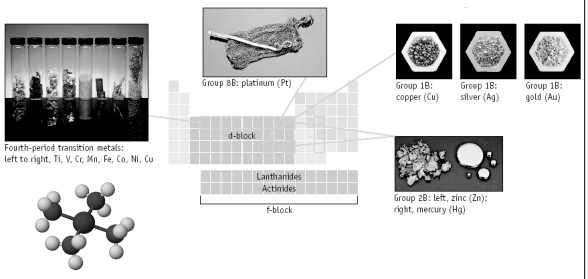
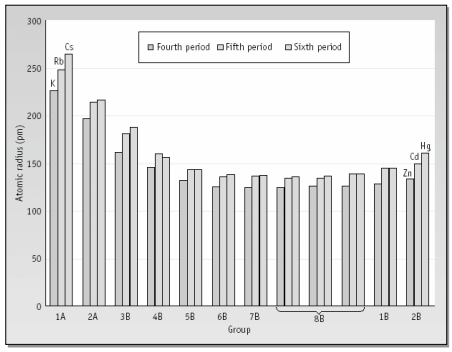
1

Transition Metal Chemistry



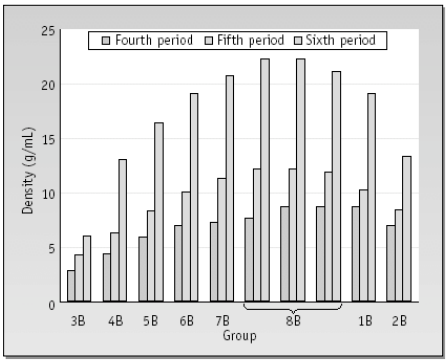
2

Periodic Trends: Atom Radius



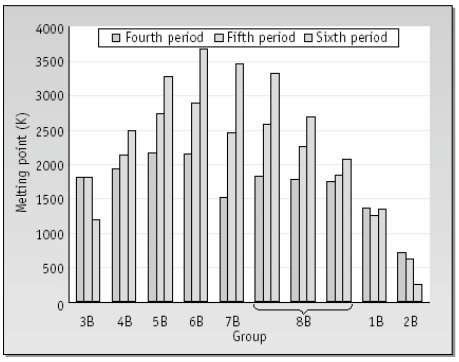
3

Periodic Trends: Density



4

Periodic Trends: Melting Point



5

Transition Metal Chemistry

(a) Paint pigments: yellow, CdS; green, Cr_2O_3; white, TiO_2 and ZnO; purple, $Mn_3(PO_4)_2$; blue, Co_2O_3 and Al_2O_3; ochre, Fe_2O_3.

(c) Traces of transition metal ions are responsible for the colors in purple amethyst (iron), green jade (iron), red corundum (chromium), and blue lapis lazuli and turquoise (copper).

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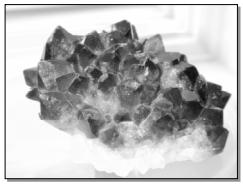
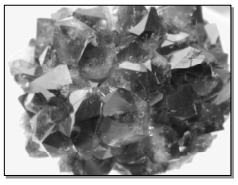
Gems & Minerals





Citrine and amethyst are quartz (SiO_2) with a trace of cationic iron that gives rise to the color.

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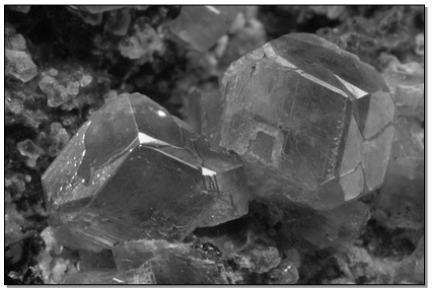
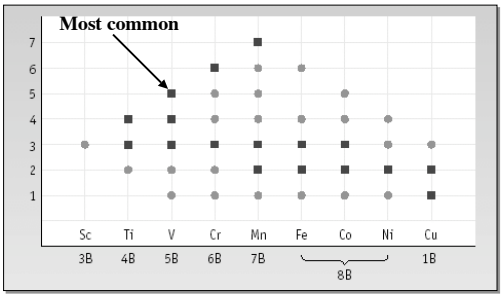
Gems & Minerals



