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Pre-Health Post-Baccalaureate Program
Study Guide and Practice Problems

Course: CHM2046

Textbook Chapter: 23 (Silberberg 6e)

Topics Covered: Transition Elements

Created by Isaac Loy

1. What are the transition elements?

The transition elements are the elements in blocks *d* (transition metals) and *f* (inner transition elements) of the periodic table. These elements are metals, and cations of transition elements exist in many complex ions. Other shared characteristics include having multiple oxidation states and having color.

2. Electron configurations

Chromium and copper are exceptions to the normal electron configuration rules, because half-filled orbitals are relatively stable. In these two elements, a 4s electron moves to the 3d orbital such that both orbitals are half-filled (Cr) or such that the 4s orbital is half-filled and the 3d orbital is totally filled (Cu). To get a visual of this, look at the diagram below:

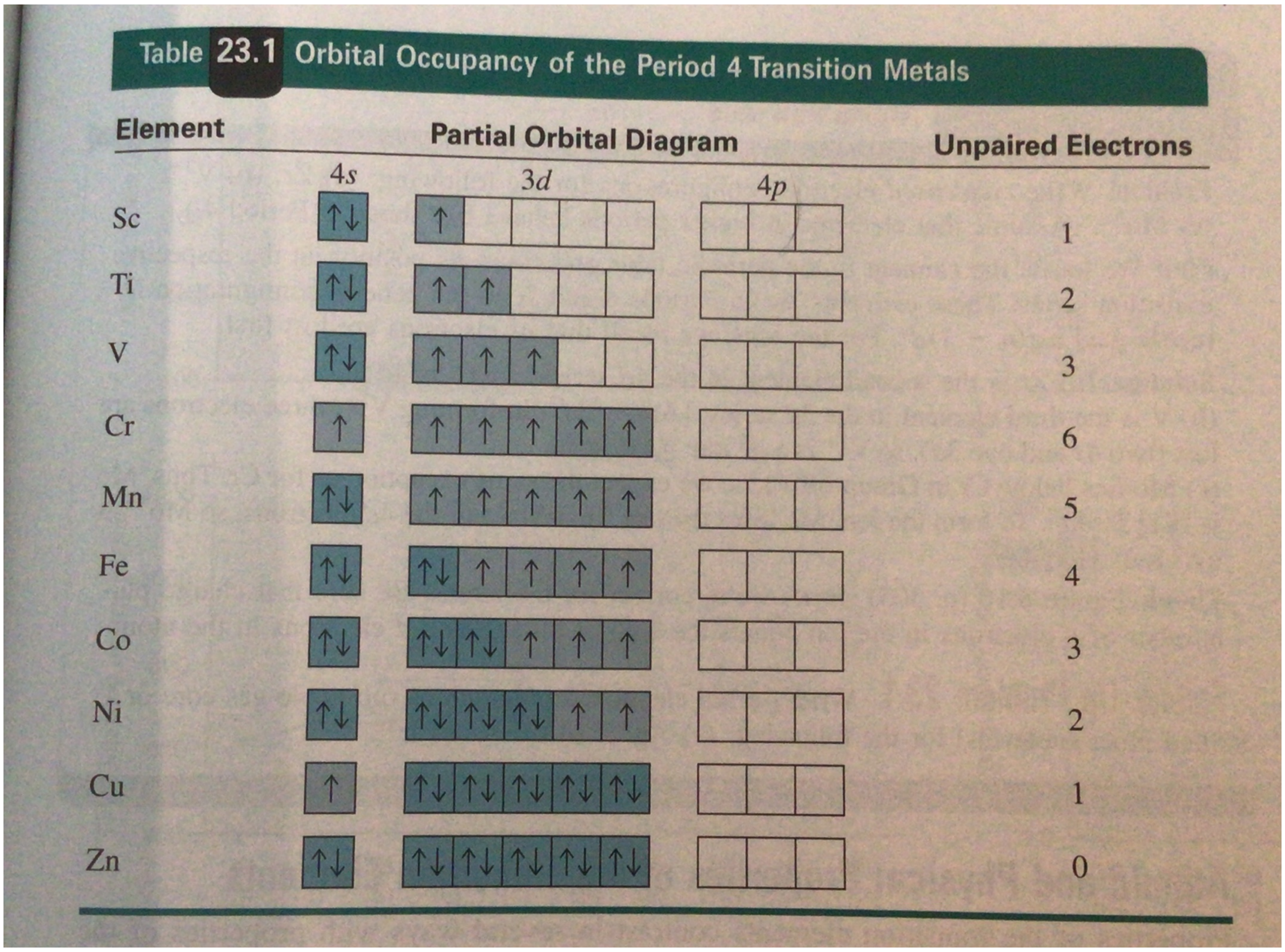

Table 23.1 Orbital Occupancy of the Period 4 Transition Metals

Element	4s	3d	4p	Unpaired Electrons
Sc	[↑↓]	[↑][ ][ ][ ][ ]	[ ][ ][ ]	1
Ti	[↑↓]	[↑][↑][ ][ ][ ]	[ ][ ][ ]	2
V	[↑↓]	[↑][↑][↑][ ][ ]	[ ][ ][ ]	3
Cr	[↑]	[↑][↑][↑][↑][↑]	[ ][ ][ ]	6
Mn	[↑↓]	[↑][↑][↑][↑][↑]	[ ][ ][ ]	5
Fe	[↑↓]	[↑↓][↑][↑][↑][↑]	[ ][ ][ ]	4
Co	[↑↓]	[↑↓][↑↓][↑][↑][↑]	[ ][ ][ ]	3
Ni	[↑↓]	[↑↓][↑↓][↑↓][↑][↑]	[ ][ ][ ]	2
Cu	[↑]	[↑↓][↑↓][↑↓][↑↓][↑↓]	[ ][ ][ ]	1
Zn	[↑↓]	[↑↓][↑↓][↑↓][↑↓][↑↓]	[ ][ ][ ]	0

When these metals ionize, they lose electrons and therefore gain a positive charge. Electrons lost come from the 4s orbital, <u>not</u> from the 3d orbital.

3. Periodic trends of transition elements

Atomic radius decreases overall but is not consistent across (L->R) a period in the transition series. Atomic radius increases from group 4 to 5, but relatively little for group 5 to 6.

