Oxford Cambridge and RSA

GCE

Chemistry A

Unit **H432A/01:** Periodic table, elements and physical chemistry

Advanced GCE

Mark Scheme for June 2017

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations available in RM Assessor

Annotation	Meaning
✓	Correct response
✗	Incorrect response
^	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore

Subject-specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

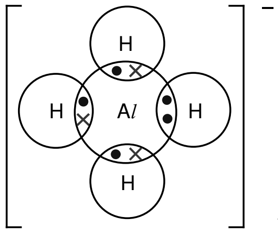
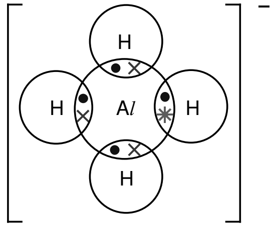
You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

SECTION A

Question	Answer	Marks	Guidance
1	D	1	
2	D	1	
3	C	1	**ALLOW** +6 in the box
4	C	1	
5	B	1	**ALLOW** 20 in the box
6	C	1	
7	A	1	
8	D	1	
9	C	1	
10	A	1	
11	A	1	
12	C	1	**ALLOW** 4.1 in the box
13	B	1	**ALLOW** 0.426 in the box
14	C	1	
15	B	1	
	Total	**15**	

SECTION B

Question			Answer	Marks	Guidance
16	(a)	(i)	 ✓	1	**IGNORE** no brackets, no charge or wrong charge Circles **not** needed **ALLOW** different sign for 'extra' electron, e.g.  **DO NOT ALLOW** 4 dots and 4 crosses
	(b)		NH_4^+: tetrahedral **AND** 109.5(º) ✓ NH_2^-: non-linear **AND** 104.5(º) ✓	2	**ALLOW** 109−110(º) **ALLOW** 104−105(º) **ALLOW** bent, v-shaped, angular **IGNORE** planar, 'not straight'

Question			Answer	Marks	Guidance
	(c)	*(i)*	NH_3 has hydrogen bonding **OR** PH_3 does **not** have hydrogen bonding ✓ Hydrogen bonding is stronger **OR** More energy to overcome hydrogen bonding ✓	2	**ORA** throughout **Assume that comparison is with PH_3** **DO NOT ALLOW** response that implies covalent or ionic bonds breaking
		(ii)	AsH_3 / As has more **electrons** (than PH_3 / P) ✓ in AsH_3, **stronger**/**more** induced dipole–dipole interactions **OR stronger**/**more** London forces (than PH_3) **OR more** energy required to overcome induced dipole–dipole interactions ✓	2	**ORA** throughout **ALLOW** larger **electron** cloud **ALLOW** 'forces' **OR** 'bonds' for 'interactions' **ALLOW** instantaneous/temporary–induced dipole interactions **ALLOW** dispersion forces **IGNORE** van der Waals' / vdW **IGNORE** permanent dipole–dipole **DO NOT ALLOW** response that implies covalent or ionic bonds breaking
			Total	7	

Question			Answer	Marks		Guidance
17	(a)		$Ba(OH)_2 + 2HCl \rightarrow BaCl_2 + 2H_2O$ ✓	1		**ALLOW multiples** **IGNORE** state symbols (even if wrong)
	(b)		*Increasing size:* Atomic radius increases **OR** more shells **OR** more (electron) shielding ✓ *Attraction* Nuclear **attraction** decreases **OR** (outer) electron(s) experience less **attraction** ✓ *Ionisation energy* Ionisation **energy** decreases **OR** less **energy** needed to remove electron(s) ✓	3		**FULL ANNOTATIONS WITH TICKS, CROSSES, CON, etc MUST BE USED** **IGNORE** more orbitals **OR** more sub-shells *Alternative must refer to shells* **ALLOW** Energy levels for shells **ALLOW more** electron repulsion between shells **IGNORE** just 'shielding' (*more/greater needed)* **IGNORE** 'nuclear shielding' **IGNORE** 'pull' for attraction **IGNORE** 'electrons less tightly held' **IGNORE** 'nuclear charge' for 'nuclear attraction' **IGNORE** 'easier to remove electron' ***Energy** is required* **ALLOW** less energy to oxidise

