**BS 1st Year**

**Semester – I INORGANIC CHEMISTRY**

**Course Code/Title CHEM 151**

**Contact Hours:** **Credit Hours:**

Theory =48 Theory =3.0

Practical = 48 Practical = 1.0

Total = 96 Total = 4.0

 **--------------------------------------------------------------------------------------**

**Course Objectives**

The objectives of the course are: -

1. To introduce students about the key introductory concepts of atomic structure and chemical bonding.
2. To introduce theories of acids and bases.
3. To learn about qualitative and quantitative analysis of inorganic compounds during laboratory work.

**COURSE LEARNING OUTCOMES:**

Upon successful completion of the course, the student will be able to:

1. Acquire the basic knowledge of determining molecular shapes.
2. Carry out qualitative and quantitative analysis.

**Course outline:**

1. **Periodic Table**

Electronic configuration and periodic table, periodicity, group trends in atomic and ionic radii. Trends in ionization energies, electro negativity, ionization potential, electron affinity, oxidation potentials, electrode potential, magnetic properties, para and diamagnetisms.

1. **Chemical Bonding**
2. Types of chemical bonding; ionic, covalent, coordinate covalent bonding, metallic bonds.
3. Theories of chemical bonding; Lewis dot diagrams, Valence Shell Electron Pair Repulsion (VSEPR) model and its use in prediction of molecular shapes, valence bond theory (VBT), hybridization, resonance (O3, NO31-, CO32- etc), bonding in electron deficient compounds (BF3, B2H6 etc.), molecular orbital theory (MOT) applied to homonuclear and heteronuclear diatomic molecules,
4. Intermolecular forces e.g. Van der waals forces and hydrogen bonding.
5. **METALLURGY**

Principles of metallurgical operations. Metallurgy of iron and Steel, Purification of metals.

**CHEM-151 Lab.**

1. Lab safety and good laboratory practices, knowledge about material safety data sheets (MSD), disposal of chemical waste and first-aid practices
2. Qualitative analysis of salt mixtures
3. Quantitative analysis, acid- base titrations, preparation and standardization of acid and alkali solutions, redox titrations, preparation and standardization of potassium permanganate solution and its use for the determination of purity of commercial potassium oxalate or oxalic acid, preparation and standardization of sodium thiosulfate solution and its use in determination of copper in a given sample.
4. Gravimetric analysis, determination of barium in a given sample, determination of chloride in a given solution.

**Teaching Methodology**

* Lecturing
* Written Assignments
* Presentations

**Assessment**

**Mid Term (40%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation 20%
* Quiz 20%

**Final Term (60%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation/Quiz 20%
* Lab/Report Writing/Viva-voce/Quiz 20%

**Text and Reference books:**

1. Shriver, D. F., Atkins, P. W., Langford, C. H.,*Inorganic Chemistry*, 2nd ed., Oxford University Press, (1994).
2. Cotton, F.A. and Wilkinson, G., *Advanced Inorganic Chemistry*, 6th ed., John-Wiley & Sons, New York, (2007).
3. Huheey, J. E., *Inorganic Chemistry: Principles of Structure and Reactivity,* 3rd ed., Harper International SI Edition, (2006).
4. House, J.E., *Inorganic Chemistry,* Academic Press. USA, (2008).
5. Lee, J.D., *Concise Inorganic Chemistry,* 5th ed., Chapman and Hall, (1996).
6. Miessler, G. L., Tarr, D. A., *Inorganic Chemistry*, 3rd ed.,Pearson Education, India, (2008).
7. Huheey, J. E., Kieter E. A., Keiter L. R., *Inorganic Chemistry: Principles of Structure and Reactivity,* 4th ed., Benjamin-Cummings Pub Co., (1993).
8. Sharpe, A. G., *Inorganic chemistry,* 3rd ed., Pearson Education India, (1981).
9. Catherine E. House croft, Alan G. Sharpe, *Inorganic Chemistry,* 3rd ed., Prentice Hall, (2008).
10. Kathleen A. H., James E. H., *Descriptive Inorganic Chemistry,* 2nd ed., Brooks Cole, (2010).
11. Wulfsberg G., *Principles of Descriptive Inorganic Chemistry,* 1st ed., University Science Books, (1991).
12. Hill, R. H. JR and Fister, D. C., *Laboratory Safety for Chemistry Students,* John-Wiley & Sons, Inc., (2010).
13. Mendham, J., Denny, R. C., Barnes, J. D., Thomas, M. and Sivasankar, B., *Vogel’s Textbook of Quantitative Chemical Analysis,* 6th ed., Pearson Education, Ltd., (2000).
14. Svehla, G., *Vogel’s Qualitative Inorganic Analysis,* 7th ed., (7th imp.), Pearson Education, Ltd., (2009).

