

Revision Sheet

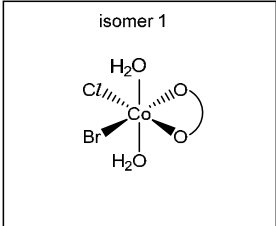
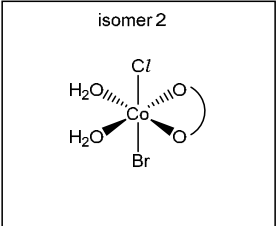
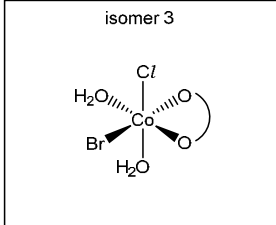
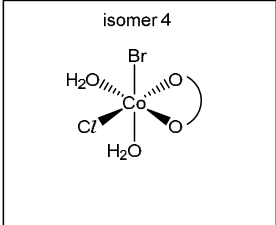
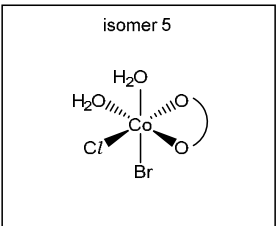
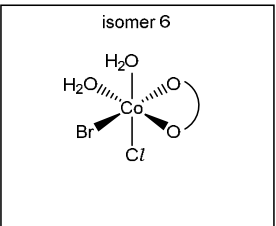
A-Level Chemistry · Unit 28 Chemistry of transition elements

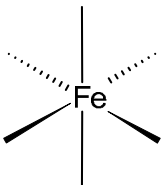
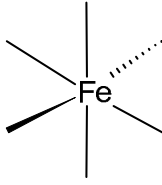
6 vocabulary items · 59 marks of exam questions (4 questions)

Part 1 · Vocabulary review answer key. Section A wants the exact English spelling.

Question	Answer	Marks
1	ligand	1
2	transition element	1
3	oxidation state	1
4	complex ion	1
5	monodentate	1
6	complex	1

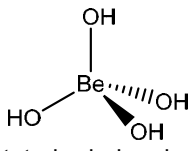
7(a)	<i>Any two from:</i> <ul style="list-style-type: none">• they have variable / multiple oxidation states OWTTE• they behave as catalysts• they form complex ions / complexes• they form coloured compounds/ions																			
7(b)(i)	(is a molecule or ion formed by a central) metal atom / metal ion bonded / surrounded by (one or more) ligands																			
7(b)(ii)	<table><tr><td>reagent added</td><td>formula of species formed</td><td>colour / state of species formed</td><td>type of reaction</td></tr><tr><td>an excess of $\text{NH}_3(\text{aq})$</td><td>$[\text{Co}(\text{NH}_3)_6]^{2+}$</td><td>brown solution ALLOW <i>yellow-brown</i> solution</td><td>ligand exchange</td></tr><tr><td>an excess of concentrated HCl</td><td>$[\text{CoCl}_4]^{2-}$</td><td>blue solution</td><td>ligand exchange</td></tr><tr><td>$\text{NaOH}(\text{aq})$</td><td>$\text{Co}(\text{OH})_2$ OR $\text{Co}(\text{OH})_2(\text{H}_2\text{O})_4$</td><td>blue ppt. ALLOW pink ppt</td><td>precipitation</td></tr></table> <p>formula and colour / state: any two [1], any four [2], all six [3] type of reaction: all three correct [1]</p>				reagent added	formula of species formed	colour / state of species formed	type of reaction	an excess of $\text{NH}_3(\text{aq})$	$[\text{Co}(\text{NH}_3)_6]^{2+}$	brown solution ALLOW <i>yellow-brown</i> solution	ligand exchange	an excess of concentrated HCl	$[\text{CoCl}_4]^{2-}$	blue solution	ligand exchange	$\text{NaOH}(\text{aq})$	$\text{Co}(\text{OH})_2$ OR $\text{Co}(\text{OH})_2(\text{H}_2\text{O})_4$	blue ppt. ALLOW pink ppt	precipitation
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7(c)(i)	M1 (a species) that donates / uses two lone pairs M2 to form a two dative / coordinate bond to a metal atom / metal ion																			

7(c)(ii)	<p>Any four from:</p> <div style="display: flex; flex-wrap: wrap;"> <div style="width: 50%; text-align: center;"> <p>isomer 1</p>  </div> <div style="width: 50%; text-align: center;"> <p>isomer 2</p>  </div> <div style="width: 50%; text-align: center;"> <p>isomer 3</p>  </div> <div style="width: 50%; text-align: center;"> <p>isomer 4</p>  </div> <div style="width: 50%; text-align: center;"> <p>isomer 5</p>  </div> <div style="width: 50%; text-align: center;"> <p>isomer 6</p>  </div> </div> <p>Any two [1], any three [2], all four [3]</p>
7(c)(iii)	<p>oxidation state of cobalt (+)3 AND type of stereoisomerism cis-trans OR geometric(al) OR optical</p>

