

1. (a) +1 or Cu⁺ (1)
 $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ or Ar $3d^{10}$ (1)
 3d sub-shell is fully filled (1) 3
- (b) CuCl₄²⁻ (1)
 Tetrahedral (1) 2
- (c) Oxidising agent (1) 1
- (d) $2e^- + 2H^+ + H_2O_2 \rightarrow 2H_2O$ (1) 1
- (e) $CuCl_4^{2-} + 6H_2O \rightarrow [Cu(H_2O)_6]^{2+} + 4Cl^-$ (1)
 Ligand, or electron pair donor (1)
 or Lewis base 2
- [9]
2. (a) electron pair acceptor (1) or lone
 proton donor (1) 2
- (b) (i) $AlCl_3 + 6H_2O \rightarrow [Al(H_2O)_6]^{3+} + 3Cl^-$ (1)
 (ii) $[Al(H_2O)_6]^{3+} + H_2O$ (or any base) (1)
 $\rightarrow [Al(OH)(H_2O)_5]^{2+}$ (1) + H_3O^+ (1) (or protonated base)
 (iii) $AlCl_3 + Cl^- \rightarrow [AlCl_4]^-$ (1)
or $[Al(H_2O)_6]^{3+} + 4Cl^- \rightarrow [AlCl_4]^- + 6H_2O$ (1) 3
- (c) (i) effervescence (1)
 brown ppt (1)
 $Fe(OH)_3$ (H₂O)₃ or $Fe(OH)_3$ (1)
 (ii) green (1) solution (1)
 (ignore mention of ppt)
 $[Cr(OH)_6]^{3-}$ (1)
or $[Cr(OH)_4(H_2O)_2]^-$ 6
- [11]
3. (i) replacement of one ligand by another (1)
 (ii) $[Ti(H_2O)_4Cl_2]^+ + 2H_2O \rightarrow [Ti(H_2O)_6]^{3+} + 2Cl^-$ (1)
 (iii) change of ligand (1) 3
- [3]

4. $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ (1)
 AgCl (1)
 $[\text{Ag}(\text{NH}_3)_2]^+$ (1)
 $[\text{CoCl}_4]^{2-}$ (1)
 $[\text{Co}(\text{OH})_2(\text{H}_2\text{O})_4]$ or $\text{Co}(\text{OH})_2$ (1)
 $[\text{Co}(\text{NH}_3)_6]^{2+}$ (1)
 $[\text{Co}(\text{NH}_3)_6]^{3+}$
 CoCl_2 or $\text{CoCl}_2 \cdot x\text{H}_2\text{O}$ (1)
- [8]
5. (a) A shared electron pair or a covalent bond (1)
Both electrons from one atom (1)
OR when a Lewis base reacts with a Lewis acid
Mark points separately 2
- (b) *Brønsted-Lowry acid*: A proton or H^+ donor (1)
Not H_3O^+
- Lewis acid*: A lone or electron pair acceptor (1) 2
- (c) Two atoms or two points of attachment (1)
Each donating a lone electron pair (1)
OR forms 2 (1) co-ordinate bonds (1)
OR donates two (1) pairs of electrons (1)
- 2
- (d) *Change in co-ordination number*: 6 to 4 (1)
Reason for change: chloride ligands are larger than water ligands (1)
OR greater repulsion between chloride ligands
DO NOT allow chlorine or Cl
- 2
- (e) Same number (1), and same type of bonds (1), broken and made 2
- (f) $\text{ClNH}_3\text{CH}_2\text{CH}_2\text{NH}_3\text{Cl}$ (1)
OR $(\text{NH}_3\text{CH}_2\text{CH}_2\text{NH}_3)^{2+} 2\text{Cl}^-$
Allow $\text{C}_2\text{H}_{10}\text{N}_2\text{Cl}_2$ and $\text{NH}_3\text{ClCH}_2\text{CH}_2\text{NH}_3\text{Cl}$
- 1
- [11]
6. (a) octahedral (1) 1
- (b) $[\text{Fe}(\text{H}_2\text{O})_6]^{3+} + \text{H}_2\text{O} \rightarrow [\text{Fe}(\text{OH})(\text{H}_2\text{O})_5]^{2+} + \text{H}_3\text{O}^+$ (1)
(or any base) (protonated base) 1
- (c) $[\text{Fe}(\text{OH})(\text{H}_2\text{O})_5]^{2+}$ or $[\text{Fe}(\text{OH})_2(\text{H}_2\text{O})_4]^+$ (1) 1