**Semester – II INORGANIC CHEMISTRY**

**Course Code/Title CHEM 251**

**Contact Hours:** **Credit Hours:**

Theory =48 Theory =3.0

Practical = 48 Practical = 1.0

Total = 96 Total = 4.0

**Course Objectives**

**Course Outcomes**

1. Acids and Bases

Review of the concepts of Chemical Equilibrium, Arrhenius and Bronsted theories of acids and bases, Self-Ionization of water, pH scale, Kw, Strong and Weak Acids and Bases, Ka and Kb, Polyprotic Acids, Ions as Acids and Bases, Common Ion Effect in acid base Equilibria, Buffer Solutions, Molecular structure and acid base behaviour. Indicators, Neutralization Reactions, Titration Curves, Solutions of Salts of Polyprotic Acids, Solubility Equilibria, pH, Lewis Acids and Bases, Hard and Soft Acids and Bases.

1. CoordinationChemistry

Introduction, application of complex compounds, Ligands and their types, Nomenclature, The concept of Effective Atomic Number, Coordination Number, Geometry of Complex Ions, Isomerism in complexes, Bonding in complex Ions : Applications of Valence Bond theory (Linear, Trigonal Planar, Square Planar, Tetrahedral, Square Pyramidal, Trigonal Bipyramidal, Octahedral), Crystal Field theory (Octahedral and Tetrahedral Complexes).

Books Recommended

1. Whitten KW, Raymond ED, Larry MP and Stanely G “General Chemistry” 7th Ed (2004) Thomas Learning
2. Hill JW and Petrucci RH”General Chemistry” 8th Ed (2002) Printice Hall
3. Masterton WL “Chemistry: Principles and Reactions” (2000) John Wiley and Sons, Inc
4. Zlewsky AV “Stereochemistry of Coordination compounds” (1996) John Wiley & Sons, Inc
5. Harwood WS and Petrucci RH “General Chemistry” (1993) Macmillan Publishing Company
6. Sharpe AG “Inorganic Chemistry” (1992) Longman
7. Shriver DF, Atkins PW and Langford CH“Inorg Chem“(1990) Oxf
8. Brady JE, Russel JW and Holum JR “Chemistry Matter and its Changes” (1989) Saunders College Publishing
9. Vogel AI “Textbook of Quantitative Inorganic Analysis” (1989) Longman Group, Printed in Great Britain by Bath Press Ltd
10. Basolo F and Johnson “Coordination Chemistry” (1964) W. A. Benjamin Inc

**CHEM 351 INORGANIC CHEMISTRY**

**BS V**

**Contact Hours:** **Credit Hours:**

Theory = 48 Theory =3.0

Practical = 48 Practical = 1.0

Total = 96 Total = 4.0

**Course Objectives**

* To introduce the chemistry of non-metals and p-block elements.
* To study the various families of p-block elements and their properties.

**Learning Outcomes**

Upon successful completion of the course, the student will be able to:

* To understand fully the arrangement and chemistry of non-metals.
* To comprehend the energetics of non-metals with respect to thermodynamics

 **Chemistry of Non metals**

Hydrogen and Hydrides; Chemistry of noble gases with reference to synthesis properties of Xenon compounds and properties of Xenon compounds. Determination of structure of these compounds.

**Chemistry of Halogens**

Group trend, preparation and properties of oxides, oxo acids, oxo salts of halogens. Inter halogen and poly halides; Pseudohalogens.

**Chemistry of Oxygen and SulFur**

Group trend, Preparation and properties of Oxides, Sulphides and oxoacids of Sulphur

**Chemistry of Carbon and Silicon**

Group trend, Fullerene, Silicones and Silicates

 **Chemistry of Boron**

General Characteristics of Boron. Preparation, Properties and Structure of Boron Hydride.

**Inorganic Energetics**

Energetics involved in nonmetals **(**Thermochemistry, Enthalpy, Thermochemical equations, Law of Thermochemistry, Problem related to calculation of ΔHrxn of non-metals; Thermodynamics: Entropy, Free Energy, Relation among ΔG, ΔH, ΔS and equilibrium constant K of a reaction.)

