Mark Scheme (Results)

October 2020

Pearson Edexcel GCE
In Chemistry (9CH0)
Paper 3: 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: • addition of (dilute/strong) name/formula of acid **(1)** • effervescence/bubbling/fizzing **(1)**	Allow weak acids If formula given then must be correct Allow Gas given off which turns limewater cloudy Do not award just 'gas/ CO_2 given off' Do not award incorrect observations such as precipitate forming due to addition of acid M2 dependent on M1 or 'near miss'	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that makes reference to: • addition of barium chloride/nitrate (solution) **(1)** • white precipitate forms **(1)**	Accept formulae $BaCl_2$/$Ba(NO_3)_2$ Ignore addition of acids such as HCl or HNO_3 but do not award M1 if addition of sulfuric acid Allow white solid If ppt identified then must be correct M2 dependent on M1 or 'near miss'	**(2)**

(Total Question 1 = 4 marks)

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	An answer that makes reference to: • (potassium ions) lilac **and** (strontium ions) crimson / red	Allow scarlet Ignore 'shades' except Do not award 'brick red' / 'orange-red'	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An answer that makes reference to: • the crimson/red colour will mask/hide/obscure the (lighter) lilac colour	Allow 'one colour will hide the other' Allow only one colour seen Allow difficult to distinguish the two colours Allow TE from colours in (a)(i) Do not award colour from chloride ions Do not award idea of new colour resulting from both Ignore reference to impurities	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	An answer that makes reference to: • nichrome produces no colour (when heated in the flame test) **or** iron can produce a colour/sparks **(1)** • nichrome is inert/ stable to heat/unreactive **or** iron reacts with oxygen/air and or hydrochloric acid **(1)**	Allow does not change the flame colour Ignore references to melting/cost Ignore reference to nichrome not being a transition element	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An answer that makes reference to: • (the wire is heated) to remove the residue of any previous sample being tested	Allow 'to clean the wire' Ignore 'to sterilise/sanitise/disinfect the wire'	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(iii)	An answer that makes reference to: • the acid can become contaminated with residue from previous tests (which can give incorrect results)		**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(iv)	An answer that makes reference to: • (concentrated hydrochloric acid) forms volatile chlorides	Allow (the wire is moistened) to enable some of the solid metal salt to become attached/stick to the wire (and then tested in the Bunsen flame) Do not award reference to bonding or reacting or adsorb or absorb with the wire	(1)

Question Number	Answer	Additional Guidance	Mark
2(c)	An explanation that makes reference to: • electrons are excited/ promoted (by heat to higher energy levels / orbitals) **(1)** • electrons fall from the excited state (to their ground state/to lower energy levels) **(1)** • electrons release energy/photons as (visible) light/ in visible region **(1)**	Lack of reference to 'electrons' results in a maximum of (2) for an otherwise correct answer Allow raised/jump/moved up for 'excited' Allow return/drop/de-excite for 'fall' Allow Wavelength/ frequency/ radiation for 'energy' Do not award reflected for 'release' Do not award colour for 'energy'	(3)

(Total Question 2 = 10 marks)

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	A description that makes reference to two of the following: • rinse the glass rod (into the beaker) **or** rinse beaker (several times) **or** rinse the funnel **(1)** • transfer the washings to the (volumetric) flask **(1)**	Ignore reference to weighing	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	An answer that makes reference to: • removal of the excess solution will remove some of the dissolved sodium hydroxide (so that the exact concentration will be unknown) **or** the concentration won't be known because the total volume will be more than $250cm^3$	Allow 'not just removing deionised water' Ignore just 'decrease the concentration'	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	An answer that makes reference to any **two** of the following: • the tip of the burette must be filled with solution **(1)** • remove the funnel **(1)** • ensure the burette is held vertical **(1)** • eyes are level with the bottom of the meniscus **(1)**	Allow 'jet space' for tip Allow just 'remove air bubbles' Allow 'upright' for vertical Allow 'take readings at eye-level' Allow 'read from the bottom of the meniscus' Ignore reference to clamping and use of stand	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An answer that makes reference to • the titre will be larger because **either** there is water left in the burette **or** the sodium hydroxide solution will be diluted/lower	Allow the titre will be larger because the burette should have been rinsed with sodium hydroxide	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(c)(i)	An assessment that includes • (**M1**) the vertical part of the graph is at ~7 – 10/ the mid-point is at 8.5-8.8 **(1)** • (**M2**) the mid-point of the colour change of methyl red is 5.1 **(1)** • (**M3**) pH range of methyl red does not lie (completely) within the vertical range of the pH curve (so it is not suitable) **(1)** • (**M4**) the colour change will be complete before the equivalence point is reached **(1)**	Allow 'equivalence point/end-point' for 'the vertical part of the graph/ the mid-point' Allow methyl red changes colour in the range/ has a pH range 4.2 – 6.3/ pK_{in} 5.1 Allow, after stating M1 and M2, 'this means that methyl red is unsuitable' Allow end-point/neutralisation point for equivalence point Do not award colour change to red Ignore references to choice of other indicators	**(4)**

