Unit 6 · Transition Metals

WORKSHEET

Full marks 33

Name _____ Class _____ Roll no. _____ Date _____ Marks _____ / 33

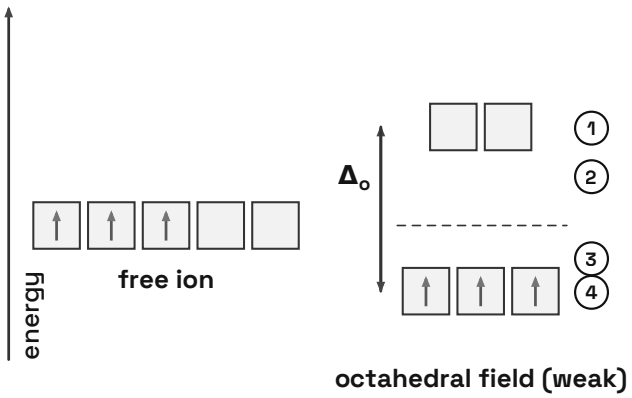
1 Key words [4]

Match each term in column A with its meaning in column B. Two meanings in column B are not needed. Each match carries 0.5 mark.

Column A		Column B
1. ligand	☐	**a.** the number of donor atoms bonded to the central metal
2. coordination number	☐	**b.** an atom, ion or molecule that gives a lone pair to a central metal in a complex
3. chelating ligand	☐	**c.** drawn into a magnetic field, because of unpaired electrons
4. paramagnetic	☐	**d.** the color of the light a solution absorbs
5. diamagnetic	☐	**e.** orbitals of the same energy
6. degenerate orbitals	☐	**f.** ligands in order of the splitting they cause
7. crystal field splitting energy	☐	**g.** a ligand that holds the metal in a ring through two or more donor atoms
8. spectrochemical series	☐	**h.** an element whose d subshell is completely full
		i. the energy gap between the t_{2g} and e_g sets of d orbitals
		j. with all its electrons paired, and not drawn into a magnetic field

2 Label the diagram [2]

The diagram shows how the d orbitals of Cr^{3+} split in an octahedral field. Write what belongs in place of 1 to 4. Each carries 0.5 mark.



1. _____ **2.** _____

3. _____ **4.** _____

3 Multiple choice [5]

Choose the correct option for each of the following questions.

i. The oxidation state of iron in potassium hexacyanidoferrate(II), $K_4[Fe(CN)_6]$, is: [1]

a. +3 **b.** +2

c. +4 **d.** −4

ii. What is the coordination number of cobalt in $[Co(en)_3]^{3+}$, where en is ethane-1,2-diamine? [1]

a. 3 **b.** 4

c. 6 **d.** 9

iii. The spin-only magnetic moment of V^{3+} (Z of V = 23) is about: [1]

a. 1.73 BM **b.** 2.83 BM

c. 3.87 BM **d.** 0 BM

iv. Which of these ligands splits the d orbitals of a metal ion the least? [1]

a. Cl^- **b.** H_2O

c. NH_3 **d.** CN^-

v. In the contact process for sulphuric acid, the transition metal compound used as the catalyst is: [1]

a. iron **b.** nickel

c. vanadium(V) oxide, V_2O_5 **d.** titanium(IV) chloride, $TiCl_4$

4 Short answers [7]

Write short answers to the following questions.

a. Write the IUPAC names of: a. $[Co(NH_3)_6]Cl_3$; b. $K_2[NiCl_4]$. [2]

b. Distinguish a high-spin complex from a low-spin complex, with one example of each. [2]

c. Write the electronic configurations of Mn^{2+}, Mn^{3+}, Fe^{2+} and Fe^{3+} (Z: Mn 25, Fe 26). Use them to explain why Mn^{2+} is more stable than Mn^{3+}, while Fe^{3+} is more stable than Fe^{2+}. [3]

5 Long answer [4]

Write a long answer to the following question.

What is a complex? Using tetraamminecopper(II) sulphate, $[Cu(NH_3)_4]SO_4$, explain the terms central metal ion, ligand, coordination number and coordination sphere. Classify ligands by the number of donor atoms, with one example of each kind.

6 Numerical problems [8]

Solve the following problems. Show your working. Take the spin-only formula $\mu = \sqrt{n(n+2)}$ BM; h = 6.626×10^{-34} J s, c = 3.00×10^{8} m s^{-1}, $N_A = 6.022 \times 10^{23}$ mol^{-1}; Z: Cr 24, Mn 25.

a. Compare $[Mn(H_2O)_6]^{2+}$ (water a weak-field ligand) with $[Mn(CN)_6]^{4-}$ (cyanide a strong-field ligand). **[4]**

i. Find the oxidation state of manganese, and its d configuration, in both.

ii. How many unpaired electrons does each have?

iii. Find the spin-only magnetic moment of each.

iv. Find the crystal field stabilization energy of each, in terms of Δ_o and the pairing energy P.

Answer:

b. The violet ion $[Cr(H_2O)_6]^{3+}$ absorbs light most strongly at 575 nm, by a d–d transition from t_{2g} to e_g. **[4]**

i. Find the energy of one photon of this light.

ii. Find Δ_o in kJ/mol.

iii. Find the crystal field stabilization energy of this ion in kJ/mol.

iv. Find its spin-only magnetic moment.

Answer: _____

7 Think **[3]**

Two complexes of cobalt(III) ($3d^6$) are $[CoF_6]^{3-}$, which is blue, and $[Co(NH_3)_6]^{3+}$, which is yellow-orange. Which of them splits the d orbitals more, and which absorbs light of the longer wavelength? Which one is paramagnetic? Explain.

8 Activity: Colors of metal salts (not marked)

In the laboratory, dissolve a little of each of these solids in water in a test tube, and fill in the table. Work out each metal ion's d configuration first.

Substance	Metal ion	d configuration	Color in water
Copper(II) sulphate crystals			
Zinc sulphate			
Nickel(II) sulphate			
Cobalt(II) chloride			
Potassium permanganate			

Which ions are colorless, and why? Why is permanganate deeply colored, though it has no d electrons?