13.1 Transition Metals

Question Paper

Course	DP IB Chemistry
Section	13. The Periodic Table- Transition Metals (HL only)
Topic	13.1 Transition Metals
Difficulty	Medium

Time allowed: 70

Score: /55

Percentage: /100

Question 1a

a)
Explain why transition metals exhibit variable oxidation states compared to the elements in group 1.

[2 marks]

Question 1b

b)
Transition metal compounds and ions are often coloured. For example, $[Cr(H_2O)_6]^{3+}$ is green.

Explain why $[Cr(H_2O)_6]^{3+}$ and other complex ions are coloured.

[3 marks]

Question 1c

c)
Water acts as a ligand when it reacts with zinc and cobalt ions, forming the complexes $[Zn(H_2O)_4]^{2+}$ and $[Co(H_2O)_6]^{2+}$

Explain how water acts as a ligand in forming these complexes and predict the shape of $[Co(H_2O)_6]^{2+}$.

[3 marks]

Question 1d

d)
Explain why solutions containing $[Co(H_2O)_6]^{2+}$ are coloured but solutions containing $[Zn(H_2O)_4]^{2+}$ are not.

[4 marks]

Question 2a

a)
Complete **Table 1** below to show the oxidation state of the **transition element.**

Table 1

Ion	$[Cu(Cl_4)]^{2-}$	$[Fe(H_2O)_6]^{3+}$	$Cr_2O_7^{2-}$
Oxidation state			

[3 marks]

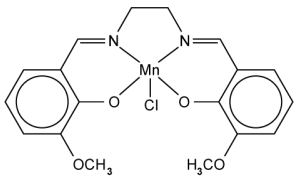
Question 2b

b)
Explain why chromium is the most paramagnetic element in the first transition series and why zinc is diamagnetic.

[3 marks]

Question 2c

c)
EUK-134 is a complex ion of manganese(III) used in skin care products to protect against UV damage as it has antioxidant properties.



i)
State the electron configuration of the manganese(III) ion in complex shown above

ii)
State the name given to species that bond to a central metal ion, and identify the type of bond present.

[3 marks]

Question 2d

d)
Transition metals have certain characteristic properties.

State **two** properties that are involved in EUK-134 rapidly decreasing the concentration of oxidising agents.

[2 marks]

Question 3a

a)
A characteristic property of transition elements, like chromium, is that they form coloured compounds. Using Section 17 of the Data Booklet, explain why $Ni^{2+}(aq)$ is green but $Sc^{3+}(aq)$ is colourless.

[5 marks]

Question 3b

b)
The colour intensity of solutions of complex ions is one method of determining the concentration of transition metal ions. Excess aqueous ammonia is sometimes added before measuring the absorption of copper(II) ions.

Describe why the addition of excess ammonia to aqueous copper(II) ions causes the shade of the blue colour to change.

[3 marks]

Question 3c

c)
Increasing the concentration of chloride ions in an aqueous solution of vanadium(III) chloride causes the vanadium complex to change from $[V(H_2O)_6]^{3+}$ to $[VCl(H_2O)_5]^{2+}$ to $[VCl_2(H_2O)_4]^{+}$

Outline what would happen to the wavelength at which the vanadium complex ions would absorb light as the concentration of chloride ions is increased, using Section 15 of the Data Booklet.

[2 marks]

Question 3d

d)
Ferrocyanide salts, $[Fe(CN)_6]^{4-}$, are used in the production of Prussian blue, which was the first modern synthetic pigment.

i)
Deduce the oxidation number of iron in $[Fe(CN)_6]^{4-}$

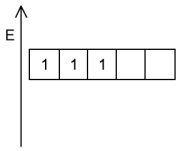
ii)
Draw the abbreviated orbital diagram for the **iron ion in $[Fe(CN)_6]^{4-}$** using the arrow-in-box notation to represent electrons.

[2 marks]

Question 4a

a)
The energy level diagram showing the electrons in the five 3d orbitals of a chromium atom is shown in the figure below.

Draw the completed diagram showing the d orbitals in $[Cr(H_2O)_6]^{3+}$ after splitting.



[1 mark]

Question 4b

a)
State and explain what happens to the splitting of the d orbitals if the ligand is changed from H_2O to NH_3.

[2 marks]

Question 4c

c)
Explain, in terms of acid-base theories, what type of a reaction is the formation of $[Fe(H_2O)_6]^{2+}$ from Fe^{2+} and water

[2 marks]

Question 4d

d)
The complex ion $[Ni(NH_3)_6]^{2+}$ is blue and $[Ni(H_2O)_6]^{2+}$ is green

Explain why the $[Ni(H_2O)_6]^{2+}$ complex ion is coloured and outline why changing the identity of the ligand changes the colour of the ion.

[4 marks]

Question 5a

a)
Dilute copper(II) chloride solution is light blue, while copper(I) chloride is colourless.

Describe how the blue colour is produced in the copper(II) chloride. Refer to Section 17 of the Data Booklet.

[4 marks]

Question 5b

b)
Explain why the copper(I) chloride is colourless.

[2 marks]

Question 5c

c)
When excess ammonia is added to copper(II) chloride solution, the dark blue complex ion, $[Cu(NH_3)_4(H_2O)_2]^{2+}$, forms.

State the molecular geometry of this complex ion, and the bond angles within it.

[2 marks]

Question 5d

d)
Outline the relationship between the Brønsted–Lowry and Lewis definitions of a base, referring to the ligands in the complex ion $[CuCl_4]^{2-}$.

[3 marks]