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	An answer that includes • two ticks and two crosses as shown	See table below Do not award blank boxes for (x)	**(1)**

Indicator	pH range	Tick or Cross
Bromocresol purple	5.2 – 6.8	x
Thymol blue	8.0 – 9.6	✓
Thymolphthalein	8.3 – 10.6	✓
Alizarin yellow R	10.1 – 13.0	x

Question Number	Answer	Additional Guidance	Mark
3(d)(i)	• completed table	Exemplar table <table><tr><td>Titration number</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>Final burette reading / cm^3</td><td>13.00</td><td>25.50</td><td>37.90</td><td>50.00</td></tr><tr><td>Initial burette reading / cm^3</td><td>0.25</td><td>13.00</td><td>25.50</td><td>37.90</td></tr><tr><td>Titre / cm^3</td><td>12.75</td><td>12.50</td><td>12.40</td><td>12.10</td></tr><tr><td>Concordant titres (✓)</td><td></td><td>✓</td><td>✓</td><td></td></tr></table>COMMENT Allow 12.5/ 12.4 /12.1 Do not award additional ticks	**(1)**

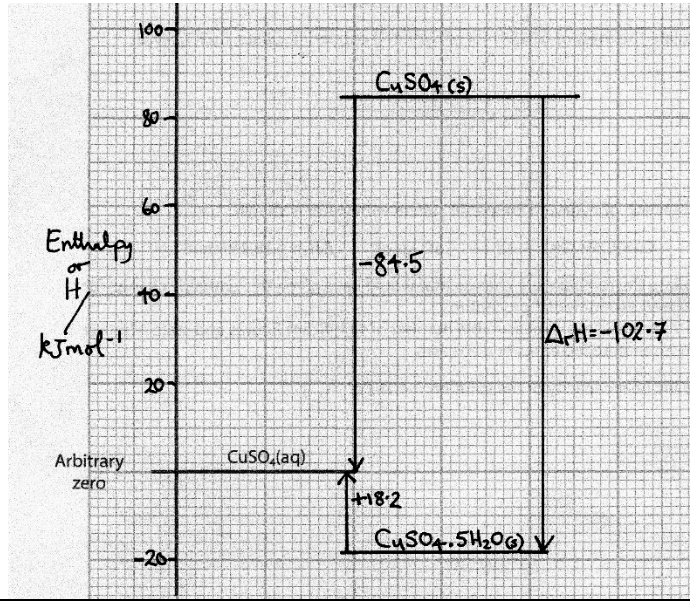
Question Number	Answer	Additional Guidance	Mark
3(d)(ii)	• calculation of percentage measurement uncertainty	Example of calculation (%= ((0.05 x 4) ÷ 12.40 x 100) = 1.6%/1.61% / 2% Ignore SF Do not award 1.65% rounded to 2%	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(e)	• (**M1**) calculation of number of moles of NaOH weighed out **(1)** • (**M2**) concentration of NaOH solution **(1)** • (**M3**) number of moles of NaOH in titre **(1)** • (**M4**) molar concentration of CH_3COOH solution **(1)** • (**M5**) concentration in g dm^{-3} of CH_3COOH solution to 2/3SF **(1)**	<u>Example of calculation</u> n(NaOH)= 3.80 ÷ 40 = 0.095/ 9.5×10^{-2} (mol) [NaOH]= 0.095÷0.250=0.38(mol dm^{-3}) n(NaOH) = 0.38 x 0.0119 = 0.004522/ 4.522×10^{-3} (mol) [CH_3COOH] = 4.522×10^{-3} ÷ 0.025 = 0.18088 (mol dm^{-3}) [CH_3COOH] = 0.18088 x 60 = 10.8528 (g dm^{-3}) = 10.9 / 11 (g dm^{-3}) Do not award 10.90 (g dm^{-3}) Correct answer without working scores (5) Accept steps in a different order, e.g. moles x 60 before dividing by 0.025 TE throughout Penalise incorrect units in M5 only	**(5)**

