INORGANIC CHEMISTRY CHEAT SHEET

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1. Periodic Trends & Effective Nuclear Charge

Slater's Rules for Effective Nuclear Charge (Z^*):

$$Z^* = Z - S$$

where S is the shielding constant:

- Electrons in same group (ns, np): count 0.35 each (0.30 for $1s$).
- Electrons in $(n-1)$ shell: count 0.85 each.
- Electrons in $(n-2)$ or lower shells: count 1.00 each.
- For d or f electrons: same group 0.35, lower groups 1.00.

General Periodic Trends:

- **Atomic Radius:** Increases down, decreases across →.
- **Ionization Energy (IE):** Increases across →, decreases down. *Exceptions:* $IE_1(\text{Be}) > IE_1(\text{B})$ ($2s^2$ vs $2p^1$), $IE_1(\text{N}) > IE_1(\text{O})$ (half-filled $2p^3$).
- **Electron Affinity (EA):** Most negative for Halogens. Cl > F due to inter-electronic repulsion in compact $2p$ of F.
- **Electronegativity (χ):** F(4.0) > O(3.5) > N/Cl(3.0) > Br(2.8) > C/S/I(2.5) > H/P(2.1).

2. VSEPR Theory & Geometries

Steric Number (SN):

$$\text{SN} = \frac{1}{2}[V + M - C + A]$$

V: valence e^-, M: monovalent atoms, C: cationic charge, A: anionic charge.

SN	bp	lp	Geometry	Example
2	2	0	Linear (180°)	$BeCl_2, CO_2$
3	3	0	Trig. Planar (120°)	BF_3
3	2	1	Bent (< 120°)	SO_2, NO_2^-
4	4	0	Tetrahedral (109.5°)	CH_4, NH_4^+
4	3	1	Trig. Pyramidal	NH_3, PCl_3
4	2	2	Bent (104.5°)	H_2O, OF_2
5	5	0	Trig. Bipyramidal	PCl_5
5	4	1	Seesaw	SF_4
5	3	2	T-shaped	ClF_3
5	2	3	Linear	XeF_2, I_3^-
6	6	0	Octahedral (90°)	SF_6
6	5	1	Sq. Pyramidal	BrF_5
6	4	2	Sq. Planar	XeF_4

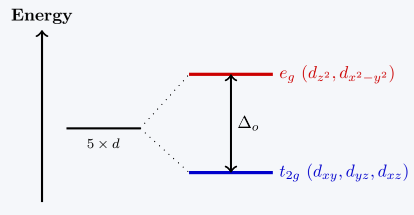
Bent's Rule: More electronegative substituents prefer hybrid orbitals with **less** s-character (axial positions in TBP). Lone pairs prefer orbitals with **more** s-character (equatorial positions in TBP).

3. Coordination Chemistry & CFT

Crystal Field Splitting (Δ):

- **Octahedral (O_h):** d-orbitals split into t_{2g} (d_{xy}, d_{yz}, d_{xz}) at $-0.4\Delta_o$ and e_g $(d_{z^2}, d_{x^2-y^2})$ at $+0.6\Delta_o$.
- **Tetrahedral (T_d):** Inverted splitting: e lower ($-0.6\Delta_t$), t_2 higher ($+0.4\Delta_t$).

$$\Delta_t = \frac{4}{9}\Delta_o$$



Spectrochemical Series (Weak to Strong Field):

$I^- < Br^- < S^{2-} < SCN^- < Cl^- < F^- < OH^- < C_2O_4^{2-} < H_2O$

Magnetic Moment (μ_s):

$$\mu_s = \sqrt{n(n+2)}\ \text{B.M.} \quad (n = \text{number of unpaired } e^-)$$

Jahn-Teller Distortion: Occurs when degenerate orbitals are unsymmetrically occupied (strongest in high-spin d^4, low-spin d^7, d^9 in O_h).

4. Industrial Processes & Main Group

Key Chemical Processes:

- **Haber-Bosch Process (Ammonia):**

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \quad \Delta H = -92 \text{ kJ/mol}$$

Cat: Fe with K_2O/Al_2O_3 promoter $(450°C, 200 \text{ atm})$.

- **Contact Process (Sulfuric Acid):**

$$2SO_2 + O_2 \xrightarrow{V_2O_5, 450°C} 2SO_3$$

$$SO_3 + H_2SO_4 \rightarrow H_2S_2O_7 \xrightarrow{H_2O} 2H_2SO_4$$

- **Ostwald Process (Nitric Acid):**

$$4NH_3 + 5O_2 \xrightarrow{Pt/Rh, 500K} 4NO + 6H_2O$$

- **Solvay Process (Soda Ash):**

$$NaCl + NH_3 + CO_2 + H_2O \rightarrow NaHCO_3 \downarrow + NH_4Cl$$

$$2NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O + CO_2$$

5. Metallurgy & Ellingham Diagrams

Principles of Metallurgy:

- **Calcination:** Heating in absence of air (carbonates $\rightarrow$ oxides).
- **Roasting:** Heating in excess air (sulfides $\rightarrow$ oxides).
- **Zone Refining:** Based on principle that impurities are more soluble in molten metal than solid (Si, Ge).
- **Mond Process (Ni):** $Ni + 4CO \xrightarrow{330K} Ni(CO)_4 \xrightarrow{450K} Ni + 4CO$.
- **Van Arkel Process (Zr, Ti):** $Zr + 2I_2 \rightarrow ZrI_4 \xrightarrow{1800K} Zr + 2I_2$.

Ellingham Diagram Guidelines:

- Plots $\Delta G°$ vs T for oxide formation.
- Slope $= -\Delta S°$. Positive slope for most metals $(M + O_2 \rightarrow MO)$.
- Any metal line **below** another can reduce the oxide of the upper metal at that temperature.

6. Qualitative Analysis & Flame Colors

Flame Test Colors:

- Li^+: Crimson Red Na^+: Persistent Yellow
- K^+: Lilac / Violet Ca^{2+}: Brick Red
- Sr^{2+}: Crimson Ba^{2+}: Apple Green
- Cu^{2+}: Blue-Green Pb^{2+}: Pale Blue

Qualitative Analysis Cation Groups:

- **Grp I** $(Pb^{2+}, Ag^+, Hg_2^{2+})$: Precipitate as Chlorides with dil. HCl.
- **Grp II** $(Cu^{2+}, Cd^{2+}, Bi^{3+}, Pb^{2+}, Hg^{2+})$: Precipitate as Sulfides in acidic H_2S.
- **Grp III** $(Fe^{3+}, Al^{3+}, Cr^{3+})$: Precipitate as Hydroxides with $NH_4OH + NH_4Cl$.
- **Grp IV** $(Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+})$: Precipitate as Sulfides in basic H_2S/NH_4OH.
- **Grp V** $(Ba^{2+}, Sr^{2+}, Ca^{2+})$: Precipitate as Carbonates with $(NH_4)_2CO_3$.

7. Organometallics & 18-Electron Rule

18-Electron Rule:

$$\text{Total Valence Electrons (TVE)} = \text{Metal Valence } e^- + \text{Ligand El}$$

Stable transition metal organometallic complexes usually have 18 electrons.

Common Ligand Electron Counts (Neutral Method):

- $1e^-$ donors: H, CH_3, Cl, Br, I
- $2e^-$ donors: $CO, PR_3, NH_3, H_2O, CH_2 = CH_2$
- $3e^-$ donors: η^3-allyl
- $4e^-$ donors: $1,3$-butadiene
- $5e^-$ donors: η^5-Cp (Cyclopentadienyl)
- $6e^-$ donors: η^6-benzene