Question			Answer	Marks		Guidance
	(c)	(i)	*Disproportionation*: oxidation and reduction of the same **element** ✓ *Redox*: Cl is oxidised from +5 (in $KClO_3$) to +7 (in $KClO_4$) ✓ C*l* is reduced from +5 (in $KClO_3$) to –1 (in KCl) ✓	3		**ALLOW** 'chlorine' **OR** 'Cl' for same element **IGNORE** 'species' for 'element' **ALLOW** after number, e.g. 5+ **IGNORE** ionic charges, e.g. Cl^{5+} **IGNORE** '5' (signs required) **IGNORE** any reference to electron loss/gain (even if wrong) **ALLOW** one redox mark if oxidation numbers are correct but reduction/oxidation is incorrectly assigned
		(ii)	potassium chlorate(VII) ✓	1		Brackets required
	(d)	(i)	*Equation* $Ba(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaNO_3(aq)$ ✓ *Entropy change **and** explanation* entropy decreases **OR** entropy change negative **AND** ($BaSO_4$) solid/ppt has less disorder/ more order/ fewer ways of arranging energy/ less freedom/ less random particles/dispersal of energy ✓	2		**ALLOW** multiples M2 is dependent on $BaSO_4(s)$ (even if formula is incorrect – eg $Ba(SO_4)_2(s)$) seen as a product in the attempted equation as long as reactants are not solid. $BaSO_4$ solid/ppt may be assumed from $BaSO_4(s)$ seen in the attempted equation.

Question			Answer	Marks		Guidance
		(ii)	*Equation* ½ I_2(s) → I(g) ✓ *state symbols required* *Entropy change **and** explanation* entropy increases **OR** entropy change positive **AND** gas has more disorder/ less order/ more ways of arranging energy/ more freedom/ more random particles / more dispersal of energy ✓	2		**DO NOT ALLOW** I_2(s) → 2I(g) **DEPENDENT** on ½ I_2(s) → I(g) **OR** I_2(s) → 2I(g)
			Total	**12**		

Question			Answer	Marks	Guidance
18	(a)		**$\Delta G = \Delta H - T\Delta S$** linked to $y = mx + c$ (somewhere) ✓ **gradient** = $-\Delta S$ ✓ **P:** ΔH / enthalpy change ✓ **Q**: (temperature) for reaction to be feasible/unfeasible **OR** (temperature) at which feasibility changes ✓	4	Could be: $\Delta G = -\Delta S\,T + \Delta H$ – sign required ALLOW $\Delta S = -gradient$ **ALLOW** 'point of feasibility' For Feasibility: **ALLOW** can take place/happen **OR** is spontaneous **IGNORE** 'minimum/maximum temperature'
	(b)	(i)	(Species have) different states/phases ✓	1	
		(ii)	(K_p =) $p(CO(g))^4$ ✓	1	Allow species without state symbols and without brackets, e.g. $p_{CO}{}^4$, $ppCO^4$, PCO^4, $p(CO^4)$ etc. **DO NOT ALLOW** square brackets
		(iii)	*ΔG at 25 C* $\Delta G = \Delta H - T\Delta S = 676.4 - (298 \times 0.7031)$ = (+) 467 (kJ mol^{-1}) **OR** (+) 466876 (J mol^{-1}) ✓ *Non-feasibility statement* Non-feasible when $\Delta G > 0$ **OR** $\Delta G > 0$ **OR** $\Delta H > T\Delta S$ ✓ *Minimum temperature* minimum temperature = $\frac{\Delta H}{\Delta S} = \frac{676.4}{0.7031}$ = 962(.0) K ✓	3	**IGNORE** units **ALLOW** (+) 467 up to calculator value of 466.8762 correctly rounded ECF for any positive value determined in M1 **ALLOW** 962 up to calculator value of 962.0253165 correctly rounded