(Total Question 3 = 18 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)	• molar mass of hydrated copper(II) sulfate **(1)** • mass of 0.0250 mol hydrated copper(II) sulfate **(1)**	<u>Example of calculation</u> $M_r(CuSO_4.5H_2O)$= 249.6 (g mol^{-1}) $m(CuSO_4.5H_2O)$= 6.24 (g) Answer to 2 / 3SF Correct answer with no working scores (2) TE from incorrect M_r	**(2)**

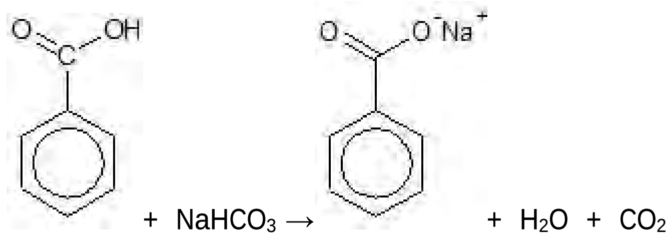
Question Number	Answer	Additional Guidance	Mark
4(b)	• evaluation of Q **(1)** • rearrangement to give ΔT **(1)** • Answer to 1 or 2SF and temperature change **(1)**	<u>Example of calculation</u> Q =(ΔH x n)=18.2 x 0.025 = 0.455(kJ) or 455 **J** ΔT=Q ÷(m x c) = 455 ÷ (45.00 x 4.18) = 2.4189…(°C) ΔT = 2/2.4 °C/ K **and** decrease Allow -2/2.4 °C/ K Correct final answer without working scores (3) TE throughout	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	• labelled y axis, including units, with appropriate scale **(1)** • direction and placement of enthalpy changes, +18.2 and −84.5 **(1)** • Entities with state symbols **(1)**	Allow energy for ‘enthalpy’ Ignore horizontal axis Do not award enthalpy change/Δ*H* for y axis Allow ΔH_1 and ΔH_2 for respective values Arrows must be shown and in the correct direction Ignore activation energy ‘curves’ Do not award double-headed arrows Ignore inclusion of ‘+ aq’ <u>Example of diagram</u> 	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(c)(ii)	• Use of Hess's law to calculate $\Delta_r H$ shown on the diagram	Value from diagram = −102.7 (kJ mol^{-1}) Allow $\Delta_r H = \Delta H_2 - \Delta H_1 = -84.5 - (+18.2) = -102.7$ (kJ mol^{-1}) Allow −103 (kJ mol^{-1}) Do not award if no working shown on the diagram	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(d)	An answer that makes reference to • Cannot react exactly 5 mol of water with 1 mol of anhydrous copper(II) sulfate	Cannot measure the temperature (change) for a **solid** Description that states more (than 5) water molecules will attach to some $CuSO_4$ while less (than 5) water molecules will attach to other $CuSO_4$ ACCEPT reasonable ideas such as some water may evaporate (due to exothermic reaction) Ignore heat loss to surroundings if given as an alternative reason Do not award heat is needed to start the reaction	**(1)**

(Total Question 4 = 10 marks)

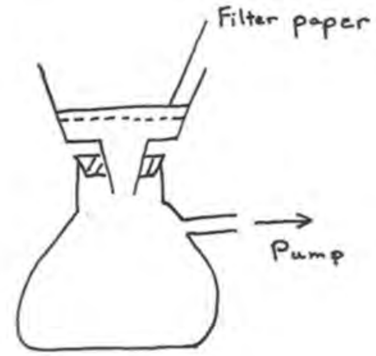
Question Number	Answer	Additional Guidance	Mark
5(a)	• formula of sodium benzoate **(1)** • remainder of equation **(1)**	<u>Example of equation</u>  Accept C_6H_5COONa and/or $C_6H_5COO^{(-)}Na^{(+)}$ Allow omission of charges Allow Kekulé structures Do not award O–Na Ignore state symbols even if incorrect Standalone mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)	An answer that makes reference to: • invert the funnel **and** then open the tap	Allow Just removal of stopper/bung/lid/top Ignore shaking	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An answer that makes reference to • (Water is) more dense (than ether/than the organic layer)	Accept reverse argument Ignore references to immiscibility Do not award references to water being insoluble	(1)

