Chemistry 104, Dr. Batterton
Help Sheet #10 – Chapter 22 – Coordination Chemistry
Tony Jacob

CHAPTER 22: COORDINATION CHEMISTRY

***Nuggets**: coordination compounds, ligands, metals, color wheel*

TRANSITION METALS

$ns^2(n-1)d^{1-10}$; when ionized, **s electrons** are removed first;

TRENDS:

Oxidation state: 1st row, typically +2 and +3 though there are many exceptions to this;
Common oxidation states: Ti^{+4}; Cr^{+3}, Cr^{+6}; Mn^{+2}, Mn^{+3}, Mn^{+7}; Fe^{+2}, Fe^{+3}; Co^{+2}, Co^{+3}; Ni^{+2}; Cu^{+}, Cu^{+2}; Zn^{+2}

Size (1^{st} row of transition metals; 3d row): large radii for first 3 elements, then decreases, then increases (see Fig. 7.9). Outer most electron shell determines atom size with the outer most shell being 4s. As electrons are added going from Sc to Zn, they populate the 3d subshell which does not increase the size of the atom since these orbitals are closer to the nucleus than the 4s subshell. However, the effective nuclear charge also increases because at the same time an electron is added, a proton is also added and the increasing Z_{eff} causes the shells to be pulled toward the nucleus. Near the end of the row, the atoms increase in size because there is more electron-electron repulsion which increases the size of the atom.

Density: Inversely tracks the atomic radii: small for first 3 elements, then larger, then smaller (Fig. 22.3)

Melting points (Fig 22.3)

COORDINATION COMPOUNDS: *Complex ion + counter ions*

Complex Ion: transition metal + ligands enclosed in brackets, [ ]

Central Metal: - the transition metals; act as Lewis Acids and accept e^- pairs from Lewis Bases (ligands)

Ligands: Lewis Bases which are atoms or groups of atoms that donate a pair of e^-

Dentate refers to how many sites around the metal the ligand occupies

Monodentate ligands: occupies 1 site; common ones: aqua = H_2O, carbonyl = CO, ammine = NH_3, cyano = CN^-, thiocyanate = SCN^-, fluoro, chloro, bromo, iodo = X^-, hydroxo = OH^-

Bidentate ligands: occupies 2 sites; oxalate (ox) = $C_2O_4^{-2}$; ethylenediammine (en) = $H_2NCH_2CH_2NH_2$

Tridentate ligands: occupies 3 sites; diethylenetriamine (dien) = $H_2NCH_2CH_2NHCH_2CH_2NH_2$

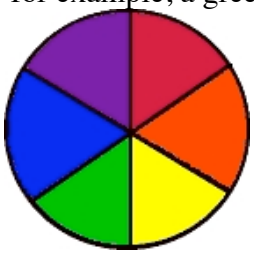
Hexadentate ligands: occupies 6 sites; ethylenediammine tetraacetic acid (EDTA)

Counter ions: the ions necessary to make the coordination compound neutral; placed in front of the complex ion if the counter ion is a cation, placed after the complex ion if the counter ion is an anion

Coordination numbers: the number of sites around a metal that ligands occupy (typically 2, 4, or 6)

Geometry: typical molecular shapes are octahedral (CN= 6), tetrahedral (CN = 4), and square planar (CN = 4)

Color wheel - The color that a substance appears and the color the substance absorbs are complementary (across from one another on the color wheel): for example, a green colored substance absorbs red light



---

1. What is the electronic configuration for each ion/atom? a. Mn^{5+} b. Zn c. Cu^{+} d. Mo^{2+}

2. Identify the metal, determine its oxidation number and electron configuration, list each ligand (L) present, identify the counter ion when one is present, determine the charge on the complex ion and the coordination number (CN) of the metal for each molecule below.
a. $[Ti(H_2O)_6]PO_4$ b. $K_4[Fe(CN)_6]$ c. $[Pt(NH_3)_2(H_2O)_2]Cl_2$ d. $[Fe(H_2O)_4Cl_2]Cl$
e. $[Cr(NH_3)_3ClBr_2]PO_4$ f. $K_2[CoCl_4]$

3. Many copper(II) compounds are blue or green in color. If a specific copper(II) compound, $CuSO_4 \cdot 5H_2O$ is blue, what color light is absorbed by this compound?

ANSWERS

1. a. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$ b. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10}$ c. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$
d. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 4d^4$

2. a. M = Ti; oxidation number = +3; L = H_2O; counter ion = PO_4^{-3}; complex ion charge = +3; CN = 6;

b. M = Fe; oxidation number = +2; L = CN^-; counter ion = K^+; complex ion charge = -4; CN = 6;

c. M = Pt; oxidation number = +2; L = H_2O and NH_3; counter ion = Cl^-; complex ion charge = +2; CN = 4;

d. M = Fe; oxidation number = +3; L = H_2O and Cl; counter ion = Cl^-; complex ion charge = +1; CN = 6;

e. M = Cr; oxidation number = +6; L = NH_3, Cl^-, Br^-; counter ion = PO_4^{-3}; complex ion charge = +3; CN = 6;

f. M = Co; oxidation number = +2; L = Cl^-; counter ion = K^+; complex ion charge = -2; CN = 4;

3. orange