Question			Answer	Marks	Guidance
		(iv)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF answer = –110.5, Award 3 marks.** -- **Correct expression** $-13.5 = (4 \times -393.5) - (-1118.5 + 4 \times \Delta_f H(CO))$ ✓ **Correct subtraction using ΔH and $\Delta_f H(Fe_3O_4)$** $4 \times \Delta_f H(CO) = (4 \times -393.5) - (-1118.5) + 13.5$ $= \mathbf{-442(.0)}$ (kJ mol^{-1}) ✓ **Calculation of $\Delta_f H(CO)$ formation** $\Delta_f H(CO) = -\frac{442}{4} = \mathbf{-110.5}$ (kJ mol^{-1}) ✓	3	**For answer,** **ALLOW –111 (kJ mol^{-1})** -- **NOTE:** IF any values are omitted, **DO NOT AWARD** any marks. e.g. –393.5 OR –13.5 may be missing -- **Common errors** **(+)110.5** *wrong/omitted sign* **2 marks** **(+)184.625 / 184.63 / 184.6 / 185** *No 4CO$_2$* **2 marks** **(+)738.5 / 739** *No 4CO$_2$ and no CO/4* **1 mark** **–117.25 / –117.3 / –117** *Wrong cycle* **2 marks** **–469** *Wrong cycle, no CO/4* **1 mark** **(+)177.875 / 177.88 / 177.9 / 178** *Wrong cycle, no 4CO$_2$* **1 mark** **–360.5** *Used 118.5* **2 marks** Any other number: **CHECK** for **ECF** from 1st marking point for expressions using **ALL** values with **ONE** error only e.g. one transcription error:, e.g.395.3 for 393.5
			Total	**12**	

Question			Answer	Marks	Guidance
19	(a)		$n(H_2O_2) = 2.30 \times \frac{25.0}{1000}$ **OR** = 0.0575 (mol) ✓ vol $O_2 = \frac{0.0575}{2} \times 24000 = 690$ **cm³** ✓ Collect in 1000 cm³/1 dm³ measuring cylinder ✓	3	**ALLOW** 0.69(0) **dm³** 2nd mark subsumes 1st mark **ALLOW** 1000 cm³/1 dm³ syringe Needs a **name** of actual apparatus, not just 'container' 'measuring cylinder' without volume is insufficient **DO NOT ALLOW** burette For other possible apparatus, contact Team Leader **ALLOW** volumes from 700–1000 cm³ but should be realistic apparatus, e.g. 700, 750, 800, 850, 900, 950.
	(b)		Measure mass (loss) ✓	1	**ALLOW** weight for mass **ALLOW** take samples and titrate (remaining H_2O_2)