Question Number	Answer	Additional Guidance	Mark
5(d)	An answer that makes reference to: • some sodium benzoate has dissolved in the ether (instead of the aqueous sodium carbonate)	Ignore to increase the yield of sodium benzoate Ignore to remove the product from the ether	(1)

Question Number	Answer	Additional Guidance	Mark
5(e)	An explanation that makes reference to: • The benzoate ion is protonated by the hydrochloric acid **(1)** • benzoic acid is less soluble (in water) than the sodium salt **(1)**	Allow HCl/acid reacts to form benzoic acid Allow benzoic acid is insoluble	(2)

Question Number	Answer	Additional Guidance	Mark
5(f)	A labelled diagram that includes • Buchner/side-armed flask connected to vacuum/ pump/ water aspirator **(1)** • funnel with flat filter paper **(1)**	<u>Example of diagram</u>  Do not award fluted filter paper Do not award water flow into the flask	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(g)	Method 1 • (**M1**) mass of benzoic acid in 50 cm^3 **(1)** • (**M2**) no. of moles of benzoic acid in 50 cm^3 **(1)** OR Method 2 • (**M1**) moles of benzoic acid in 1000 cm^3 **(1)** • (**M2**) no. of moles of benzoic acid in 50 cm^3 **(1)** then • (**M3**) evaluation of the number of molecules of benzoic acid in 50 cm^3 **(1)**	<u>Example of calculation</u> m=(1.70 x 0.05=)0.0850 (g) n=(0.0850 ÷ 122=) 6.967 … x 10^{-4} (mol) n=(1.70 ÷ 122 =) 0.01393… (mol) n=(0.01393… x 0.05 =) 6.967 … x 10^{-4} (mol) N= (6.967 …x 10^{-4} x 6.02 x 10^{23}=) =4.19 x 10^{20} / 4.2 x 10^{20} Ignore sf except 1sf Penalise excessive (6+) SF Allow use of 6.0 x 10^{23} to give 4.18 x 10^{20} for (3) Correct final answer without working scores (3) TE throughout	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(h)	A comparison that makes reference to • (melting temperature) is a (wide) range/ not sharp **(1)** • (it is lower) because impurities are present **(1)**	Ignore just lower for M1 Allow water/phenol is present Allow 'it is not pure'	**(2)**

(Total Question 5 = 14 marks)

Question Number	Answer	Additional Guidance		Mark
6(a)	• correct formula (phenol) **(1)** • • balanced equation **(1)**	<u>Example of equation</u> $C_6H_5OH + 7O_2 \rightarrow 6CO_2 + 3H_2O$ Allow C_6H_6O Do not award [O] Ignore state symbols even if incorrect		**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	• mass of carbon in both substances **(1)** • molar masses of both substances **(1)** • calculation of percentages by mass of carbon **(1)**	<u>Example of calculation</u> (12 x 7 =) 84 Phenylmethanol 108 and Benzoic acid 122 Phenylmethanol (84 ÷ 108) x100 = 78%/ 77.8%/ 77.78% / $77.\dot{7}$ % Benzoic acid (84 ÷ 122) x 100 = 68.85%/ 68.9%/69% Ignore sf except 1 Allow TE on incorrect M_r values Allow (2) for 11.1% and 9.8% calculated using 12 not 84 Allow ‘rescue’ (1) for one substance completely correct	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	A description that makes reference to: • black smoke	Allow Black fumes/soot/(yellow) smoky flame / grey smoke Ignore carbon particulates Do not award carbon monoxide/yellow flame	(1)

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	An answer that makes reference to • Alkenes	Allow Cycloalkenes/cycloalkanes/alkynes/ carbon-carbon double bonds Ignore Ethene/named alkenes/named alkynes Do not award benzene/arenes	(1)