Electronegativity increases overall but remains pretty constant across a period in the transition series. Electronegativity increases from group 4 to 5, but relatively little for group 5 to 6.

Ionization energy increases slightly overall across a period and down a group in the transition series.

This is largely a review, so if you desire a more in-depth explanation of periodic trends, view the CHM2045 Ch. 8.3 - 9.3 study guide posted under “current students” on the PHPB website.

4. Coordination compounds

Coordinate compounds or complexes involve complex ions and counter ions.

We previously talked briefly about complex ions (typically positively charged), and if you recall, complex ions contain a central transition metal cation bonded to ligands, which can be either anions or molecules.

Counter ions (typically negatively charged) are paired with complex ions such that the overall coordinate compound is neutral.

Look at the following coordinate compound:

$$[Co(NH_3)_6]Cl_3$$

Complex ion = $[Co(NH_3)_6]^{3+}$

Ligands = $(NH_3)_6$

Counter ions = $(Cl^-)_3$

Because there are six ammonia molecules bonded to our central transition metal cation, we say that the coordination number is six.

Knowing the coordination number of a complex ion helps us to understand its geometry. This is similar to what you previously learned with VESPR theory.

If the coordination number = 2, then the shape is linear.

If the coordination number = 4 and the metal ion is d8, then the shape is square planar.

If the coordination number = 4 and the metal ion is d10, then the shape is tetrahedral.

If the coordination number = 8, then the shape is octahedral.

Furthermore, ligands can be classified as monodentate, bidentate, or polydentate depending on how many connection or bonding points the ligand has with the central ion.

Monodentate means that only one atom in a ligand is bonded to the central cation.

Bidentate means that two atoms in a ligand are bonded to the central cation.

Polydentate means that more than two atoms in a ligand are bonded to the central cation.

