9701 Chemistry Theory — Transition Metals

Alston

1 Introduction

My compiled notes for the transition metal section of the CAIE 9701 Chemistry course.

2 Transition Element Basics

Definition 2.1 – Transition Element A transition element is a d-block element that forms one or more stable ions with an incomplete d subshell.

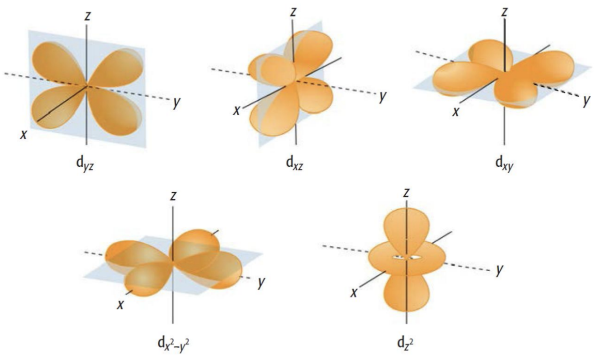
Notice that Scandium (Sc) and Zinc (Zn) are therefore **NOT** transition elements.

The variable oxidation states of the transition elements comes from the similar energy in the $3d$ and $4s$ orbitals, so there are many options of number of electrons to remove to end up at a stable ion.

For the transition metals, as they go across the row, the most common oxidation state becomes $+2$. This is due to the fact that the $3d$ sub electrons are more stable.

2.1 Cause of Colour

When ligands are attached to a transition element, the d-orbitals are split into two non-degenerate orbitals of different energy levels. Electrons absorb energy to jump up the orbital, and when they come down they release the excess energy in the form of light. The $d_{x^2-y^2}$ and d_{z^2} orbitals have different energy than the other 3.



5 different arrangements of d-orbitals.

3 Complex Ion Formation

Definition 3.1 – Ligands A species that contains a lone pair of electrons that forms a dative (coordinate) bond with a central transition element.

Definition 3.2 – Complex Ion A complex ion is an ion formed by a central transition element surrounded by one or more ligands.

Definition 3.3 – Coordination Number A coordination number of a complex ion is the number of dative bonds to the central transition element.

3.1 Isomerism

Complex ions can form geometric or optical isomers. Generally, optical isomers happen when a transition element is bonded to 3 bidentate ligands. The Cis-Trans isomers happen when there are more than one type of ligands bonded to a central atom.

4 Reactions: Redox and Ligand Exchange

Copper (Cu)		
$[Cu(H_2O)_6]^{2+}$	Blue	Octahedral
$[Cu(H_2O)_4(OH)_2]$	Blue ppt	Octahedral
$[CuCl_4]^{2-}$	Yellow/green	Tetrahedral
$[Cu(NH_3)_4(H_2O)_2]^{2+}$	Deep blue	Square planar/dist. octahedral
Cobalt (Co)		
$[Co(H_2O)_6]^{2+}$	Pink	Octahedral
$[CoCl_4]^{2-}$	Blue	Tetrahedral
$[Co(NH_3)_6]^{2+}$	Brown/	Octahedral
Nickel (Ni)		
$[Ni(H_2O)_6]^{2+}$	Green	Octahedral
$[Ni(NH_3)_6]^{2+}$	Violet	Octahedral
$[Ni(CN)_4]^{2-}$	Colourless	Square planar
Iron (Fe)		
$[Fe(H_2O)_6]^{2+}$	Pale green	Octahedral
$[Fe(H_2O)_6]^{3+}$	Yellow-brown	Octahedral
Chromium (Cr)		
$[Cr(NH_3)_6]^{3+}$	Purple	Octahedral

5 Stability Constants

K_{stab} is just another form of an equilibrium constant and it's calculated in the same way as the other ones. The higher a K_{stab} is, the more stable the complex ion.