

Introduction to Inorganic Chemistry

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Key concepts, scope, and foundational ideas

1. What Is Inorganic Chemistry?

Aspect	Description
Definition	Study of the properties, synthesis, and reactivity of inorganic compounds—those that typically do not contain carbon-hydrogen (C-H) bonds.
Contrast with Organic Chemistry	Organic chemistry focuses on carbon-based molecules (e.g., hydrocarbons, biomolecules). Inorganic chemistry covers metals, minerals, coordination complexes, and many non-metallic substances.
Historical Roots	Early chemistry dealt almost exclusively with inorganic substances (metals, salts, minerals). The field expanded with the discovery of transition-metal complexes, organometallics, and solid-state materials.

2. Scope of Inorganic Chemistry

1. Main-Group Chemistry

- Elements of groups 1, 2, and 13-18.
- Topics: acids/bases, oxides, halides, hydrides, and main-group element clusters.

2. Transition-Metal Chemistry

- d-block elements (groups 3-12).
- Topics: coordination complexes, ligand field theory, catalysis, redox behavior.

3. Lanthanides & Actinides (f-block)

- Rare-earth and actinide chemistry.
- Topics: magnetic properties, nuclear applications, separation chemistry.

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4. Solid-State & Materials Chemistry

- Crystalline solids, ceramics, semiconductors, superconductors.
- Topics: crystal structures, band theory, defect chemistry.

5. Bioinorganic Chemistry

- Role of metal ions in biology (e.g., hemoglobin, nitrogenase).
- Topics: metalloenzymes, metal-based drugs, metal homeostasis.

6. Industrial & Environmental Inorganic Chemistry

- Catalysis (e.g., Haber-Bosch, Fischer-Tropsch).
- Materials for energy storage, water treatment, and pollution control.

3. Fundamental Concepts

3.1 Periodic Trends

- **Atomic size, ionization energy, electronegativity, oxidation states** vary predictably across periods and groups.
- Transition metals show **variable oxidation states** due to partially filled d-orbitals.

3.2 Bonding Types

Bonding Mode	Typical Examples	Key Features
Ionic	NaCl, MgO	Electrostatic attraction between cations and anions; high lattice energies.
Covalent (molecular)	SiCl ₄ , PCl ₅	Shared electron pairs; discrete molecules.
Metallic	Fe, Cu	Delocalized electrons; conductivity, malleability.
Coordinate (dative)	[Fe(CN) ₆] ⁴⁻ , [Cu(NH ₃) ₄] ²⁺	Ligand donates both electrons to a metal center; central to coordination chemistry.
Polymeric/Network	SiO ₂ , Al ₂ O ₃	Extended 3D lattices; high melting points.

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3.3 Coordination Chemistry Basics

- **Ligand** – donor atom(s) that bind to a metal ion.
- **Coordination number** – number of donor atoms attached to the metal (commonly 4, 5, 6).
- **Geometry** – tetrahedral, square planar, octa