1. Atomic Structure Periodic Trends

- **Effective Nuclear Charge (Z_{eff}):**

$$Z_{\text{eff}} = Z - S$$

where Z is the atomic number and S is the screening constant (Slater's rules).

- **Slater's Rules for S:**
  - For electrons in (ns, np): 0.35 each (except $1s$ which is 0.30).
  - For electrons in $(n-1)$ shell: 0.85 each.
  - For electrons in $(n-2)$ or lower: 1.00 each.
- **Periodic Trends (Left $\rightarrow$ Right, Top $\rightarrow$ Bottom)**:
  - Atomic Radius: Decreases $\rightarrow$, Increases $\downarrow$
  - Ionization Energy: Increases $\rightarrow$, Decreases $\downarrow$
  - Electron Affinity: Increases (more -ve) $\rightarrow$, Decreases $\downarrow$
  - Electronegativity: Increases $\rightarrow$, Decreases $\downarrow$

2. Chemical Bonding VSEPR

- **Formal Charge**:

$$\text{FC} = V - N - \frac{B}{2}$$

(V = valence electrons, N = non-bonding, B = bonding electrons).

- **Bond Order (MO Theory)**:

$$\text{Bond Order} = \frac{N_b - N_a}{2}$$

- **VSEPR Geometries**:
  - 2 Steric Number: Linear (180°)
  - 3 Steric Number: Trigonal Planar (120°)
  - 4 Steric Number: Tetrahedral (109.5°)
  - 5 Steric Number: Trigonal Bipyramidal ($90°, 120°$)
  - 6 Steric Number: Octahedral (90°)

3. Coordination Chemistry

- **Crystal Field Stabilization Energy (CFSE)**:

$$\text{CFSE} = [-0.4n(t_{2g}) + 0.6n(e_g)]\Delta_o + \text{P.E.}$$

- **Magnetic Moment (Spin-only)**:

$$\mu = \sqrt{n(n+2)}\ \text{BM}$$

where n is the number of unpaired electrons.

- **Isomerism**:
  - Structural: Ionization, Hydrate, Linkage, Coordination, Polymerization.
  - Stereoisomerism: Geometrical (cis/trans, fac/mer) and Optical (d and l).

4. Acids, Bases Solvents

- **Hard Soft Acid Base (HSAB) Principle**: Hard acids prefer hard bases; soft acids prefer soft bases to form stable ionic/covalent complexes.
- **Bronsted-Lowry**: Acid = proton donor; Base = proton acceptor.
- **Lewis Theory**: Acid = electron pair acceptor; Base = electron pair donor.

5. Organometallics Catalysis

- **18-Electron Rule**: Stable organometallic complexes tend to have a total valence electron count of 18.

Total Electrons = Metal valence e^-+Ligand contributions

- **Key Catalytic Cycles**:
  - Hydroformylation (oxo process)
  - Wacker Process
  - Ziegler-Natta Polymerization