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)

Any two from:
- 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

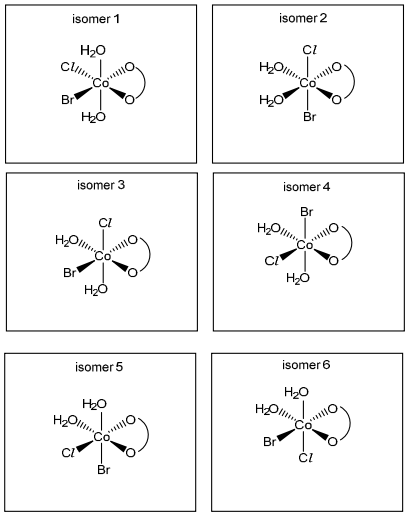
7(b)(ii)

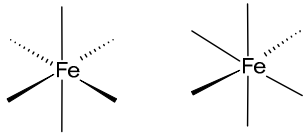
reagent added	formula of species formed	colour / state of species formed	type of reaction
an excess of $NH_3(aq)$	$[Co(NH_3)_6]^{2+}$	brown solution **ALLOW** *yellow-brown* solution	**ligand** exchange
an excess of concentrated HC*l*	$[CoCl_4]^{2-}$	blue solution	**ligand** exchange
NaOH(aq)	$Co(OH)_2$ **OR** $Co(OH)_2(H_2O)_4$	blue ppt. **ALLOW** pink ppt	precipitation

formula and colour / state: any two [1], any four [2], all six [3]
type of reaction: all three correct [1]

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)	*Any four from:*  Any two [1], any three [2], all four [3]
7(c)(iii)	oxidation state of cobalt (+)3 **AND** type of stereoisomerism cis-trans **OR** geometric(al) **OR** optical

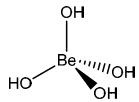
8(a)(i)	donates **one lone pair** / forms **one** dative bond **AND** to **metal atom** / to **metal ion** [1]
8(a)(ii)	$Mo(CO)_6$ 0 / no charge / neutral / zero $Fe(CN)_6$ 3– both formulae [1] both charges [1]
8(a)(iii)	either of these renditions, with a CN on each bond:  **AND** 180° bond angle between two opposite bonds [1]
8(b)(i)	$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$ **OR** $Cu^{2+} + 2H_2O + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}$ [1]
8(b)(ii)	M1 **d**-orbitals split (could be in diagram) [1] M2 electrons transition to higher orbital / electrons promoted or excited [1] M3 wavelength / frequency / light / photon / hf / hn absorbed [1] M4 colour seen / reflected / transmitted is complement of colour absorbed [1]

8(c)(i)	$[Cu(NH_3)_4(H_2O)_2]^{2+} + 4HCl \rightarrow CuCl_4^{2-} + 2H_2O + 4NH_4^+$ **OR** $[Cu(NH_3)_4(H_2O)_2]^{2+} + 4Cl^- (+ 4H^+) \rightarrow CuCl_4^{2-} + 2H_2O + 4NH_3 (+ 4H^+)$ M1 formula and charge of $CuCl_4^{2-}$ [1] M2 rest of equation [1]
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)	<table><tr><th></th><th>geometry</th><th>CN</th><th>bond angle</th></tr><tr><td>$[Cu(H_2O)_6]^{2+}$</td><td>octahedral</td><td>6</td><td>90 or 180</td></tr><tr><td>$[CuCl_4]^{2-}$</td><td>tetrahedral</td><td>4</td><td>109 to 110</td></tr></table>
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]

<table>
<tr><td>10(a)</td><td>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</td></tr>
<tr><td>10(b)(i)</td><td>M1 $K_{sp} = [Be^{2+}][OH^-]^2$
M2 $mol^3\ dm^{-9}$ ecf</td></tr>
<tr><td>10(b)(ii)</td><td>M1 solubility of $Be(OH)_2 = 2.40 \times 10^{-6} / 43 = 5.58 \times 10^{-8}$ $(mol\ dm^{-3})$ ecf (b)(i)
M2 $K_{sp} = 4 \times (5.58 \times 10^{-8})^3 = 6.95 \times 10^{-22}$ ecf min 2sf</td></tr>
<tr><td>10(c)(i)</td><td>as a molecule or ion formed by a central metal atom / metal ion dative bonded to / surrounded by one or more ligands</td></tr>
<tr><td>10(c)(ii)</td><td>
tetrahedral and correct 3D structure</td></tr>
<tr><td>10(d)(i)</td><td>d orbitals that are energetically accessible
OR empty / vacant d orbitals AND form dative bonds / accept a lone pair from a ligand</td></tr>
<tr><td>10(d)(ii)</td><td>
<table>
<tr><th>complex ion</th><th>shape</th><th>coordination number</th><th>polarity</th></tr>
<tr><td>cis-$[Pt(en)Cl_2]$</td><td>square planar</td><td>4</td><td>polar</td></tr>
<tr><td>$[Ag(NH_3)_2]^+$</td><td>linear</td><td>2</td><td>non-polar</td></tr>
<tr><td>$[Fe(C_2O_4)_3]^{3-}$</td><td>octahedral</td><td>6</td><td>non-polar</td></tr>
</table>
three for one mark, six for two marks
</td></tr>
<tr><td>10(e)(i)</td><td>the equilibrium constant for the formation of the complex ion in a solvent (from its constituent ions or molecules)</td></tr>
<tr><td>10(e)(ii)</td><td>M1 $K_{stab} = [Ni(en)_3^{2+}] / [Ni(H_2O)_6^{2+}][en]^3$
M1 units = $mol^{-3}\ dm^9$ ecf</td></tr>
<tr><td>10(e)(iii)</td><td>the equilibria lie to the right / product side OR equilibrium 1 lies more to the right
AND
en complex is more stable / $[Ni(en)_3]^{2+}$ is more stable</td></tr>
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