- (d) $\text{HNO}_3 \equiv \text{H}_3\text{O}^+$ addition or increases concentration of acid (1)
 reverses equilibrium or forms $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ (1) 2
- (e) change of ligand (1)
 change of shape or coordⁿ number (1) 2
- (f) *Identity* H_2 (1)
 $\text{Fe}(\text{OH})_3(\text{H}_2\text{O})_3$ **or** $\text{Fe}(\text{OH})_3$ (1)
 $3\text{Mg} + 2[\text{Fe}(\text{H}_2\text{O})_6]^{3+} \rightarrow 3\text{Mg}^{2+} + 3\text{H}_2 + 2[\text{Fe}(\text{OH})_3(\text{H}_2\text{O})_3]$ (1)
 or 2 separate eqns each correct but not necessarily combined
 or $\text{Mg} + [\text{Fe}(\text{OH})(\text{H}_2\text{O})_5]^{2+} \rightarrow \text{Mg}^{2+} + \text{H}_2 + [\text{Fe}(\text{OH})_3(\text{H}_2\text{O})_3]$ 3

[10]

7. (a) $3d^7$ 1
- (b) $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ 1
 Pink 1
- (c) (i) $[\text{Co}(\text{NH}_3)_6]^{2+}$ 1
 Pale brown or straw 1
- (ii) $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 6\text{NH}_3 \rightarrow [\text{Co}(\text{NH}_3)_6]^{2+} + 6\text{H}_2\text{O}$ 1
- (d) $[\text{Co}(\text{NH}_3)_6]^{3+}$ 1
 An oxidising agent 1

[8]

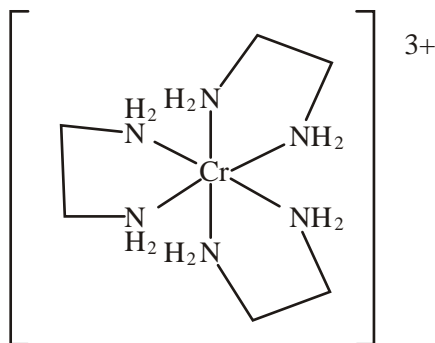
8. (a) oxidation state of N in $\text{Cu}(\text{NO}_3)_2$: +5; 1
 oxidation state of N in NO_2 : +4; 1
 oxidation product: oxygen; 1
- (b) copper-containing species: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$; 1
 shape: octahedral; 1
- (c) (i) precipitate B: $\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2$ or $\text{Cu}(\text{OH})_2$ or name; 1
 equation: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow \text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 2\text{NH}_4^+$
 OR
 $\text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4^+ + \text{OH}^-$
 and
 $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{OH}^- \rightarrow \text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 2\text{H}_2\text{O};$ 1
- (ii) NH_3 accepts a proton; 1

- (d) (i) identity: $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$; 1
 colour: deep blue; 1
 equation: 1
 $\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2 + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 2\text{H}_2\text{O} + 2\text{OH}^-$
- (ii) NH_3 is an electron pair donor; 1
- (e) identity: $[\text{CuCl}_4]^{2-}$; 1
 colour: yellow-green; 1
 shape: tetrahedral; 1
- (f) (i) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$; 1
 (ii) role of Cu: a reducing agent; 1

[17]