Question Number	Answer	Additional Guidance	Mark
6(b)(iv)	An explanation that makes reference to • (window) above the safety line means the exhaust system is not strong enough to draw in the fumes **(1)** • so the toxic fumes will escape (into the laboratory) **(1)**	Allow reverse argument Allow reference to exhaust/fan not able to prevent gas escaping Allow poisonous/harmful/irritant/ carbon monoxide/soot for 'toxic fumes' Ignore reference to protection from splashing etc	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	An answer that makes reference to • (**M1**) (similarity) all have arene C–H absorptions Either 3030 (cm^{-1}) **or** 750 and/or 700 (cm^{-1}) **(1)** • (**M2**) only phenol and phenylmethanol have O–H 3750 – 3200 (cm^{-1}) **(1)** • (**M3**) only benzoic acid has O–H 3300 – 2500 (cm^{-1}) **(1)** • (**M4**) only benzoic acid has C=O 1700 – 1680 (cm^{-1}) **(1)** • (**M5**) only phenylmethanol has alkane C–H absorptions either 2962 – 2853 (cm^{-1}) or 1485 – 1365 (cm^{-1}) **(1)**	Bond and wavenumber ranges necessary for each mark Do not award 880/830/780 (cm^{-1}) Do not award –OH / C–OH by penalising once only in M2 and M3 All 5 correct bonds with no wavenumber ranges scores (3) 4 correct etc scores (2) and 3 correct etc scores (1) All 5 correct wavenumber ranges with no bonds or incorrect bonds scores (3) 4 correct etc scores (2) and 3 correct etc scores (1) Penalise any additional peaks once only Ignore references to different fingerprint regions	**(5)**

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	An answer that makes reference to • five peaks (in the ^{13}C NMR spectrum) **(1)** • (four) aromatic peaks within the chemical shift range of 165 – 105 (ppm) **(1)** • (one) peak (for the C–OH) within the chemical shift range of 75 – 55 (ppm) **(1)**	Allow any range within the stated ranges Penalise single values as opposed to ranges once only Accept annotations on diagram Penalise additional peaks once only when three or more types of peak are stated	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(c)(iii)	An answer that makes reference to • suitable formula of fragment ion **(1)** • matching *m*/*z* value **(1)**	<u>Example of a suitable formula</u> $C_6H_5COO^+$ or $C_6H_5CO^+$ Do not award $C_7H_5O_2^+$ or $C_7H_5O^+$ *m*/*z* = 121 or 105 Allow $COOH^+$ (1) Do not award bond to the fragment, e.g. $-COOH^+$ *m*/*z* = 45 (1) No TE on incorrect fragment ions such as CH_3^+	**(2)**

(Total Question 6 = 19 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*7</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 and overall score of 3 marks (3 marks for indicative content and zero marks for linkages).
Penalise incorrect chemistry such as bond angles of 90^o for tetrahedral complexes or incorrect oxidation number by deducting a reasoning mark</td><td>(6)</td></tr>
</table>

	Indicative content • **IP1** formulae and colour of first complex ion • **IP2** formulae and colour of second complex ion • **IP3** definition of ligand • **IP4** definition of and example(s) of coordination number • **IP5** shape of complex ion(s) • **IP6** the chloride ion is larger (than the oxygen in water ligand or nitrogen in the ammonia ligand)	Accept any six indicative content points More than one indicative marking point may be made within the same comment or explanation $[Co(H_2O)_6]^{2+}$ allow $[Co(NH_3)_6]^{2+}$ or $[Co(EDTA)]^{2-}$ or $[Co(en)_3]^{2+}$ **and** pink or yellow/brown for the hexaamine complex $[CoCl_4]^{2-}$ allow $[Co(OH)_4]^{2-}$ **and** blue Atom/ion/molecule/species dative covalently bonded/ coordinately bonded to a central metal ion which can be shown on a diagram The number of dative covalent bonds (to a central metal ion) **and** Six and/or four respectively which may be in a diagram Octahedral and/or tetrahedral respectively and can be a diagram. If two given then both must be correct Allow chloride ions are large and only fit four around the metal ion Do not award 'molecule' when referring to chlorine Accept reverse argument	

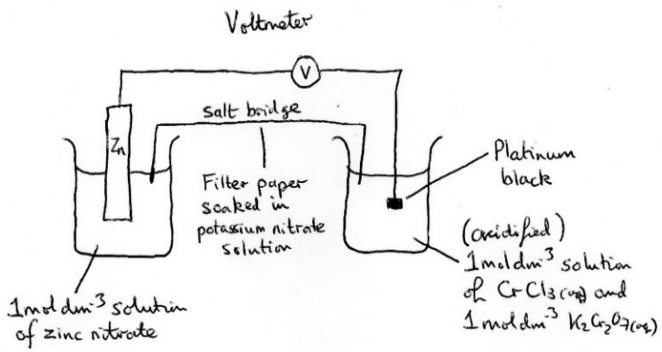
Total Question 7 = 6 marks)

