

# SEMESTER -3 (Inorganic Chemistry)

## Advanced Inorganic Chemistry

### CHE(I) 501

#### Coordination Chemistry of Transition Metals:

##### UNIT 1

Stability constants of complexes and their determination by various methods. Thermodynamic stability and Kinetic stability of Complexes. Importance of determining Stability constants of complexes. Stereochemistry of Coordination compounds with special reference to chelating ligands ( Optical activity of metal complexes with chiral ligands). Metal Clusters.  $\delta$  bond. Transition metal complexes of  $\pi$  acceptor ( $\pi$ - Acid) ligands.

##### UNIT 2

Effect of Crystal field splitting. Splitting of d orbital in low symmetry environment. Spin crossover in coordination compounds. selection rules for d-d transitions. Charge transfer spectra. Nephelauxetic effect, other evidences of metal ligand orbital overlap. Terms and Symbol, Spin orbit coupling, Orgel diagram. Spectra of distorted octahedral and square planar complexes. Strong field case and correlation diagram. Calculation of  $Dq$ ,  $B$  and  $\beta$ . Tanabe Sugano diagram.

##### Unit 3 – Chemistry of Non Transition Elements

Synthesis, Properties and structure of boranes, Carboranes, borazines, silicates, carbides, silicones, phosphazenes, sulphur nitrogen compounds, phosphorous cyclic compounds and noble gas compounds.

Iso and heteropoly acids

##### Unit 4- Solid state Chemistry

Molecular orbital theory of solids, electrical properties, insulators and semiconductors, super conductors, Schottky and Frenkel defects, Intermetallic, interstitial and non stoichiometric compounds, defects and non stoichiometry, electrical conductivity, Spinel structure, ferromagnetic antiferromagnetic, perovskite and related phases Chevrel phases, Atom and ion diffusion, mechanism of diffusion.

##### **References:**

1. Advanced Inorganic Chemistry, F. A. Cotton and Wilkinson, John Wiley,
2. Inorganic Chemistry, J. E. Huhey, Harpes & Row.
3. Chemistry of the Elements, N. N. Greenwood and A. Earnshaw, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5. Shriver, D. F., Atkins, P. W. & Langford, C. H. *Inorganic Chemistry*, 2nd Ed., Oxford Univ. Press (1998).
6. Purcell, K. F. & Kotz, J. C. *Inorganic Chemistry*, W. B. Saunders and Co.: N. Y. (1985).
7. Wulfsberg, G. *Inorganic Chemistry* Univ. Science books: USA (2000); Viva Books: New Delhi.
8. Inorganic Chemistry, Third Edition, Gary L. Miessler, Donald A. Tarr(Pearson).
9. Modern Inorganic Chemistry, Second Edition, William L. Jolly.
10. Inorganic Chemistry, International Student Edition, Third Edition, Alan G. Sharpe
11. C. N. R. Rao and J. Gopalkrishnan, New Directions in solid state chemistry, Paper back edition, Cambridge University Press, 1989. A survey of crystal chemistry and recent developments in solid state chemistry with a section on superconductivity.
12. A.R. West- solid state chemistry and its applications, John Wiley- 1987
13. Solid State Chemistry, Second Edition, D. K. Chakrabarty, New Age International Publishers.

**SEMESTER -3 (Inorganic Chemistry)**  
**Selected topics in Inorganic Chemistry**  
**CHE(I) 502**

**Unit 1 – Ion Exchange**

Ion exchange : Synthesis, characterization and properties of Ion exchangers, mechanism of ion exchange : equilibria –Rate Theory, Donnan equilibria, liquid ion exchangers and chelate ion – exchange resins. Separation of metals and non-meals using ion exchangers. Inorganic ion exchangers : The clay minerals, zeolites, heteropolyacid salts, hydrous oxides and insoluble salts and their applications

**Unit 2 – Corrosion**

Principles of corrosion and rate expressions, Different forms of corrosion – corrosion by sea water, corrosion of boilers, contact and crevice corrosion, stress corrosion cracking and related phenomena, hydrogen cracking corrosion prevention –corrosion inhibitors and passivators cathodic and anodic protection, metallic coating, role of paints and pigments, plastic linings, alloying for corrosion resistance.

**Unit 3 - Electrochemical Methods**

- (a) **Electrochemical methods** : Polarography, principle, types of currents, polarographic potentials, instrumentation, pulse polarography, different pulse polarography , voltammetry : hydrodynamic , cyclic and anodic stripping voltammetry and applications.