Rhodochrosite, $MnCO_3$

8

Periodic Trends: Oxidation Numbers



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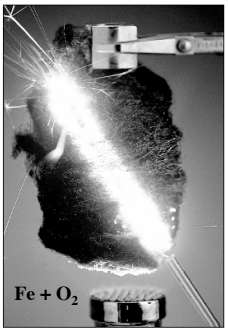
Reactions: Transition Metals

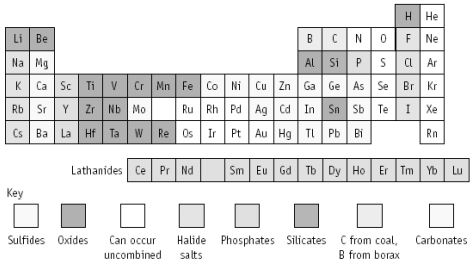


$Fe + Cl_2$

Fe + HCl

10

Metallurgy: Element Sources



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Pyrometallurgy

- **Involves high temperature, such as Fe**
- **C and CO used as reducing agents in a blast furnace**
- **$Fe_2O_3 + 3\ C \rightarrow 2\ Fe + 3\ CO$**
- **$Fe_2O_3 + 3\ CO \rightarrow 2\ Fe + 3\ CO_2$**
- **Lime added to remove impurities, chiefly SiO_2**

  $SiO_2 + CaO \rightarrow CaSiO_3$
- **Product is impure cast iron or pig iron**

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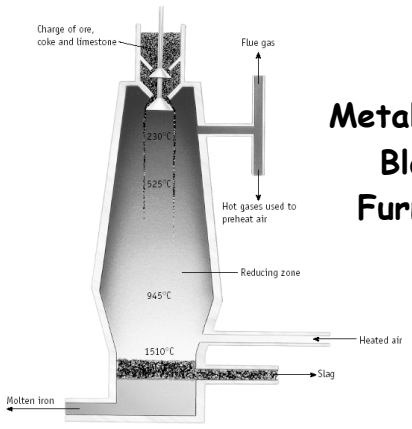
Metallurgy: Blast Furnace



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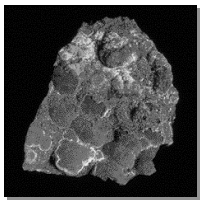
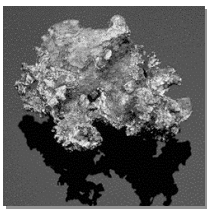
Metallurgy: Copper Ores



Azurite, $2CuCO_3 \cdot Cu(OH)_2$



Native copper

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Metallurgy: Hydrometallurgy

- **Uses aqueous solutions**
- **Add $CuCl_2$(aq) to ore such as $CuFeS_2$ (chalcopyrite)**
  $CuFeS_2$ (s) + 3 $CuCl_2$ (aq) --> 4 CuCl(s) + $FeCl_2$ (aq) + 2 S(s)
- **Dissolve CuCl with xs NaCl**
  CuCl(s) + Cl^-(aq) --> $[CuCl_2]^-$
- **Cu(I) disproportionates to Cu metal**
  2 $[CuCl_2]^-$ --> Cu(s) + $CuCl_2$ (aq) + 2 Cl^-

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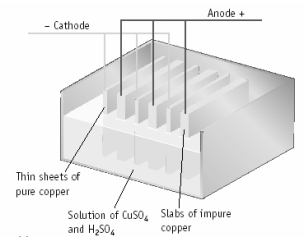
Electrolytic Refining of Cu



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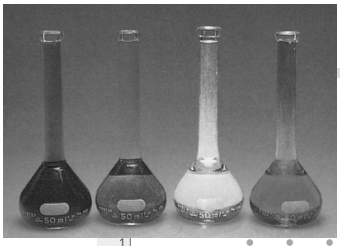
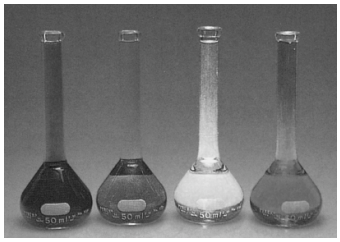
Transition Metal Chemistry



Chem of transition metal is largely redox chemistry

17

Transition Metal Chemistry



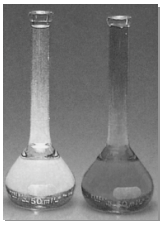
$Co(H_2O)_6^{2+}$ $Ni(H_2O)_6^{2+}$ CrO_4^{2-} $Cr_2O_7^{2-}$

_____ _____ _____ _____

Oxidation number of the metal ion?