Question Number	Answer	Additional Guidance	Mark
8(a)	A description that makes reference to • green ppt. **(1)** • ppt dissolves (in excess NaOH) to give a green solution **(1)**	Accept 'green solid' Allow 'grey-green ppt Do not award blue-green Ignore shades M2 dependent upon M1 or near-miss	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	• four correct species **(1)** • balancing and the correct number of electrons **(1)**	<u>An example of equation</u> $[Cr(OH)_6]^{3-} + 2OH^- \rightarrow CrO_4^{2-} + 4H_2O + 3e^-$ Accept multiples	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	• equation	<u>An example of equation</u> $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ Accept $\rightleftharpoons$ / multiples	**(1)**

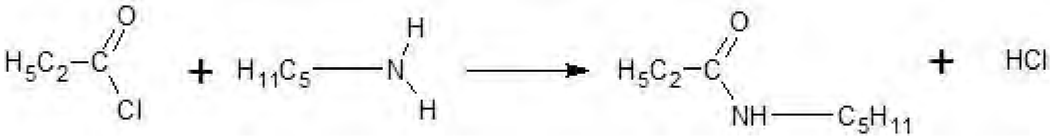
Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	• oxidation half equation **(1)** • reduction half equation **(1)** • overall equation **(1)**	$H_2O_2 \rightarrow 2H^+ + O_2 + 2e^-$ $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ $Cr_2O_7^{2-} + 8H^+ + 3H_2O_2 \rightarrow 2Cr^{3+} + 7H_2O + 3O_2$ for M3 do not award if H^+/ e^- left on both sides Accept multiples Allow ⇌ Ignore state symbols even if incorrect Oxidation and reduction half equations scores (2) if not identified but in correct order Award (1) only for M1 and M2 if half equations are not in correct order No TE on incorrect half equations	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(c)	A diagram that includes	Example of diagram 	**(7)**
	• (**M1**) (high resistance) voltmeter / V **(1)**		
	• (**M2**) salt bridge to complete circuit **(1)**	Salt bridge must dip into the solutions	
	• (**M3**) filter paper soaked in (saturated) potassium nitrate / KNO_3 solution **(1)**	Allow sodium chloride / potassium chloride for potassium nitrate	
	(**M4**) zinc electrode of zinc metal and suitable zinc salt **(1)**	e.g. $ZnSO_4$	
	• (**M5**) platinum (black) electrode **(1)**		
	• (**M6**) suitable chromium salts **(1)**	e.g. $CrCl_3$ / $K_2Cr_2O_7$	
	• (**M7**) all solutions to be 1 mol dm^{-3} (wrt ions) **(1)**	if $Cr_2(SO_4)_3$ is used then M7 can only be awarded if its concentration is 0.5 mol dm^{-3} Allow electrodes drawn the other way round Ignore temperature is 298 K Penalise use of just names once only	

(Total Question 8 = 15 marks)

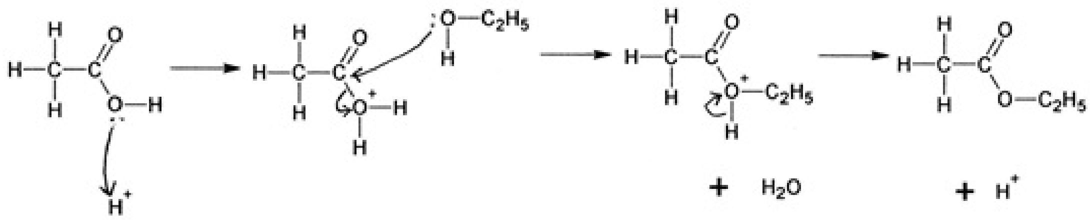
Question Number	Answer	Additional Guidance	Mark
9(a)	An answer that makes reference to • (similarity) both are reduction reactions **(1)** • (difference 1) reagents for preparation of phenylamine are tin and (conc.) hydrochloric acid **(1)** • (difference 2) reagents for preparation of butylamine are either Hydrogen gas **and** nickel catalyst **or** lithium tetrahydridoaluminate(III) **and** (dry) ether **(1)**	Ignore both require hydrogen Allow Iron for tin Do not award dilute hydrochloric acid/ sulfuric acid Lithium aluminium hydride / Lithal / $LiAlH_4$	**(3)**