Question			Answer	Marks	Guidance
	(c)*		*Please refer to the marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5–6 marks)** A comprehensive conclusion using quantitative data from the graph to correctly determine initial rate **AND** half lives/gradient with 1st order conclusion for H_2O_2 **AND** determination of *k*. *There is a well-developed line of reasoning which is clear and logically structured.* *Clear working for initial rate, half life*/gradient *and order and k.* *Units mostly correct throughout.* **Level 2 (3–4 marks)** Attempts to describe all three scientific points but explanations may be incomplete. **OR** Explains two scientific points thoroughly with few omissions. *There is a line of reasoning with some structure and supported by some evidence. The scientific points are supported by evidence from the graph.* **Level 1 (1–2 marks)** Reaches a simple conclusion using at least one piece of quantitative data from the graph. Attempts to calculate initial rate **OR** half life. *There is an attempt at a logical structure with a reasoned conclusion from the evidence.* **0 marks** *No response worthy of credit.*	6	**Indicative scientific points may include:** **Initial rate** • Tangent shown on graph as line at t = 0 s • Gradient determined in range: $1.5 – 2.0 \times 10^{-3}$ e.g. $\frac{2.3}{1300} = 1.77 \times 10^{-3}$ • *initial rate* as gradient value with units: mol dm^{-3} s^{-1}, *For other methods contact TL* **Evidence for 1st order 2 methods** • 1st order clearly linked to half-life **OR** 2 gradients: **1. Half life** • Half life shown on graph • Half life range 800–1000 s • Two 'constant' half lives ±50 s **2. Two gradients → two rates** • 2 tangents shown on graph at *c* and *c*/2 • Gradient at *c*/2 is half gradient at *c* e.g. *c* = 2.3 mol dm^{-3}, gradient = 1.6×10^{-3} **AND** *c* = 1.15 mol dm^{-3}, gradient = 0.8×10^{-3} • For chosen method, conclusion: H_2O_2 is 1st order **Determination of *k* 2 methods** • *k* clearly linked to rate **OR** half-life: $k = \frac{rate}{[H_2O_2]}$ e.g. $k = \frac{1.6 \times 10^{-3}}{2.3} = 7 \times 10^{-4}$ s^{-1} **OR** $k = \frac{\ln 2}{t_{1/2}}$ e.g. $k = \frac{0.693}{950} = 7.3 \times 10^{-4}$ s^{-1}
			Total	**10**	

Question			Answer	Marks	Guidance
20	(a)		**Conditions** Low/decreased pressure **AND** high/increased temperature ✓ **Pressure**: Right-hand/product side has more (gaseous) moles/molecules **OR** left-hand side/reactant side has fewer (gaseous) moles/molecules ✓ **Temperature**: (Forward) reaction is endothermic / takes in heat **OR** reverse reaction is exothermic / gives out heat ✓	4	**ANNOTATE ANSWER WITH TICKS AND CROSSES ETC** **DO NOT ALLOW** more atoms on right-hand side **OR** fewer atoms on left-hand side. **DO NOT ALLOW** incorrect shift direction
			Low pressure gives a slow rate **OR** High temperature uses a large amount of energy/fuel ✓		**ORA** **IGNORE** 'expensive' **IGNORE** use of catalyst
	(b)	(i)	$(K_c =)\ \dfrac{[SO_3]^2}{[SO_2]^2\,[O_2]}$ ✓ Units: $dm^3\ mol^{-1}$ ✓	2	**IGNORE** state symbols in K_c expression, even if wrong. For units, **ALLOW** $mol^{-1}\ dm^3$ **DO NOT ALLOW** dm^3/mol **NOTE**: If K_c upside down, units become $mol\ dm^{-3}$ by **ECF** No other **ECF** allowed for units.

Question			Answer	Marks	Guidance
		(ii)	**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = 2.45, Award **4 marks.** --- **Equilibrium concentrations (moles × 2.5) 1 MARK** SO_2 = 0.135 (mol dm^{-3}) **AND** O_2 = 0.0675 (mol dm^{-3}) ✓ **Calculation of [SO_3(g)] 2 MARKS** [SO_3] = $\sqrt{(K_c \times [SO_2]^2 \times O_2)}$ **OR** $\sqrt{((3.045 \times 10^4) \times 0.135^2 \times 0.0675)}$ ✓ = 6.12039291 (mol dm^{-3}) ✓ *Answer scores both [SO_3] marks automatically* **Calculation of *n*(SO_3) in 400 cm^3 1 MARK** *n*(SO_3) = 6.12039291/2.5 = 2.45 (mol) ✓ ***3SF required (Appropriate number)***	4	**FULL ANNOTATIONS NEEDED** **IF** there is an alternative answer, check to see if there is any **ECF** credit possible using working below --- **ALLOW ECF** from incorrect concentrations of SO_2 and/or O_2 **ALLOW ECF** from incorrect [SO_3] **ALLOW 3 SF**, 6.12, up to calculator value of 6.12039291 correctly rounded. **Common errors** **37.5 1 mark** *No √ for [SO_3]^2 and no scaling by 1/2.5* **15.0 2 marks** *No √ for [SO_3]^2* **0.619 3 marks** *Use of mol of SO_2 and O_2* **1.55 2 marks** *No conc used and Use of mol of SO_2 and O_2*
			Total	**11**	