9. (a) A $\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3$ (or $\text{Co}(\text{OH})_3$) 1
 B CO_2 1
 $2[\text{Cr}(\text{H}_2\text{O})_6]^{3+} + 3\text{CO}_3^{2-} \rightarrow 2[\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3] + 3\text{CO}_2 + 3\text{H}_2\text{O}$ 1
(or gives $2\text{Cr}(\text{OH})_3 + 3\text{CO}_2 + 9\text{H}_2\text{O}$)
- (b) (i) NaOH 1
 (or KOH)
- (ii) +6 1
 (or 6 or +VI or VI)
- (iii) H_2O_2 1
 (or Na_2O_2 or BaO_2)
 $[\text{Cr}(\text{OH})_6]^{3-} + 2\text{OH}^- \rightarrow \text{CrO}_4^{2-} + 4\text{H}_2\text{O} + 3e^-$ 1
(or $[\text{Cr}(\text{OH})_6]^{3-} \rightarrow \text{CrO}_4^{2-} + 2\text{H}_2\text{O} + 2\text{H}^+ + 3e^-$)

(c) (i)



At least one $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ with correct structure and bonding to Cr via N

1

6 co-ordination with 3 en drawn correctly

1

Correct 3+ charge

1

(Mark independently but must not have 6 monodentate ligands)

(ii) Same (or similar) type of bonds broken and made

1

Same number of bonds broken and made
(or same co-ordination number)

1

(iii) Entropy change (or ΔS) is positive
(or increase in disorder)

1

Because there are more product particles than reactant particles

1

(d) $[\text{Cr}(\text{H}_2\text{O})_6]^{2+}$

1

Reducing agent

1

(mark independently)

(e)	(i)	Ethanal (or CH_3CHO) (not CH_3COH)	1	
	(ii)	Ethanoic acid (or correct formula)	1	
				[18]

10.		Pale green solution	1	
		Green precipitate formed	1	
		Insoluble in excess ammonia	1	
		Equation:		
		e.g. $[\text{Fe}(\text{H}_2\text{O})_6]^{2+} + 2\text{NH}_3 \rightarrow [\text{Fe}(\text{H}_2\text{O})_4(\text{OH})_2] + 2\text{NH}_4^+$	Species	1
			Balance	1
			Max 4	

NB Allow equations with H_2O and OH^- if reaction of H_2O with NH_3 also given

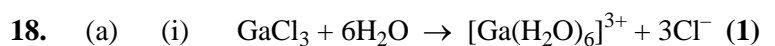
[4]

11.	(a)	(i)	An atom, ion or molecule which can donate a lone electron pair	1	
		(ii)	A central metal ion/species surrounded by co-ordinately bonded ligands or ion in which co-ordination number exceeds oxidation state	1	
		(iii)	The number of co-ordinate bonds formed to a central metal ion or number of electron pairs donated or donor atoms	1	
	(b)	(i)	<i>Allow the reverse of each substitution</i> $[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 6\text{NH}_3 \rightarrow [\text{Co}(\text{NH}_3)_6]^{2+} + 6\text{H}_2\text{O}$ Complex ions Balanced	1 1	
			<i>Allow partial substitution</i>		
		(ii)	$[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow [\text{CoCl}_4]^{2-} + 6\text{H}_2\text{O}$ Complex ions Balanced	1 1	
			<i>or H_2O or NH_3 or $\text{C}_2\text{O}_4^{2-}$ by Cl^-</i>		
eg.	(iii)		$[\text{Co}(\text{H}_2\text{O})_6]^{2+} + 3\text{C}_2\text{O}_4^{2-} \rightarrow [\text{Co}(\text{C}_2\text{O}_4)_3]^{4-} + 6\text{H}_2\text{O}$ Complex ions Balanced	1 1	
			<i>Allow all substitution except</i> <i>(i) NH_3 by H_2O</i> <i>(ii) more than 2Cl^- substituted for NH_3 or H_2O</i>		
eg.	(iv)		$[\text{Co}(\text{H}_2\text{O})_6]^{2+} + \text{EDTA}^{4-} \rightarrow [\text{Co}(\text{EDTA})]^{2-} + 6\text{H}_2\text{O}$ Complex ions Balanced	1 1	
			<i>or H_2O or NH_3 by $\text{C}_2\text{O}_4^{2-}$ and NH_3 or Cl^- by EDTA^{4-}</i>		
	(c)	(i)	$[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$	1	
		(ii)	$\text{Fe}(\text{OH})_2$ or $\text{Fe}(\text{OH})_2(\text{H}_2\text{O})_x$ where $x = 0$ to 4	1	
		(iii)	Fe^{2+} is oxidised to Fe^{3+} or $\text{Fe}(\text{OH})_3$ By oxygen in the air	1 1	