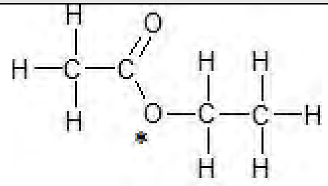
Question Number	Answer	Additional Guidance	Mark
9(b)	An answer that makes reference to: • (similarity) both are basic because they have a lone pair of electrons on the nitrogen atom which accepts a proton **(1)** • (difference 1)in $C_6H_5NH_2$ the lone pair of electrons of the nitrogen atom becomes incorporated with the delocalised ring of electrons and so is less able to accept a proton hence a weaker base **(1)** • (difference 2) the alkyl group/ C_4H_9 is electron-releasing / positively inductive and means the lone pair of electrons of the nitrogen atom are more able to accept a proton hence a stronger base **(1)**	Diagrams can be used to score Comparison of basicity/nitrogen's lone pair of electrons/proton acceptance only need to be mentioned once.	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(c)	• equation **(1)** • name **(1)**	$C_2H_5COCl + C_5H_{11}NH_2 \rightarrow C_2H_5CONHC_5H_{11} + HCl$ or  Allow skeletal/structural/combination of formulae Allow $C_2H_5COCl + 2C_5H_{11}NH_2 \rightarrow C_2H_5CONHC_5H_{11} + HCl + C_5H_{11}NH_3Cl$ Do not award molecular formulae N-pentylpropanamide Do not award N-pentylpropylamine	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(d)	• amine monomer structure or name	$H_2N(CH_2)_6NH_2$ / 1,6-diaminohexane Accept any mixture of displayed, structural or skeletal formulae Do not award molecular formulae or $H_2N\ C_6H_{12}\ NH_2$ If name and formula given then both must be correct	**(1)**

(Total Question 9 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
10(a)(i)	• oxygen lone pair and curly arrow to the H^+ **(1)** • curly arrow from oxygen lone pair on the ethanol to the carbon of the C = O **(1)** • curly arrow from C-O bond to oxygen of water molecule **(1)** • curly arrow from O–H bond back to the O^+ oxygen **(1)**	Example of reaction mechanism  Penalise additional curly arrows for each marking point Penalise missing lone pair on oxygen once only in M1 and M2	**(4)**

Question Number	Answer	Additional Guidance	Mark
10(a)(ii)	• correct oxygen identified **(1)** • the single bond C–O in the carboxylic acid breaks rather than the one in ethanol **or** the oxygen in ethanol acts as the nucleophile (to attack the carbon of the carboxylic acid group and so ends up in the ester) **(1)**	 Allow 'loss of OH from the carboxylic acid'	**(2)**

Question Number	Answer	Additional Guidance	Mark
10(a)(iii)	• (**M1**) calculation of ΔG **(1)** • (**M2**) correct equation **(1)** • (**M3**) rearrangement of equation **(1)** • (**M4**) calculation of ΔS_{system} **(1)** • (**M5**) rearrangement of equation so $S_{(\text{ethyl ethanoate})}$ = **(1)** • (**M6**) calculation of $S_{(\text{ethyl ethanoate})}$ with sign and units **(1)**	<u>Example of calculation</u> $\Delta G = -RT \ln K = -8.31 \times 298 \times \ln 4.0$ $= -3433$ (J mol^{-1}) $\Delta G = \Delta H - T\Delta S_{system}$ $\Delta S_{system} = (\Delta H - \Delta G) \div T$ $\Delta S_{system} = (-6.0 \times 10^3 - (-3433)) \div 298$ $= -8.614....$ (J mol^{-1} K^{-1}) ($\Delta S_{system} = \Sigma S_{(\text{products})} - \Sigma S_{(\text{reactants})}$) $S_{(\text{ethyl ethanoate})} = \Delta S + \Sigma S_{(\text{reactants})} - S(water)$ $S_{(\text{ethyl ethanoate})} = (-8.614 + (159.8+160.7) - 69.9)$ $= +242/240$ J mol^{-1} K^{-1} Ignore SF except 1SF Correct final answer without working scores (6) TE throughout	**(6)**

Question Number	Answer	Additional Guidance	Mark
10(b)	A comparison that makes reference to: (with ethanoyl chloride) • the reaction is irreversible compared to reversible **(1)** • hydrogen chloride is the by-product rather than water **(1)** • the reaction is very fast/occurs at room temperature so an acid catalyst is not needed **(1)**	Accept reverse arguments Allow steamy fumes for 'HCl'	**(3)**

(Total Question 10 = 15 marks)