# Practicals

1. Estimation of anions in mixtures:

Chloride-phosphate, chloride-nitrate, oxalate-chloride, sulphate-phosphate, bromide-nitrate, borate-acetate, iodide-nitrate.

1. Iodometric titration with potassium iodate.
2. Gravimetric estimation of oxalate.
3. Precipitation Titrations.
	1. Determination of strength of NaCl given solution by AgNO3 using Fluorescene as indicator.
	2. Determination of % age purity of KBr using Fluorescene as indicator.
	3. Determination of % composition of mixture of KI & KNO3 using Eosine as indicator.
4. Spectrophotometric determination of cerium.
5. Separation of heavy metals using solvent extraction technique

**Teaching Methodology**

* Lecture
* Written Assignments
* Presentations

**Assessment**

**Mid Term (40%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation 20%
* Quiz 20%

**Final Term (60%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation/Quiz 20%
* Lab/Report Writing/Viva-voce/Quiz 20%

# Books Recommended

1. Sharp AG “Inorganic Chemistry” 4th Ed (2007) Addison Wesley Longman Ltd

2. Cotton FA, Wilkinson G, Murillo CA and Bochmann M **“**Advanced Inorganic Chemistry” 6th Ed (1999) John Wiley & Sons, Inc

3. Liptrot GF, Thompson JJ and Walker GR “Modern Inorganic Chemistry” 4th Ed (1986) Bell & Hymann Limited

4. Purcell KF and Kotz JC “An Introduction to Inorganic Chemistry” (1980) Saunders College Publishing

**Semester – V INORGANIC CHEMISTRY**

**Course Code/Title CHEM 451**

**Contact Hours:** **Credit Hours:**

Theory =48 Theory = **3.0**

Practical = 48 Practical = 1.0

Total = 96 Total = **4.0**

 **--------------------------------------------------------------------------------------**

**Course Objectives**

The objectives of the course are: -

1. To acquire knowledge about the physical and chemical properties of d-& f- block elements on the basis of their electronic configurations.
2. To be able to make structures of coordination compounds on the basis of VBT, CFT MOT and LFT.

**COURSE LEARNING OUTCOMES:**

Upon successful completion of the course, the student will be able to:

1. To have an in-depth knowledge of electronic configuration d- & f- block elements and its impact on structural properties.
2. To understand the chemistry of lanthanides and actinides.
3. To acquire laboratory skills for the preparation of inorganic complexes.
4. To be able to illustrate the basic principles of chromatographic separations.
5. To be able to analyze the transition metals using spectrophotometry.

**Course outline:**

1. Chemistry of d-block elements and coordination complexes:

Background of coordination chemistry, nomenclature and structure of coordination complexes with coordination number 2-6, chelates and chelate effect,theories of coordination complexes,Werner's theory, valence bond theory (VBT), crystal field theory (CFT) and molecular orbital theory (MOT), Ligand Field Theory (LFT), Jahn-Teller theorem,magnetic properties, spectral properties, isomerism, stereochemistry, synthesis, mechanism of substitution and redox reaction and stability constants of coordination complexes.

1. Chemistry of f-block elements:
2. Lanthanides: General characteristics, occurrence, extraction and general principles of separation,electronic structure and position in the periodic table, lanthanides contraction, oxidation states, spectral and magnetic properties and uses.
3. Actinides: General characteristics, electronic structure, oxidation state and position in the periodic table, half-life and decay law.
4. CHEM-451 Lab.
5. Preparations of following Inorganic Complexes;
	* 1. Tetraamminecopper (II) sulphate.
		2. Potassiumtrioxalatochromate (III).
		3. Potassiumtrioxalatoaluminate (III).
		4. cis-Dioxalatodiaquachromate (III)cis-Potassium dioxalatodiaquachromate (III).
		5. Potassium hexanitritocobaltate III
6. Determination of zinc and cadmium by complexometric titration.
7. Chromatographic separations of transition metals;
8. Separation of Ni2+& Co2+ ions in a mixture by Ion exchange chromatography.
9. Separation of Ni2+& Cu2+ ions in a mixture by Ion exchange chromatography.
10. Separation of Cu2+& Fe2+ ions in a mixture by Ion exchange chromatography.
11. Analysis of the synthesized coordination complexes using Spectrophotometer and Flame photometer