[15]

12.	(i)	Cobalt-containing species: $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ (1)		
		Precipitate M: $\text{Co}(\text{H}_2\text{O})_4(\text{OH})_2$ or $\text{Co}(\text{OH})_2$ (1)		
	(ii)	$[\text{Co}(\text{NH}_3)_6]^{2+}$ (1)		
	(iii)	Type of reaction: Co^{2+} oxidised to Co^{3+} (1)		
		Reactant responsible: Oxygen (1)		
			5	[5]
13.	(a)	(i)	$\text{Cu } 3d^{10} 4s^1 / 4s^1 3d^{10}$) (1)	
) mark independently	
			$\text{Cu}^{2+} 3d^9$) (1)	2
	(b)	(i)	coordinate / dative / dative covalent (1)	1
		(ii)	octahedral (1)	
			tetrahedral / square planar (1)	2
		(iii)	any blue not blue-green or green (1)	
			to yellow / green (1)	2
	(c)	(i)	any blue precipitate	
			royal / darker / deep blue solution not just blue (1)	
			if solution said to form before precipitate then 0 marks	2
		(ii)	$[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ only (1)	1
				[10]
14.	(a)	(i)	dissolves in acids and alkalis (bases) (1)	
			<u>or</u> reacts with	
			<u>or</u> behaves as	
		(ii)	(Al species correct (1)/balance (1))	
		Equation 1	$[\text{Al}(\text{OH})_3(\text{H}_2\text{O})_3]$ (or $\text{Al}(\text{OH})_3$) + 3 H_3O^+ (or H^+) \rightarrow	
			$[\text{Al}(\text{H}_2\text{O})_6]^{3+} + 3\text{H}_2\text{O}$ [2]	
		Equation 2	$[\text{Al}(\text{OH})_3(\text{H}_2\text{O})_3] + \text{OH}^- \rightarrow [\text{Al}(\text{OH})_4(\text{H}_2\text{O})_2]^- + \text{H}_2\text{O}$ [2]	
			<u>or</u> $[\text{Al}(\text{OH})_4]^-$	
			<u>or</u> $[\text{Al}(\text{OH})_6]^{3-}$	5
	(b)	Cl^-/Br^- reagent stated (1)	XS (1)	XS NaOH (1)
		filter off AgX (1)	NH_3 (1)	filter off Ag_2O (1)
		dissolve in NH_3	filter off $\text{Al}(\text{OH})_3$	dissolve in NH_3
		or $\text{Na}_2\text{S}_2\text{O}_3$	or precipitates	or $\text{Na}_2\text{S}_2\text{O}_3$
		or KCN (1)	(1)	or KCN
				or HNO_3 (1)
			$[\text{Ag}(\text{NH}_3)_2]^+$, $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$, $[\text{Ag}(\text{CN})_2]^-$, $[\text{Ag}(\text{H}_2\text{O})_2]^+$ (1)	
		linear (1)		5
				[10]