**Unit 4 - Thermal methods**

- (b) **Thermal methods** : Principles, instrumentation and application of TGA, DTA and DSC.

**References:**

1. Vogel's Text book of Quantitative Chemical Analysis, 6<sup>th</sup> Edition, J. Mendham R C Denney, J. D. Barnes, M J K Thomas
2. C. E. Harland 1994 Ion exchange theory and practice, 2<sup>nd</sup> edn, Royal society of Chemistry Cambridge.
3. J. Korkisch 1989 Handbook of ion exchange resins, their application to inorganic chemistry CRC Press, Boca Raton FL.
4. Principles of Instrumental Analysis" by Douglas A. Skoog, 3<sup>rd</sup> Edition, Holt-Saunders International Edition
5. Advanced Inorganic Chemistry Vol. 1, Gurdeep Raj, Krishna Publication Meerut.
6. UHLIGS Corrosion Handbook, R. Winston Revie., Jhon Wiley & Sons JNC.
7. An Introduction to metallic corrosion, U.R. Evans, Cambridge, England.

**SEMESTER -3 (Inorganic Chemistry)**  
**Inorganic Pharmaceutical & Medicinal Chemistry**  
**CHE(I) 503**

**Unit 1.**

- (a) Pharmacopocia and Monography  
Electrolytes, major physiological ions, physiological acid-base balance, acid base imbalance, electrolytes used for replacement therapy, electrolytes used in combination therapy.
- (b) Gastro-intestinal tract agents – Acidifying agents, gastric antacids, protective and adsorbents, saline cathartics  
Antioxidants and buffers

**Unit 2**

- (a) Expectorants and Emetics- symptoms of respiratory disease, expectorants, anti-tussive and emetics.
- (b) Topical agents – Protective, astringents and antimicrobials

**Units 3**

- (a) Trace elements- copper, iron, iodine, manganese, zinc, their compounds and their relevance.
- (b) Metals in medicine : Biomedical significance. Role of metal ions in drug design  
Platinum antitumor agents- discovery and development, synthesis.

**Unit 4**

- (a) Vanadium complexes –oxovanadium(IV) complexes for diabetes treatment
- (b) Medicinal applications of metal complexes of N-Heterocyclic carbenes (NHC)-  
NHC precursors and metal complexes –pyridine based NHC precursors and metal complexes, NHC Rhodium complexes.

**References :**

1. *A handbook of Inorganic Pharmaceutical Chemistry, Dr. K. G. Bothara, Nirali Prakashan.*
2. *Medicinal Inorganic Chemistry, American Chemical Society, Washington, DC*
3. *Medicinal Inorganic Chemistry : Orvig, C, Abrams, M. J. Eds.; Chemical Reviews Vol. 99, No.9, American Chemical Society, Washington, D.C. 1999.*
4. *Metallopharmaceuticals I & II, Clarke, M. J., Sadler, P., Eds., Springer, Verlag, New York, Inc., 1999.*
5. *Uses of Inorganic Chemistry in Medicine, Farrell, N., Ed., Springer-Verlag, New York, Inc.1999.*

**SEMESTER -3 (Inorganic Chemistry)**  
**Supramolecular Chemistry**  
**CHE(I) 504**

**Supramolecular Chemistry**

An examination of non-covalent interactions and their impact in chemistry. Topics will include self-assembly with special emphasis on supramolecules derived from calix systems, molecular recognition, and their applications for the design and synthesis of nanostructured materials

- I. Introduction to Supramolecular Chemistry and molecular forces responsible for supramolecular structures.
- II. Molecular Structure: Shape and Size
  - (i) Van der Waals radii
  - (ii) Bond lengths and bond angles
  - (iii) Conformation
- III. Common Motifs in Supramolecular Chemistry with a brief overview of experimental techniques in supramolecular Chemistry.
- IV. Host / Guest Chemistry
  - (i) Cation binding
  - (ii) Anion binding
  - (iii) Neutral molecule binding

**References:**

1. *Supramolecular Chemistry* by Jonathan Steed & Jerry Atwood will be the primary textbook.
2. *Supramolecular Chemistry: Concepts and Perspectives* By Jean-Marie Lehn
3. *Core Concepts in Supramolecular Chemistry and Nanochemistry* By Jonathan W. Steed, David R. Turner, Karl Wallace