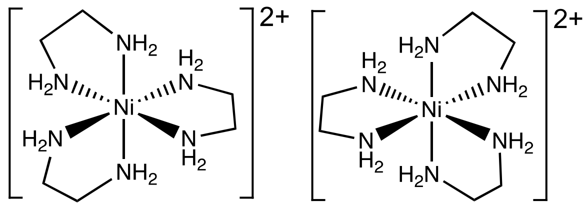
Question			Answer	Marks	Guidance
21	(a)		**FIRST, CHECK THE ANSWER ON ANSWER LINE** **IF** answer = **0.753**, award **3 marks** **---** $[H^+] = 10^{-pH} = 10^{-2.440} = 3.63 \times 10^{-3}$ (mol dm^{-3}) ✓ $[CH_3COOH] = \frac{[H^+]^2}{K_a}$ **OR** $\frac{(3.63 \times 10^{-3})^2}{1.75 \times 10^{-5}}$ ✓ = 0.753 (mol dm^{-3}) ✓	3	**ALLOW** use of **HA** and **A$^-$** **ALLOW 3 SF** up to calculator value of $3.630780548 \times 10^{-3}$ correctly rounded **NOTE:** Answer is same from unrounded [H$^+$] calculator value and 3 SF [H$^+$] value **ALLOW** 0.749 if [H$^+$] has been subtracted from [CH_3COOH] for greater accuracy at end
	(b)		$CH_3COOH + FCH_2COOH \rightleftharpoons CH_3COOH_2^+ + FCH_2COO^-$ ✓ **B2** **A1** **A2** **B1** **OR** **B1** **A2** **A1** **B2** ✓ *i.e. labels other way round*	2	Watch for opposite order on RHS, i.e.: $FCH_2COO^- + CH_3COOH_2^+$ Take **great care** matching labels **ALLOW ECF** for incorrect proton transfer as below. This is the **ONLY ECF** $CH_3COOH + FCH_2COOH \rightleftharpoons CH_3COO^- + FCH_2COOH_2^+$ ✗ **A1** **B2** **B1** **A2** **OR** **A2** **B1** **B2** **A1** ✓**ECF** *i.e. labels other way round*