18

Chromium Chemistry



_____ + ___ CrO_4^{2-} $\rightleftharpoons$ $Cr_2O_7^{2-}$ + _____

What type of reaction?

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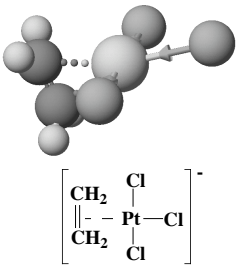
Coordination Chemistry

- **Coordination compounds**
  - **combination of two or more atoms, ions, or molecules where a bond is formed by sharing a pair of electrons originally associated with only one of the compounds.**



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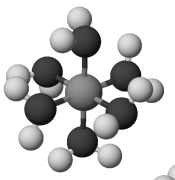
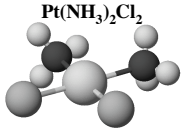
Coordination Chemistry

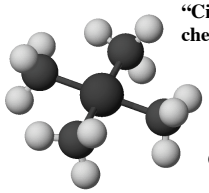


$Co(H_2O)_6^{2+}$

$Pt(NH_3)_2Cl_2$



"Cisplatin" - a cancer chemotherapy agent



$Cu(NH_3)_4^{2+}$

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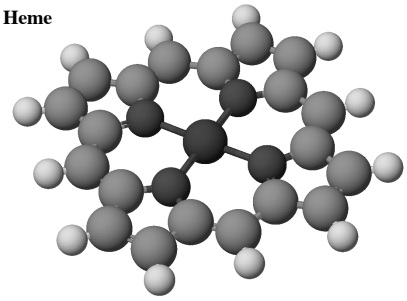
Coordination Chemistry

Heme



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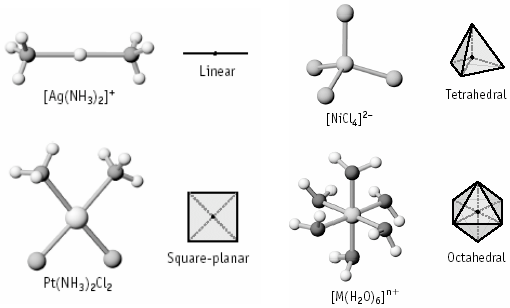
Structures of Coordination Compounds



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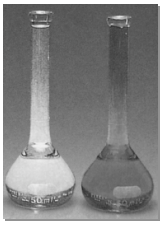
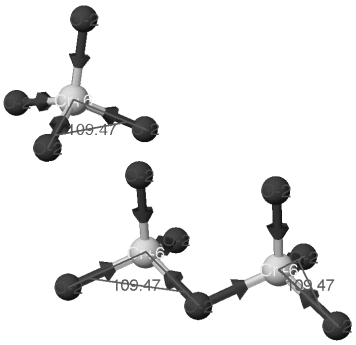
Structures of Chromate Ions





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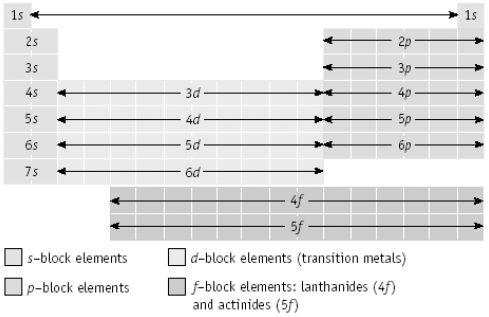
Electron Configurations and the Periodic Table



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Transition Element Configurations

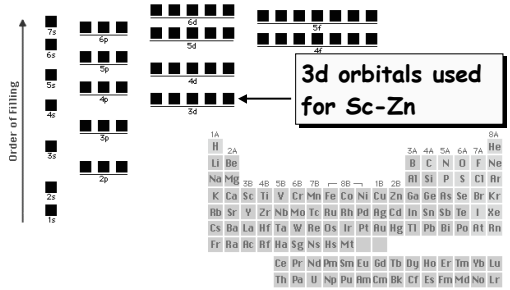

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Table 8.4 Orbital Box Diagrams for the Elements Ca Through Zn