15. (i) *Yellow-green species* $[\text{CuCl}_4]^{2-}$ (1)
Shape tetrahedral (1)
Oxidation state of copper +2 (1)
- (ii) $[\text{CuCl}_4]^{2-} + 6\text{H}_2\text{O} \rightleftharpoons [\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^-$ (1)
- (iii) Cu^+ has full d-shell ($[\text{Ar}]\text{d}^{10}$) (1) 5 [5]
16. (a) Fe (1)
 $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ (1)
 $[\text{Fe}(\text{OH})_2(\text{H}_2\text{O})_4]$ (1)
 $[\text{Fe}(\text{OH})_3(\text{H}_2\text{O})_3]$ (1) 4
- (b) Cu (1)
 $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$ (1)
 $[\text{CuCl}_4]^{2-}$ (1)
 $[\text{Cu}(\text{OH})_2(\text{H}_2\text{O})_4]$ (1)
 $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ (1) 5 [9]
17. (a) (i) $[\text{Cr}(\text{H}_2\text{O})_6]^{3+} + \text{H}_2\text{O} \rightarrow [\text{Cr}(\text{H}_2\text{O})_5(\text{OH})]^{2+} + \text{H}_3\text{O}^+$ (1)
OR $[\text{Cr}(\text{H}_2\text{O})_6]^{3+} \rightleftharpoons [\text{Cr}(\text{H}_2\text{O})_5(\text{OH})]^{2+} + \text{H}^+$
DO NOT allow reactions with bases other than water
Allow loss of up to 2 H^+
- (ii) Cr^{3+} is smaller than Cr^{2+} (1)
OR Cr^{3+} has a greater charge density or charge to size ratio
 Cr^{3+} is more polarising (1)
OR draws electron density from oxygen
 So more O—H bonds break (weakened) (1)
Max 2 from three 3
- (b) (i) $\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3$ **or** $\text{Cr}(\text{OH})_3$ **or** $\text{Cr}(\text{OH})_3 \times \text{H}_2\text{O}$, where x =, 1, 2 or 3 (1)
OR name chromium (III) hydroxide
- (ii) Base or electron pair donor or proton acceptor (1)
NOT alkali, ignore nucleophile but penalise 'ligand'
- (iii) *Gas evolved:* CO_2 or name (1)
Equation:
 $3\text{CO}_3^{2-} + 2[\text{Cr}(\text{H}_2\text{O})_6]^{3+} \rightarrow 2[\text{Cr}(\text{H}_2\text{O})_3(\text{OH})_3] + 3\text{CO}_2 + 3\text{H}_2\text{O}$ (1)
N.B if separate equations for CO_3^{2-} and Cr^{3+} (aq) given an overall equation must be deduced 4 [9]



(ii) 2 – 5 (1)

Ga^{3+} ion or high charge density (1)

hydrolysis or polarises H_2O or O–H bond (1)

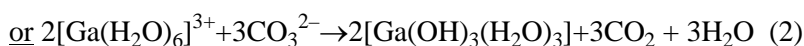
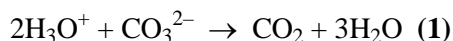
or correct eqn showing H_3O^+ formation (2)

4

(b) (i) effervescence (1)

ppt (1)

penalise if coloured



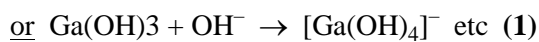
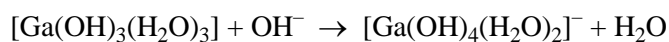
(ii) ppt (1)

not if coloured

dissolves in excess (1)



or $[\text{Ga}(\text{H}_2\text{O})_6]^{3+} + 3\text{H}_2\text{O}$ (as above), then $\text{H}_3\text{O}^+ + \text{OH}^- \rightarrow 2\text{H}_2\text{O}$



8

[12]

19. (a) electron donor (1)
electron pair acceptor (1) 2
- (b) $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ (1)
no lone pair or not a Lewis base (1) 2

(c) (i)	Zn <u>or</u> Sn <u>or</u> Fe/HCl	or HNO_3		BaCl ₂ /HCl	(1)
		HCl or H_2SO_4			
		nothing	nothing	white ppt	(1)
		colour	colour	nothing	(1)
		seen	seen		

		(K ₂ Cr ₂ O ₇ /H ⁺)		
(ii)	NaOH <u>or</u> NH ₃ <u>or</u> Na ₂ CO ₃	KMnO ₄ /H ⁺	Na ₂ CO ₃	(1)
		(green)		
	green ppt	decolourised	no fizz	(1)
	brown ppt	nothing no	fizz	(1)

alternatives:-	conc HCl	KI	6
	nothing	nothing	
	yellow	red/brown	

[13]