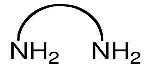
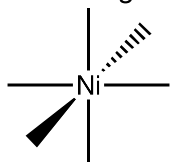
Question			Answer	Marks	Guidance
	(c)	(i)	**[CH_3COO^-]** $n(CH_3COONa) = \frac{9.08}{82.0}$ **OR** 0.111 ✓ (Calc: 0.1107317073) $[CH_3COO^-] = \frac{9.08}{82.0} \times \frac{1000}{250} = 0.443$ (mol dm^{-3}) **OR** $n(CH_3COOH) = 0.800 \times \frac{250}{1000} = 0.200$ (mol) ✓ **[H^+]** $[H^+] = K_a \times \frac{[CH_3COOH]}{[CH_3COO^-]}$ **OR** $K_a \times \frac{n(CH_3COOH)}{n(CH_3COO^-)}$ $= 1.75 \times 10^{-5} \times \frac{0.800}{0.443}$ **OR** $1.75 \times 10^{-5} \times \frac{0.200}{0.111}$ ✓ $= 3.16 \times 10^{-5}$ (mol dm^{-3}) ✓ **pH (must come from *calculated* [H^+])** pH = –log (3.16×10^{-5}) = 4.50 ✓ --- **LAST 3 marks** are **NOT** available using • K_a square root approach (weak acid pH) • K_w /10^{-14} approach (strong base pH) --- **Henderson–Hasselbalch (HH) alternative** $pK_a = -\log 1.75 \times 10^{-5} = 4.757$ (or 4.756961951..) $pH = pK_a + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$ **OR** $= pK_a - \log \frac{[CH_3COOH]}{[CH_3COO^-]}$ **OR** $pK_a + \log \frac{0.443}{0.800}$ **OR** $= pK_a - \log \frac{0.800}{0.443}$ ✓ $= pK_a - 0.257$ ✓ $= 4.757 - 0.257 = 4.50$ ✓	5	**ALLOW** 2 sig fig **ALLOW** use of **HA** and **A$^-$** Mark by **ECF** --- **Alternative method** (If both methods are attempted, mark the method which produces the higher mark) **[H^+]** $[H^+] = 10^{-pH} = 10^{-4.50}$ $= 3.16 \times 10^{-5}$ (mol dm^{-3}) ✓ **[CH_3COO^-]** $[CH_3COO^-] = K_a \times \frac{[CH_3COOH]}{[H^+]}$ **OR** $1.75 \times 10^{-5} \times \frac{0.800}{3.16 \times 10^{-5}}$ ✓ $= 0.443$ (mol dm^{-3}) ✓ **mass of CH_3COONa** mass $CH_3COONa = 0.443 \times \frac{250}{1000}$ **OR** 0.111 ✓ $0.111 \times 82.0 =$ **9.08** (g) ✓ --- **Common errors** **4.64** Use of $M(CH_3COONa) = 60$ 4 marks **2.40** Use of K_a of FCH_2COOH 4 marks

Question			Answer	Marks	Guidance
		(ii)	pH is the same/constant ✓ ratio/proportion [HA]/[A^-] is the same ✓	**2**	M2 is dependent upon M1 **ALLOW** Change in [HA] and [A^-] is proportional
			Total	**12**	

Question			Answer	Marks	Guidance
22	(a)	(i)	*Circuit*: complete circuit **AND** voltmeter **AND** *labelled* salt bridge linking two half-cells ✓ *Half cells*: Pt **AND** Fe^{2+} **AND** Fe^{3+} ✓ Zn **AND** Zn^{2+} ✓ *Standard conditions*: 1 mol dm^{-3} (solution(s)) **AND** 298 K / 25ºC ✓	4	Electrodes / salt bridge must at least touch the surface **ALLOW** small gaps in circuit wires **ALLOW** half cells drawn either way around **ALLOW** 1 mol/dm^3 **OR** 1 M **ALLOW** 1 mol dm^{-3}/1M if omitted here but shown for just one solution in diagram **IGNORE** pressure **DO NOT ALLOW** 1 mol(e) for concentration
		(ii)	1.53 (V) ✓	1	**IGNORE** sign
	(b)		*strongest reducing agent*: Zn ✓ *strongest oxidising agent*: MnO_4^- ✓	2	 **NOTE**: H^+ has been ignored
	(c)		**AWARD 2 marks** for correct balancing **AND** all species cancelled on both sides of equation: $2MnO_4^- + 6H^+ + 5SO_3^{2-} \rightarrow 2Mn^{2+} + 3H_2O + 5SO_4^{2-}$ ✓ ✓ **AWARD 1 mark** for correct balancing but **not** all species (H_2O, H^+) cancelled on both sides of equation ✓ e.g. $2MnO_4^- + 16H^+ + 5SO_3^{2-} + 5H_2O$ $\rightarrow 2Mn^{2+} + 8H_2O + 5SO_4^{2-} + 10H^+$	2	**ALLOW** correct multiples e.g. $MnO_4^- + 3H^+ + 2½SO_3^{2-}$ $\rightarrow Mn^{2+} + 1½H_2O + 2½SO_4^{2-}$ **IGNORE** state symbols e.g. $MnO_4^- + 8H^+ + 2½SO_3^{2-} + 2½H_2O$ $\rightarrow Mn^{2+} + 4H_2O + 2½SO_4^{2-} + 5H^+$
			Total	9	

