

Inorganic Chemistry

What is inorganic chemistry? All of the chemistry not covered in carbon-centered organic and biochemistry—the remaining 90 or so elements!

PERIODIC TABLE OF THE ELEMENTS

Periodic Table

1. Elemental Forms

- Monatomic** - Noble Gases: helium, neon, argon, krypton, xenon, radon; non-reactive
- Diatomic molecules**
Gas: fluorine, chlorine, hydrogen, oxygen, nitrogen
Liquid: bromine Solid: iodine
- Molecular solid**: sulfur
- Covalent solid**: carbon (diamond), graphite
- Metals**: most common type of element
- High coordination numbers; very dense
- Delocalized electrons form energy bands

2. Types of Compounds: large variety due to the "ionic-covalent-metallic" range

- Ionic**: electron exchange
- Covalent**: shared electrons
- Polar covalent**: unequal sharing
- Ion complex**: central ion + solvent
- Transition metal compounds**
- Coordination compound: non-bonding ligands
- Organometallic: metal-C bond
- Complex inorganic**: metal oxides and silicates

3. Periodicity: chemical properties of an element depend on valence electrons Family of elements: columns in Periodic Table

Periodic Trends

- Chemistry determined by **valence electrons**
- Atoms or ions get a bit larger as you go down the column; electronic shells are added
- Cation and anion **charge** decrease

REACTIONS

Inorganic = many types of reactions

- Acid-base neutralization**
- Dissolution of electrolytes in water**
- Oxidation**: loss of electrons, add oxygen
- Reduction**: gain of electrons, remove oxygen

TIP: Remember the acronym, OILRIG

- Precipitation**: dissolved ions form solids
- Hydrolysis**: water reacts with a compound
- Decomposition** of compounds to elements

CHEMISTRY OF THE METALS

1. Group I: Alkali Metals

- Configuration**: noble gas + 1 electron, only valence: +1
- Natural occurrence**: occur salts, oxide minerals
- Common magnetic**: strong base (NaOH, KOH); ionic salts (NaCl, KCl); soluble carbonate, nitrate, sulfate
- Reactions**: pure metals react violently with water; never found in nature as pure metal
 $2Na + 2H_2O \rightarrow 2NaOH(aq) + H_2(g)$
- Spontaneous electrolysis** of molten salts
 $NaCl(l) \rightarrow Na(l) + Cl_2(g)$
- Solubility**: water forms cage $M \cdot H_2O$
Hydration: M : 4 (Li^+) to 6 (Ca^+)
Hydration energy: varies free ion and water

2. Group II: Alkaline Earth Metals

- Configuration**: filled s-subshell, only valence: +2
- Natural occurrence**: mineral carbonates, silicates, ocean salts
- Reactions**:
 $Ca(s) + 2H_2O \rightarrow Ca(OH)_2(aq) + H_2(g)$

3. 1st Transition Series: Ti-Cu

Ti	V	Cr	Mn	Fe	Co	Ni	Cu
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- Configuration**: partially filled d-subshell; diverse chemical and electronic properties
- Periodic Trends**: electronegativity fairly constant; electrons obey Hund's Rule; density increases with Z
- Ligand Field Effect**: split d-orbitals stabilize

APP: white paint pigment



$TiCl_3 + R-OH \rightarrow$ metal alkoxides

APP: attach organic groups to inorganic solids

EX: Manganese Chemistry

Valence ranges from 0 to 7, d⁵ to d⁰

Potassiumate: MnO_4^- , oxidizing agent

$Mn(VII)$ easily reduced

4. 2nd & 3rd Transition Series: Zr-Au

Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag
Hf	Ta	W	Re	Os	Ir	Pt	Au

- Configuration**: comparable to the 1st transition series
- Trends in radii**: "lanthanide contraction"
- minimal change in radii for large Z; weak screening from f-orbitals
- M-M multiple bonds**: 2nd and 3rd series cluster compounds; delta (δ) bond, face-face d-orbitals

delta bond



EX: Tetraammine of Mn , Rh & Re

d. Complex molecular structure: NH_4^+ exists as a tetrahedron

#47 Silver: normally a non-reactive metal
Silver reacts with S $\rightarrow$ Ag_2S - silver tarnish
 $Ag_2O + heat \rightarrow Ag$

#42 Molybdenum

Quadruple M-M bond

Molybdenum $Mo_2Cl_8^{4-}$

tetrahedral - no lone pairs

Hallide: MoF_6 , dimer - Mo_2F_{10}



#43 Technetium: synthetic element

5. Platinum Metals: Rh, Os, Ru, Ir, Pd, Pt

- Oxidation state** (0-6); oxygenation platinum
APP: catalysts for hydrogenation; catalytic converter

6. Scandium, Yttrium, Lanthanum & the Lanthanides

- Lanthanide**: element with occupied f-subshell

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R. B. Heslop



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