**SEMESTER -3 (Inorganic Chemistry)**  
**CHE(I) 505 & 506 PR(PRACTICALS)**

1. Analysis of alloys and ores
2. Capacity of ion exchangers
3. Separation of cations and anions using ion exchangers
4. Determination of trace elements by atomic spectroscopy.
5. Analysis of selected drugs
6. Determination of ionization constants and stability constants by potentiometry.
7. Preparation of metal complexes and characterization by IR
8. Determination of composition of complexes by Jobs method and molar ratio method.
9. Analysis of mixtures by complexometry.
10. Thermal analysis and interpretation
11. XRD analysis of compounds.
12. Analysis of industrial effluent

**References:**

1. *Vogel's Text book of Quantitative chemical analysis*
2. *Vogel's Text book of Qualitative analysis*
3. *The Quantitative Analysis of Drugs*, D. C. Garratt

## **SEMESTER -4 (Inorganic Chemistry)**

### **Advanced Inorganic Chemistry-CHE(I) 507**

#### UNIT I

##### **Infrared Spectroscopy:**

Theory and Application of FT-IR. Symmetry and shape of AB<sub>2</sub>, AB<sub>3</sub>, AB<sub>4</sub>, AB<sub>5</sub> and AB<sub>6</sub>. Modes of bonding of ambidentate ligands. Effect on coordination on ligand Bands, Change in symmetry on coordination. Organometallic compounds. Metal ligand vibration.

##### **Electron Spin Resonance.**

Principle and presentation of the Spectrum. Hyperfine splitting. Anisotropy and interpretation of g values. Hyperfine coupling and zero field splitting. Survey of EPR spectra of first row transition metal ion complexes. Double Resonance and Fourier transform EPR techniques.

#### UNIT II

##### **Nuclear Magnetic Resonance Spectroscopy**

Principle and application of FT-NMR. Chemical shift. Contact shift and pseudocontact shift. Lanthanide complexes as shift reagents. Double resonance Technique. Proton, Boron, carbon, Nitrogen, Phosphorus NMR of inorganic Compounds.

##### **Mossbauer Spectroscopy**

Basic principle, Spectral parameters and spectrum display. Interpretation of Isomer shift. Application of Technique to the studies of bonding and structure of Fe<sup>2+</sup> and Fe<sup>3+</sup> compounds, Sn<sup>2+</sup> and Sn<sup>4+</sup> compounds and detection of oxidation states.

FAB and electrospray mass spectrometry of metal complexes.

#### UNIT III

##### **Organotransition Metal Chemistry**

Organometallic reagents in organic synthesis and in homogenous catalytic reaction (Hydrogenation, hydroformylation, isomerisation and polymerisation).  $\pi$  bonded organometallic compounds including carbonyls, nitrosyls, tertiary phosphines, hydrides, alkene, alkyne, cyclobutadiene, cyclopentadiene, arene compounds. Futuristic aspects of organotransition metal chemistry. Activation of small molecules by coordination.

#### UNIT IV

##### **Chemistry of Lanthanides and Actinides**

Separations, spectral and magnetic properties, organometallic chemistry of lanthanides and actinides.

Transuranium elements.

##### **References**

1. Structural methods in inorganic chemistry, E.A.V.Ebsworth, D.W.H. Rankin and S.Cardock
2. Spectroscopic Identification of Organic Compounds – R.M.Silverstein, G.C.Bassler and Morrill.
3. Physical Methods in Inorganic Chemistry – R.S.Drago.
4. Applications of absorption spectroscopy of organic compounds – J.Dyer.
5. Electron Spin Resonance – Elementary Theory and Practical Applications – Wertz and Bolton
7. Green, M. L. H. *Organometallic Compounds* Chapman & Hall: U.K. (1968).
8. Coates, G. E., Green, M. L. H. & Powell, P. *Principles of Organometallic Chemistry* Chapman and Hall: U.K. (1988).
9. Organometallic Chemistry a Unified Approach by R.C.Mehrotra and A.Singh,
10. Organometallic Chemistry of Transition Metals by Robert H.Crabtree.

**SEMESTER -4 (Inorganic Chemistry)**  
**Selected topics in Inorganic Chemistry**  
**CHE(I) 508**

**Unit 1 - Electrolytic process**

Electrolytic processes : The Chlor-Alkali industry –General concepts and brine electrolysis chlorine cell technology, sodium potassium.

**Unit 2 - Marine chemicals**

Marine Chemicals : Chemical properties of marine waters, salinity, chlorinity and its significance, method of determination, Recovery of metals and non metals from sea water, biochemical reactions, pollutants and impact.

**Unit 3- X-ray diffraction Methods**

Production of x-rays and Bragg's equation, instrumentation and application for structural studies.

