r, hence smaller (calculated value of) n	**(1)** **(1)** **(1)**	M3 dependent on M2 Allow smaller M_r but negligible effect on (calculated value) of n If M1 is answered as 'increase the value of the titre' then allow reverse arguments for M2 and M3	**(3)**

(Total for Question 9 = 21 marks)

TOTAL FOR PAPER = 120 MARKS

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