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1. Periodic Trends & Atomic Properties

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- **Effective Nuclear Charge (Z_{eff})**: $Z_{eff} = Z - S$ (Slater's Rules)
- **Atomic Radius**: Decreases across period (left to right), increases down group.
- **Ionization Energy (IE)**: Increases across period, decreases down group.
  - *Anomalies*: $IE_1(\text{N}) > IE_1(\text{O})$ (half-filled p^3), $IE_1(\text{Be}) > IE_1(\text{B})$ (filled s^2).
- **Electron Affinity (EA)**: Cl ¿ F ¿ Br ¿ I (F has strong e^--e^- repulsion due to small size).
- **Electronegativity (Pauling Scale)**:

$$\Delta\chi = 0.102\sqrt{E_D(\text{A-B}) - \sqrt{E_D(\text{A-A}) \cdot E_D(\text{B-B})}}$$

2. Chemical Bonding & VSEPR Theory

Steric Number (SN) $= \frac{1}{2}[V + M - C + A]$

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- V = valence e^-, M = monovalent atoms, C = cation charge, A = anion charge.

SN	Hybrid	Geometry	Examples
2	sp	Linear	CO_2, $BeCl_2$
3	sp^2	Trigonal Planar	BF_3, NO_3^-
4	sp^3	Tetrahedral	CH_4, NH_4^+
4	dsp^2	Square Planar	$[PtCl_4]^{2-}$
5	sp^3d	Trig. Bipyramidal	PCl_5, SF_4 (See-saw
6	sp^3d^2	Octahedral	SF_6, $[Fe(CN)_6]^{3-}$
7	sp^3d^3	Pent. Bipyramidal	IF_7

Fajan's Rule (Covalent Character):

$$\text{Covalency} \propto \frac{\text{Cation Charge}}{\text{Cation Size}} \propto \text{Anion Size}$$

3. Molecular Orbital Theory (MOT)

Bond Order (B.O.) $= \frac{1}{2}(N_b - N_a)$

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- Higher B.O. *arrow* Higher Stability, Higher Bond Energy, Shorter Bond Length.
- **Mixing** ($Z \leq 7$, e.g., N_2):

$$\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < (\pi_{2p_x} = \pi_{2p_y}) < \sigma_{2p_z} < \dots$$

- **No Mixing** ($Z > 7$, e.g., O_2, F_2):

$$\sigma_{1s} < \sigma^*_{1s} < \sigma_{2s} < \sigma^*_{2s} < \sigma_{2p_z} < (\pi_{2p_x} = \pi_{2p_y}) < \dots$$

4. Coordination Chemistry

Crystal Field Splitting (CFT):

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- **Octahedral (Δ_o)**: t_{2g} set (3 orbitals, $-0.4\Delta_o$), e_g set (2 orbitals, $+0.6\Delta_o$).
- **Tetrahedral (Δ_t)**: $\Delta_t = \frac{4}{9}\Delta_o$.
- **Spectrochemical Series** (Weak to Strong Field): I^- ¡ Br^- ¡ S^{2-} ¡ Cl^- ¡ F^- ¡ OH^- ¡ H_2O ¡ NH_3 ¡ en ¡ CN^- ¡ CO
- **Spin-Only Magnetic Moment**:

$$\mu = \sqrt{n(n+2)}\ \text{BM} \quad (n = \text{unpaired } e^-)$$

5. Main Group Highlights (s & p Block)

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- **Inert Pair Effect**: Relativistic contraction of $6s^2$ electrons leading to lower oxidation states being more stable down group (e.g., $Pb^{2+} > Pb^{4+}$, $Tl^+ > Tl^{3+}$).
- **Boranes**: Wade's Rules (n = number of vertices):
  - *Closo*: $[B_nH_n]^{2-}$ ($n+1$ pairs)
  - *Nido*: $[B_nH_{n+4}]$ ($n+2$ pairs)
  - *Arachno*: $[B_nH_{n+6}]$ ($n+3$ pairs)
- **Oxoacids of Phosphorus**:
  - H_3PO_2 (Hypophosphorous): 1 P-OH, 2 P-H (Reducing)
  - H_3PO_3 (Phosphorous): 2 P-OH, 1 P-H (Diprotic)
  - H_3PO_4 (Orthophosphoric): 3 P-OH (Triprotic)

6. Principles of Extraction (Metallurgy)

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- **Calcination**: Heating in absence of air (Carbonates/Hydroxides *arrow* Oxides).
- **Roasting**: Heating in presence of excess air (Sulfides *arrow* Oxides).
- **Ellingham Diagram**: Plots ΔG° vs T. Lower lines reduce upper lines.
- **Refining Methods**:
  - *Mond's Process* (Ni): $\text{Ni} + {}_4\text{CO} \xrightarrow{330\text{K}} \text{Ni(CO)}_4 \xrightarrow{450\text{K}} \text{Ni} + {}_4\text{CO}$
  - *Van Arkel* (Zr, Ti): $\text{Ti} + {}_2\text{I}_2 \xrightarrow{523\text{K}} \text{TiI}_4 \xrightarrow{1700\text{K}} \text{Ti} + {}_2\text{I}_2$
  - *Zone Refining*: Si, Ge, Ga (based on fractional crystallization).

8. Qualitative Inorganic Analysis

Group	Cations	Group Reagent
Group I	Pb^{2+}, Ag^{+}, Hg_2^{2+}	Dilute HCl
Group II	Cu^{2+}, Pb^{2+}, Bi^{3+}, Cd^{2+}	H_2S in dil. HCl
Group III	Fe^{3+}, Al^{3+}, Cr^{3+}	$NH_4OH + NH_4Cl$
Group IV	Zn^{2+}, Mn^{2+}, Ni^{2+}, Co^{2+}	H_2S in NH_4OH
Group V	Ba^{2+}, Sr^{2+}, Ca^{2+}	$(NH_4)_2CO_3$
Group VI	Mg^{2+}, Na^{+}, K^{+}, NH_4^{+}	Direct/Specific Tests