**Unit 4- surface characterization by spectroscopy**

Surface characterization : Photoelectron spectroscopy – principle, instrumentation and applications.

**References:**

1. Vogel's Text book of Quantitative Chemical Analysis, 6<sup>th</sup> Edition, J. Mendham R C Denney, J. D. Barnes, M J K Thomas
2. Principles of Instrumental Analysis" by Douglas A. Skoog, 3<sup>rd</sup> Edition, Holt-Saunders International Edition.
3. Modern Chlor-Alkali Technology, Volume 8,1. Edition - March 2001, John Wiley & Sons
4. Elements of X-Ray Diffraction (3rd Edition), B.D.Cullity,
5. "Principles and Practice of X – Ray Spectrometric Analysis", 2<sup>nd</sup> edition, Bertin, Eugene, Plenum Press, New York, 1975.
6. "An Introduction to X –Ray Spectrometry", Jenkins, Ron, Heyden & Sons, London, 1974.

**SEMESTER -4 (Inorganic Chemistry)**  
**Advanced Industrial Inorganic Chemistry**  
**CHE(I) 509**

**Advanced Industrial Inorganic Chemistry**

**Unit 1 - Nanomaterials in Chemistry**

Introduction to nanomaterials and nanochemistry, classification of nanomaterials general methods of preparation and applications. Chemical and catalytic aspects of nanocrystals – nanomaterials in catalysis, as adsorbents, as new chemical reagents.

**Unit 2 – Smart materials**

Ceramics, alloys, gels and polymers. Piezoelectric materials, electrostrictive and magnetostrictive materials, rheological, thermoresponve, pH sensitive halochromic materials, electrochromic materials and smart gels.

**Unit 3 – Chemical and Biofertilizers**

Chemical fertilizers, applications, adverse effects, Advantage of biofertilizers.

Types of Mineral Fertilizers : Nitrogenous fertilizers, phosphatic and potassic fertilizers, NPK grades.

Nitrogen biofertilizer : Rhizobium (symbiotic) Azetobactor (non symbiotic)

Phosphorus biofertilizer : P.S. B. phosphate solubilizing bacteria..

#### **Unit 4 – Environmental Chemistry**

Types of water pollutants : organic, inorganic, radionuclids and their determination  
COD, BOD and industrial waste water treatment for solids, metals, dissolved organics  
and inorganics.

Air pollutants –CO,SO<sub>x</sub>, NO<sub>x</sub>, CFC, hydrocarbon and their monitoring.

Disposal of hazardous wastes.

#### **References:**

1. *Nanoparticles, buildings blocks of nanotechnology, Rotello V. Kluwer Acad / ptenum publication, N.Y.2004*
2. *Nanoscale materials in chemistry- ed. By Klabunde K.J.John-wiley, N.Y. 2001*
3. *The chemistry of nanomaterials : Synthesis, properties and applications ed. By. C.N.R.Rao, A. Müller and A.K.Cheetham, wiley-VCH ,2004*
4. *Nanotechnology, Richard Booker, Earl Boysen, Wiley*
5. *Environmental Chemistry, Akde,Wiley Eastern Ltd.*
6. *Environmental Chemistry, B. K. Sharma, H. Kaur, Goel Publishing House, Meerut.*
7. *Environmental Chemistry, B. K. Sharma, Goel Publishing House, Meerut*

## **SEMESTER -4 (Inorganic Chemistry) Intellectual Property rights basics CHE(I) 510**

### **Unit -1**

General Introduction of IPRs

*Indian Patent System in brief*

*Important Amendments of Indian Patents Act & Rules*

*What is IPR?*

IP Protection

*Importance of IP Protection*

*Why patent protection?*

*Why trade marks protection?*

*Why design protection?*

### **Unit-2**

Basic concept in patents

Patentable and non-patentable inventions

Patentability criteria and requirements

Practical study of novelty and non obviousness

### **Unit-3**

Provisional, complete application and their contents and different types of patent applications (Basics)

Claim and their interpretation

Prosecution of patent application

**Unit-4**

Prior art Search-1

Prior art Search-2

Requirement of IPRs in Pharmaceutical & Chemical industries and career development in IPR

**References:**

1. Intellectual Property Rights, Anita Rao & Bhanaji
- 2.. The Law Of Intellectual Property Rights, Shiv Sahai Singho
3. Intellectual Property Rights in the WTO and Developing Countries, Jayashree Watal

**SEMESTER -4 (Inorganic Chemistry)**  
**dissertation/industrial training**  
**CHE(I) 511& CHE(I) 512**