8(a)(i)	<p>donates one lone pair / forms one dative bond AND to metal atom / to metal ion [1]</p>
8(a)(ii)	<p>Mo(CO)₆ 0 / no charge / neutral / zero Fe(CN)₆ 3–</p> <p>both formulae [1] both charges [1]</p>
8(a)(iii)	<p>either of these renditions, with a CN on each bond:</p> <div style="display: flex; justify-content: space-around; align-items: center;">   </div> <p>AND</p> <p>180° bond angle between two opposite bonds [1]</p>
8(b)(i)	<p>$[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$</p> <p>OR</p> <p>$\text{Cu}^{2+} + 2\text{H}_2\text{O} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ [1]</p>
8(b)(ii)	<p>M1 d-orbitals split (could be in diagram) [1]</p> <p>M2 electrons transition to higher orbital / electrons promoted or excited [1]</p> <p>M3 wavelength / frequency / light / photon / hf / hn absorbed [1]</p> <p>M4 colour seen / reflected / transmitted is complement of colour absorbed [1]</p>

8(c)(i)	$[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4\text{HCl} \rightarrow \text{CuCl}_4^{2-} + 2\text{H}_2\text{O} + 4\text{NH}_4^+$ <p>OR</p> $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4\text{Cl}^- (+ 4\text{H}^+) \rightarrow \text{CuCl}_4^{2-} + 2\text{H}_2\text{O} + 4\text{NH}_3 (+ 4\text{H}^+)$ <p>M1 formula and charge of CuCl_4^{2-} [1]</p> <p>M2 rest of equation [1]</p>
8(c)(ii)	ligand exchange / substitution / replacement / displacement [1]
8(c)(iii)	tetrahedral [1]
8(c)(iv)	yellow [1]
8(c)(v)	d-orbital splitting changes / ΔE changes [1]

9(a)	a d-block element that forms one or more stable ions with incomplete d-orbitals			
9(b)(i)		geometry	CN	bond angle
	$[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$	octahedral	6	90 or 180
	$[\text{CuCl}_4]^{2-}$	tetrahedral	4	109 to 110
9(b)(ii)	degenerate – of the same energy non-degenerate – not of the same energy / different energy			
9(b)(iii)	different frequency / wavelength / photon absorbed			
9(c)(i)	forms 2 dative / coordinate bonds			
9(c)(ii)	one isomer correct with correct 3D [1] three isomers different with correct 3D [1]			
9(c)(iii)	e.g. 1 and 2 optical [1] e.g. 1 or 2 and 3 cis-trans / geometric [1]			
9(d)	0.0230 moles ethanedioate in whole 100 cm ³ 0.00575 moles ethanedioate in 25 cm ³ sample [1] 0.00230 moles of MnO_4^- needed [1] 230 cm ³ [1]			
9(e)	Cu^{2+} is smaller / has a smaller radius / than Ba^{2+} [1] Cu^{2+} polarises / distorts the anion more [1]			

10(a)	M1 ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative M2 ΔH_{hyd} changes less / becomes less exothermic by a smaller extent OR ΔH_{latt} changes more / dominant factor / changes faster M3 ΔH_{sol} becomes more exothermic / more negative OR ΔH_{sol} becomes less endothermic / less positive																			
10(b)(i)	M1 $K_{\text{sp}} = [\text{Be}^{2+}][\text{OH}^-]^2$ M2 $\text{mol}^3 \text{dm}^{-9}$ ecf																			
10(b)(ii)	M1 solubility of $\text{Be}(\text{OH})_2 = 2.40 \times 10^{-6} / 43 = 5.58 \times 10^{-8} (\text{mol dm}^{-3})$ ecf (b)(i) M2 $K_{\text{sp}} = 4 \times (5.58 \times 10^{-8})^3 = 6.95 \times 10^{-22}$ ecf min 2sf																			
10(c)(i)	as a molecule or ion formed by a central metal atom / metal ion dative bonded to / surrounded by one or more ligands																			
10(c)(ii)	 tetrahedral and correct 3D structure																			
10(d)(i)	d orbitals that are energetically accessible OR empty / vacant d orbitals AND form dative bonds / accept a lone pair from a ligand																			
10(d)(ii)	<table><tr><th>complex ion</th><th>shape</th><th>coordination number</th><th>polarity</th></tr><tr><td>cis-[Pt(en)Cl₂]</td><td>square planar</td><td>4</td><td>polar</td></tr><tr><td>[Ag(NH₃)₂]⁺</td><td>linear</td><td>2</td><td>non-polar</td></tr><tr><td>[Fe(C₂O₄)₃]³⁻</td><td>octahedral</td><td>6</td><td>non-polar</td></tr></table>	complex ion	shape	coordination number	polarity	cis-[Pt(en)Cl ₂]	square planar	4	polar	[Ag(NH ₃) ₂] ⁺	linear	2	non-polar	[Fe(C ₂ O ₄) ₃] ³⁻	octahedral	6	non-polar			
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	three for one mark, six for two marks																			
10(e)(i)	the equilibrium constant for the formation of the complex ion in a solvent (from its constituent ions or molecules)																			
10(e)(ii)	M1 $K_{\text{stab}} = [\text{Ni}(\text{en})_3^{2+}] / [\text{Ni}(\text{H}_2\text{O})_6^{2+}][\text{en}]^3$ M1 units = $\text{mol}^{-3} \text{dm}^9$ ecf																			
10(e)(iii)	the equilibria lie to the right / product side OR equilibrium 1 lies more to the right AND en complex is more stable / $[\text{Ni}(\text{en})_3]^{2+}$ is more stable																			