20. (i) green-blue \wedge or pink \wedge ppt (1)
[Co(OH)₂(H₂O)₄] or Co(OH)₂ (1)
- (ii) goes brown (1)
[Co(OH)₃(H₂O)₃] or Co(OH)₃ (1)
or CoO(OH) 4

[10]

21. (a) (i) Conc or xs NH_3 (1) air or O₂ or H₂O₂ (1)
- (ii) Conc (1) HCl (1)
- (iii) NaOH (1) H₂O₂ (1)
- (iv) Zn (1) HCl or dil H₂SO₄ 8

- (b) Dissolve in dil HCl or dil H₂SO₄ (1)
add xs (1) Na₂CO₃ (1)
filter off ppt (1)
or FeCO₃ precipitates
Acid must be present to score last 3 marks 4

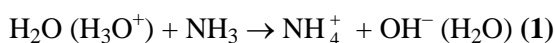
[12]

22. Formula of P [Co(H₂O)₆]²⁺ (1)
- Shape of P octahedral (1)
- Formula of B [CoCl₄]²⁻ (1)
- Shape of B tetrahedral (1)
- Equation [Co(H₂O)₆]²⁺ + 4Cl⁻ \rightleftharpoons [CoCl₄]²⁻ + 6H₂O (1) 5

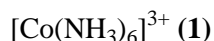
[5]

23. (a) (i) *Formula of precipitate* $[\text{Co}(\text{OH})_2(\text{H}_2\text{O})_4]$ or $\text{Co}(\text{OH})_2$ (1)

Equations



(iii) darkness or goes brown (1)

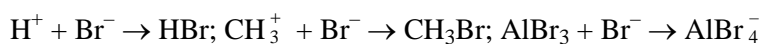


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[8]

24. (a) (i) LB = electron pair donor (1)
RA = electron donor (1)

(ii) Any rn in which Br^- donates lone pair (1)

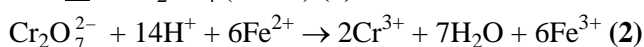


Any rn in which Br^- acts as RA (1)



4

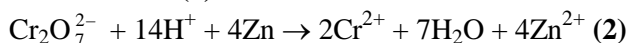
(b) $\text{FeSO}_4/\text{SO}_2/\text{H}_2\text{O}_2/\text{Fe}/\text{stated aldehyde } 1^\circ \text{ or } 2^\circ \text{ ROH}$ (1)
acid or dil H_2SO_4 (above) (1)



or two half-equations

Zn (1) HCl or dil H_2SO_4 (1)

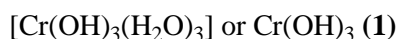
absence of air (1)



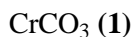
or two half-equations

9

(c) green ppt (1) effervescence (1)



ppt (1)



5

[18]

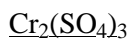
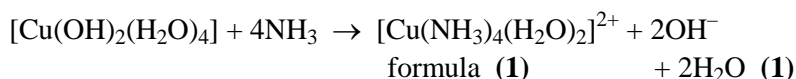
25. (a) Ligand: -
atom, ion or molecules which can donate a pair of electrons to a metal ion. 1
co-ordinate bond:-
a covalent bond 1
in which both electrons are donated by one atom 1
- (b) (i) Two correct complex ions 1
Balanced equation 1
Two correct colours 2
- (ii) Complex with a bidentate ligand 1
Balanced equation 1
NB en not allowed as a ligand unless structure also given
- More molecules/ions formed 1
Increase in entropy 1
more stable complex formed 1
- Max 2
- (c) ΔE ; energy absorbed by electron, ground to excited state (Q o L) 1
 h ; Planck's constant or a constant 1
Change in
- Oxidation state 1
Ligand 1
Co-ordination number 1
Apply list principle to incorrect additional answers

[16]

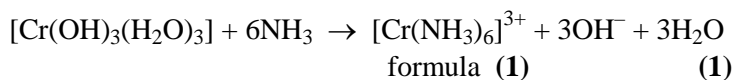
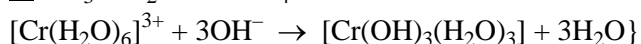
26. (a) replacement of 1 ligand by another (1)