Question			Answer	Marks	Guidance
23	(a)	(i)	$CuCl_4^{2-}$ **OR** $[CuCl_4]^{2-}$ ✓ *yellow solution* $Cu(OH)_2$ ✓ *pale blue precipitate* $[Cu(NH_3)_4(H_2O)_2]^{2+}$ ✓ *deep blue solution* CuI ✓ *white solid* I_2 ✓ *brown solution*	5	**ALLOW** $Cu(Cl)_4^{2-}$ **ALLOW** $Cu(OH)_2(H_2O)_4$ Brackets required for $[Cu(NH_3)_4(H_2O)_2]^{2+}$ **NOTE:** Take great care to check that subscripted numbers and brackets are correct
		(ii)	*Reaction 1*: ligand substitution ✓ *Reaction 2*: redox ✓	2	**ALLOW** ligand exchange **ALLOW** reduction **AND** oxidation **ALLOW** precipitation

Question			Answer	Marks	Guidance
	(b)*		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5–6 marks)** A comprehensive conclusion using all data to obtain correct formulae for **A**, **B**, **C** and **D** **AND** optical isomers shown *There is a well-developed line of reasoning which is clear and logically structured with use of 3D structures for both optical isomers of **C**, use of wedges and bonding to N.* *The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Reaches a sound conclusion for the formula of **B** **AND** obtains the correct formula of the hydrated complex **A** **OR** a 3D diagram of one optical isomer of cation **C** *There is a line of reasoning and supported by some evidence. Calculations are clear and can be followed to obtain correct conclusions. 3D diagram, if present, should use wedges mostly correctly.* *Formula of **A** to show water separately or formula of **C** to show ligands separately, as appropriate.* **Level 1 (1–2 marks)** Reaches a simple conclusion to obtain the correct formula of anhydrous complex **B** **OR** shows that **A** contains $2H_2O$ *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. Attempts more than one part of the problem.* **0 marks** *No response or no response worthy of credit.*	6	**Indicative scientific points may include:** **1. Formula of anhydrous complex B** $NiC_6N_6H_{24}Cl_2$ *Example of working* Ni : C : N : H : Cl $= \frac{18.95}{58.7} : \frac{23.25}{12.0} : \frac{27.12}{14.0} : \frac{7.75}{1.00} : \frac{22.93}{35.5}$ ***There may be other methods*** **2. Formula of hydrated complex A** $NiC_6N_6H_{24}Cl_2{\bullet}2H_2O$ **OR** $NiC_6N_6H_{24}Cl_2(H_2O)_2$ *Example of working* n(anhydrous salt) $= \frac{7.433}{309.7} = 0.02400$ (mol) $n(H_2O) = \frac{0.864}{18.0} = 0.04800$ (mol) ✓ ***There may be other methods*** **3. Formula of cation C** $[NiC_6N_6H_{24}]^{2+}$ **OR** $[Ni(H_2NCH_2CH_2NH_2)_3)]^{2+}$ (*could be in structures* 2+ charge can be shown on cation **OR** optical isomers (i.e. seen somewhere) • **Bidentate ligand D** $H_2NCH_2CH_2NH_2$ or displayed so that structure is clearly unambiguous. • **Optical isomers**  *Accuracy of structures*

Question			Answer	Marks	Guidance
					Bonding shown from Ni to N of $H_2NCH_2CH_2NH_2$ **ALLOW** $CH_3CH(NH_2)_2$ for ligand For $H_2NCH_2CH_2NH_2$ in optical isomers, **ALLOW** C–C without Hs and  Each structure to contain 2 'out wedges', 2 'in wedges' and 2 lines in plane of paper **OR** 4 lines, 1 'out wedge' and 1 'in wedge':  Bond into paper can be shown as: 
			Total	**13**	

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