5. Isomerism

Because it would be very difficult for me to draw accurate 3-D models of coordinate compounds to demonstrate isomerism, take a look at the video linked below for a good visual representation:

https://youtu.be/AVghzbJHwHM

Problems

1. Which of the following is true about transition metals?

A) They have low melting points
B) They have low boiling points
C) They often form paramagnetic compounds
D) They have high radius to charge ratios
E) They are often colorless

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Ti : $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$

Ti^{2+} : $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2$

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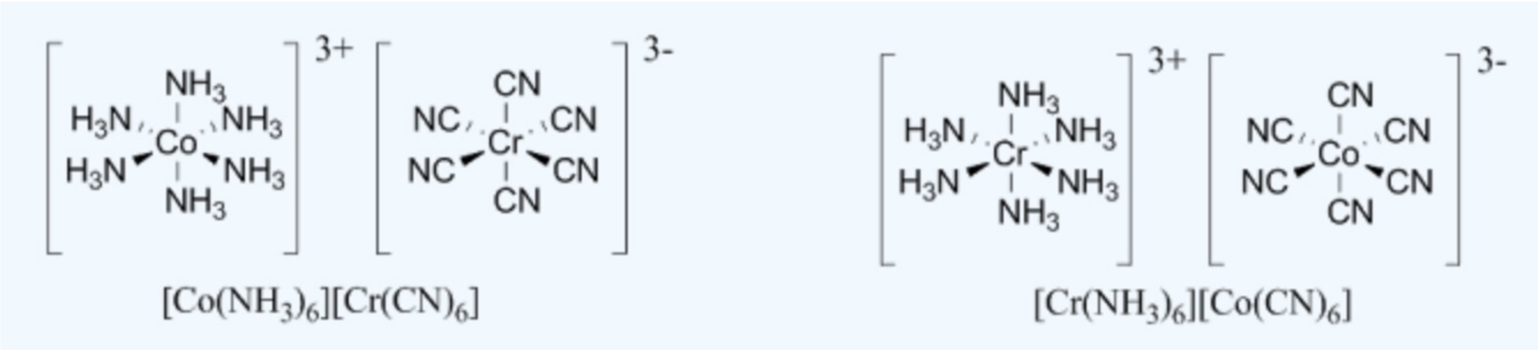
$CoBr_2$ – the lightest element in the group (Co) is the most likely to form stable compounds in lower oxidation states.

4. What kind of isomerism is on display below?



A) Coordination isomerism
B) Linkage isomerism
C) Ionization isomerism
D) Geometrical isomerism
E) These are not isomers

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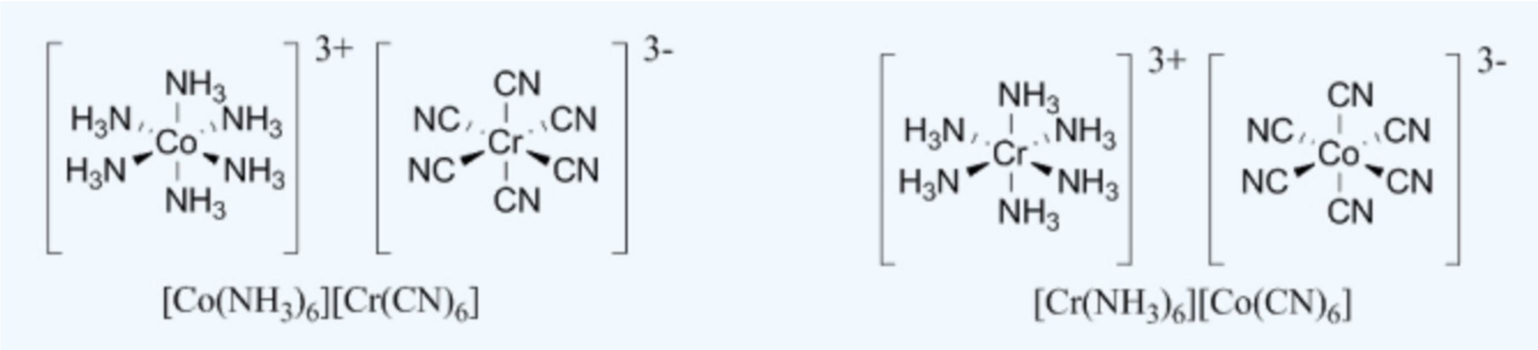

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