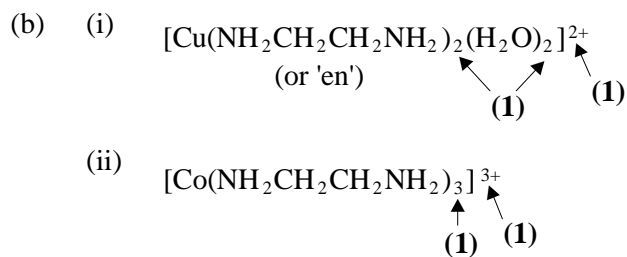
blue ppt (1) deep blue (blue violet) solution (1)



green ppt (grey-green) (1) purple (lilac, mauve) solution (1)

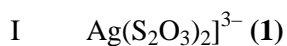
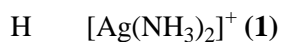
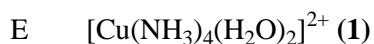
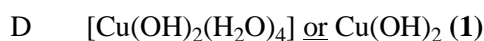
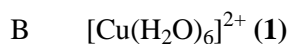


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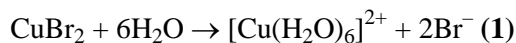


4

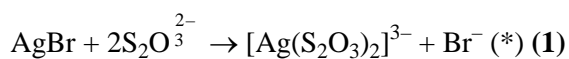
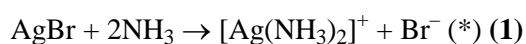
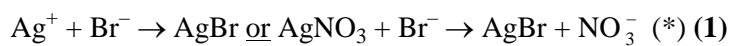
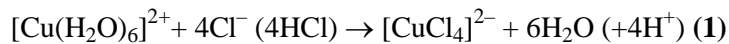
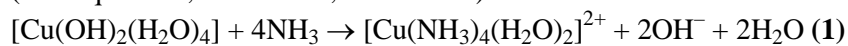
[15]



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(or 2 equations, formⁿ OH^- , use of OH^-)



(*) allow AgCl here if C given as Cl^-

max 6

[15]

28. (a) H_2O or O-H broken (1) H^+ formed (1)

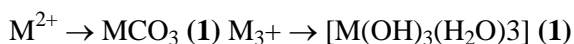


\uparrow \uparrow \uparrow
 any metal any base protonated base



M^{3+} more acidic than M^{2+} (1) higher charge/size ratio (1) or charge density

M^{3+} polarises H_2O more (1) O-H bond weakened (1)



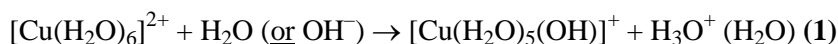
M^{2+} weaker acid than H_2CO_3 or not enough H_3O^+ to react with CO_3^{2-} (1)

M^{3+} stronger than or displaces H_2CO_3 or more H_3O^+ so can react with CO_3^{2-} (1)

or eqⁿ showing $\text{CO}_3^{2-} \rightarrow \text{CO}_2$

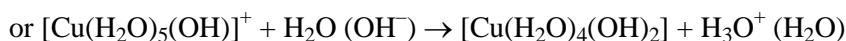
12

(b) green ppt is $[\text{Cu}(\text{H}_2\text{O})_5(\text{OH})]^+$ or $[\text{Cu}(\text{H}_2\text{O})_5(\text{OH})]_2\text{SO}_4$ (1)



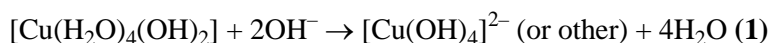
OH^- removes H_3O^+ or pushes eqⁿ to RHS (1)

blue ppt is $[\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2]$ (1)



OH^- removes H_3O^+ or pushes eqⁿ to RHS (1)

blue solution is $[\text{Cu}(\text{OH})_4]^{2-}$ or $[\text{Cu}(\text{OH})_4(\text{H}_2\text{O})_2]^{2-}$ or $[\text{Cu}(\text{OH})_3(\text{H}_2\text{O})_3]^-$ (1)



substitution or amphotericism or must be an ion (1)

Max 8

[20]