		3d	4s
Ca	$[Ar]4s^2$		↑↓
Sc	$[Ar]3d^14s^2$	↑	↑↓
Ti	$[Ar]3d^24s^2$	↑ ↑	↑↓
V	$[Ar]3d^34s^2$	↑ ↑ ↑	↑↓
Cr*	$[Ar]3d^54s^1$	↑ ↑ ↑ ↑ ↑	↑
Mn	$[Ar]3d^54s^2$	↑ ↑ ↑ ↑ ↑	↑↓
Fe	$[Ar]3d^64s^2$	↑↓ ↑ ↑ ↑ ↑	↑↓
Co	$[Ar]3d^74s^2$	↑↓ ↑↓ ↑ ↑ ↑	↑↓
Ni	$[Ar]3d^84s^2$	↑↓ ↑↓ ↑↓ ↑ ↑	↑↓
Cu*	$[Ar]3d^{10}4s^1$	↑↓ ↑↓ ↑↓ ↑↓ ↑	↑
Zn	$[Ar]3d^{10}4s^2$	↑↓ ↑↓ ↑↓ ↑↓ ↑↓	↑↓

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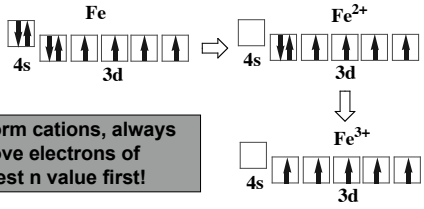
Ion Configurations

To form cations from elements remove 1 or more e- from subshell of highest n [or highest (n + l)].

Fe [Ar] $4s^2$ $3d^6$

loses 2 electrons ---> Fe^{2+} [Ar] $4s^0$ $3d^6$



To form cations, always remove electrons of highest n value first!

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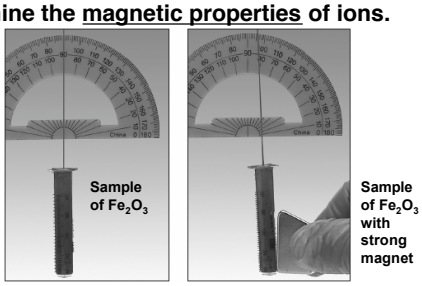
Ion Configurations

How do we know the configurations of ions?
Determine the magnetic properties of ions.



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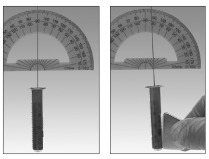
Ion Configurations

How do we know the configurations of ions?
Determine the magnetic properties of ions.

Ions with UNPAIRED ELECTRONS are PARAMAGNETIC.

Without unpaired electrons DIAMAGNETIC.



Fe^{3+} ions in Fe_2O_3 have 5 unpaired electrons and make the sample paramagnetic.

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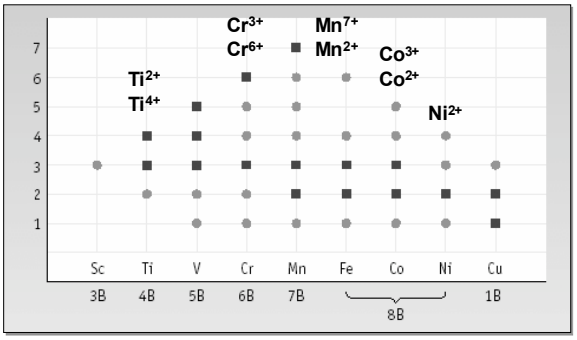
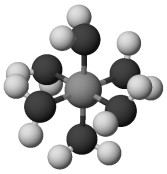
Electron Configs and Structure



Electron Configs and Structure

Ti^{2+}
Cr^{3+}
Mn^{2+}
Co^{3+}
Co^{2+}
Ni^{2+}



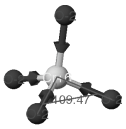
$Co(H_2O)_6^{2+}$

These ions tend to have an octahedral coordination geometry (or square planar.)

Ti^{4+}
Mn^{7+}
Cr^{6+}

All are d^0 ions

These ions (and d^{10} atoms or ions) tend to have an tetrahedral coordination geometry



$TiCl_4$
MnO_4^-
CrO_4^{2-}
$Ni(CO)_4$