HL Paper 1

$[CoCl_6]^{3-}$ is orange while $[Co(NH_3)_6]^{3+}$ is yellow. Which statement is correct?

A. $[CoCl_6]^{3-}$ absorbs orange light.

B. The oxidation state of cobalt is different in each complex.

C. The different colours are due to the different charges on the complex.

D. The different ligands cause different splitting in the 3d orbitals.

Markscheme

D

Examiners report

[N/A]

Cobalt forms the complex $[Co(NH_3)_5Cl]^{2+}$. Which statements are correct for this complex?

I. The cobalt ion acts as a Lewis acid.

II. The cobalt ion has an oxidation number of +II.

III. There are 90° bond angles between the cobalt ion and the ligands.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

B

Examiners report

According to IUPAC, oxidation numbers are quoted in Roman numerals, oxidation states in Arabic. The nomenclature is clarified in the new syllabus, taught from September 2014.

Which ion is colourless?

A. $[Sc(H_2O)_6]^{3+}$

B. $[Cr(H_2O)_6]^{3+}$

C. $[Fe(H_2O)_6]^{3+}$

D. $[Fe(CN)_6]^{3-}$

Markscheme

A

Examiners report

[N/A]

Which complex has the greatest d orbital splitting?

	Complex	Oxidation state of metal	Colour of complex
A.	$[Fe(H_2O)_6]^{2+}$	+2	green
B.	$[Fe(H_2O)_6]^{3+}$	+3	orange
C.	$[Co(H_2O)_6]^{3+}$	+3	blue
D.	$[Cr(NH_3)_6]^{3+}$	+3	violet

Markscheme

B

Examiners report

[N/A]

Part of the spectrochemical series is shown for transition metal complexes.

$$I^- < Cl^- < H_2O < NH_3$$

Which statement can be correctly deduced from the series?

A. H_2O increases the p–d separation more than Cl^-.

B. H_2O increases the d–d separation more than Cl^-.

C. A complex with Cl^- is more likely to be blue than that with NH_3.

D. Complexes with water are always blue.

Markscheme

B

Examiners report

[N/A]

What is the charge on the iron(III) complex ion in $[Fe(OH)_2(H_2O)_4]Br$?

A. 0

B. 1+

C. 2+

D. 3+

Markscheme

B

Examiners report

[N/A]

What is the correct explanation for the colour of $[Cu(H_2O)_6]^{2+}$?

A. Light is absorbed when an electron moves to a d orbital of higher energy.

B. Light is released when an electron moves to a d orbital of higher energy.

C. Light is absorbed when electrons move from the ligands to the central metal ion.

D. Light is absorbed when electrons move between d and s orbitals.

Markscheme

A

Examiners report

[N/A]

The oxidation state of cobalt in the complex ion $[Co(NH_3)_5Br]^X$ is +3. Which of the following statements are correct?

I. The overall charge, *x*, of the complex ion is 2+.
II. The complex ion is octahedral.
III. The cobalt(III) ion has a half-filled d-subshell.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

A

Examiners report

[N/A]

Which complex is colourless in solution?

A. $[Fe(H_2O)_6]Cl_2$

B. $[Ni(NH_3)_6]Cl_2$

C. $[Zn(H_2O)_6](NO_3)_2$

D. $K_3[Co(CN)_6]$

Markscheme

C

Examiners report

[N/A]

Ammonia is a stronger ligand than water. Which is correct when concentrated aqueous ammonia solution is added to dilute aqueous copper(II) sulfate solution?

A. The d-orbitals in the copper ion split.

B. There is a smaller splitting of the d-orbitals.

C. Ammonia replaces water as a ligand.

D. The colour of the solution fades.

Markscheme

C

Examiners report

[N/A]

Which statements are correct about the complex $[Cu(NH_3)_2Cl_2]$?

I. Oxidation state of copper is +2.

II. Ammonia is a ligand.

III. Chloride ions act as Lewis acids.

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

A

Examiners report

Although several teachers had concerns about this one, overall it was a fair question with half the students answering it correctly. Surprisingly a quarter of the students incorrectly identified chloride ions acting as Lewis acids.

Which species have dative covalent bonding?

I. $[Fe(H_2O)_6]Cl_3$

II. NH_4^+

III. H_2O

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

A

Examiners report

[N/A]

Which electron transitions are responsible for the colours of transition metal compounds?

A. Between d orbitals and s orbitals

B. Among the attached ligands

C. From the metal ion to the attached ligands

D. Between d orbitals

Markscheme

D

Examiners report

[N/A]

Which species cannot act as a ligand?

A. $\mathrm{NH_4^+}$

B. $\mathrm{H_2O}$

C. $\mathrm{Cl^-}$

D. $\mathrm{OH^-}$

Markscheme

A

Examiners report

[N/A]

Which solutions have a pH less than 7?

I. $\mathrm{Na_2CO_3(aq)}$

II. $\mathrm{[Fe(H_2O)_6]Cl_3(aq)}$

III. $\mathrm{(NH_4)_2SO_4(aq)}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

C

Examiners report

[N/A]

What is the electron configuration of Sn^{2+}?

A. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^2$

B. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10}$

C. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 4d^{10} 5p^2$

D. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^8 5p^2$

Markscheme

B

Examiners report

[N/A]

Which best explains why transition metal complexes are coloured?

A. As electrons return to lower energy levels, light of a certain colour is emitted, and the complementary colour is observed.

B. As electrons return to lower energy levels, light of a certain colour is emitted, so the complex appears to have the same colour.

C. As electrons are promoted to higher energy levels, light of a certain colour is absorbed, and the complementary colour is observed.

D. As electrons are promoted to higher energy levels, light of a certain colour is absorbed, so the complex appears to have the same colour.

Markscheme

C

Examiners report

[N/A]

What is the abbreviated electron configuration of the cobalt(II) ion, Co^{2+}?

A. $[Ar]3d^7$

B. $[Ar]4s^2 3d^5$

C. $[Ar]4s^2 3d^7$

D. $[Ar]4s^1 3d^6$

Markscheme

A

Examiners report

[N/A]

Ligands can form dative covalent bonds with metal ions to form complex ions. Which of the following can act as a ligand?

I. Cl^-

II. NH_3

III. H_2O

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

D

Examiners report

[N/A]

Which metal nitrate solution is coloured?

A. $Zn(NO_3)_2(aq)$

B. $Ni(NO_3)_2(aq)$

C. $Mg(NO_3)_2(aq)$

D. $\mathrm{Sc(NO_3)_3(aq)}$

Markscheme

B

Examiners report

[N/A]

Which process is responsible for the colour of a transition metal complex?

A. The absorption of light when electrons move between s orbitals and d orbitals

B. The emission of light when electrons move between s orbitals and d orbitals

C. The absorption of light when electrons move between different d orbitals

D. The emission of light when electrons move between different d orbitals

Markscheme

C

Examiners report

[N/A]

In which complexes does iron have an oxidation number of $+3$?

I. $\mathrm{[Fe(H_2O)_6]^{3+}}$

II. $\mathrm{[Fe(H_2O)_5(CN)]^{2+}}$

III. $\mathrm{[Fe(CN)_6]^{3-}}$

A. I and II only

B. I and III only

C. II and III only

D. I, II and III

Markscheme

D

Examiners report

[N/A]

Which compound is likely to be colourless?

A. $[Zn(H_2O)_6]Cl_2$

B. $[NH_4]_2[Fe(H_2O)_6][SO_4]_2$

C. $K_3[Co(CN)_6]$

D. $[Ni(NH_3)_6][BF_4]_2$

Markscheme

A

Examiners report

[N/A]