**Teaching Methodology**

* Lecturing
* Written Assignments
* Presentations

**Assessment**

**Mid Term (40%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation 20%
* Quiz 20%

**Final Term (60%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation/Quiz 20%
* Lab/Report Writing/Viva-voce/Quiz 20%

 **Text and Reference books:**

1. Housecraft, C. and Sharpe, A. G.,*Inorganic Chemistry*,4th ed., Prentice Hall, (2012).
2. Miessler, G. L. and Tarr, D.A.,*Inorganic Chemistry*, 4th ed., Pearson-Prentice Hall International, (2010).
3. Cotton, F.A., Wilkinson, G., Murillo, C. A. and Bochmann, M., *Advanced Inorganic Chemistry*,6thed., Wiley-Interscience, (1999).
4. Douglas, B., McDanial, D., Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd ed., John-Wiley & Sons, New York, (1994).
5. Shriver, D. and Atkins, P., *Inorganic Chemistry*, 5thed., W. H. Freeman & Company, (2010).
6. Lee, J.D., Concise *Inorganic Chemistry*, 5th ed., Blackwell Science Ltd., (2013).
7. Atkins, P. and Jones, L.,*Chemicals Principles,*5th ed., W. H. Freeman & Company, (2010).
8. Svehla, G., *Vogel’s Textbook of Macro and Semimicro Qualitative Inorganic Analysis*, 5th ed., Longman Group Limited, (1979).
9. Huheey, J. E., Kieter, E. A. and Kieter, R. L., *Inorganic Chemistry: Principles of Structure and Reactivity,* 4th ed., Prentice Hall, (1997).
10. Pass, G., Sutcliffe, H., *Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods,* 2nd ed., Chapman and Hall (1974).
11. Müller, U., *Inorganic Structural Chemistry,* 2nd ed., John-Wiley & Sons, Ltd., (2006).
12. Marusak R. A., Doan K., Cummings S. D., *Integrated Approach to Coordination Chemistry,* 1st ed., John-Wiley & Sons, (2007).

**Inorganic Chemistry**

**Semester – VII Inorganic Specialization Course I**

**Course Code/Title SYMMETRY AND MAGNETOCHEMISTRY**

**Contact Hours:** **Credit Hours:**

Theory =48 Theory =3.0

Practical = 00 Practical = 0.0

Total = 48 Total = 3.0

 **--------------------------------------------------------------------------------------**

**Course Objectives**

The objectives of the course are: -

1. To identify various symmetry elements (axis, plane, rotation-reflection, inversion) present in a given molecule or structure. Assignment of (correct) point groups to a given molecule or shape.
2. Form a non-degenerate representation to describe the effect of symmetry operations.
3. Reduce the non-degenerate representation to its component irreducible representations.
4. Apply the principles of symmetry & group theory to solve simple problems in chemical bonding, molecular vibrations, and electronic spectra of transition metal complexes.
5. To understand magnetic properties of transition metal compounds

**COURSE LEARNING OUTCOMES:**

Upon successful completion of the course, the student will be able to:

1. Recognize various symmetry elements (axis, plane, rotation-reflection, inversion) present in a given molecule or structure.
2. Based on the symmetry elements present, state the point group to which a given molecule belongs.
3. Form a non-degenerate representation to describe the effect of symmetry operations.
4. Reduce the non-degenerate representation to its component irreducible representations.
5. Set-up a matrix to perform a given transformation.
6. Find the character of a matrix representing a symmetry operation, using any given basis.
7. Applications to chemical bonding and spectroscopy:
8. Finding sets of hybrid orbitals with given directional properties
9. Determining the orbitals suitable for pi-bonding
10. Finding the symmetries of LCAO molecular orbitals
11. Constructing simple molecular orbital correlation diagrams
12. Finding the number of IR or Raman active vibrations
13. Determining splitting of orbitals in a given environment
14. Electronic spectra of transition metal complexes.
15. Explain magnetic properties of transition metal compounds

**Course outline:**

1. **Symmetry Elements and Operations**
2. **Point Groups**
3. **Non-degenerate Representations**
4. **Matrices**
5. **Degenerate Representations**
6. **Applications to**
7. Chemical bonding
8. Molecular vibrations
9. Transition metal complexes
10. **Magnetochemistry**
11. Theory of magnetism, diamagnetism, paramagnetism, ferro, ferri and antiferromagnetism
12. Magnetic susceptibility, magnetic moments, Faraday’s & Gouy’s methods, effect of temperature on magnetic properties of complexes.
13. Electron spin resonance spectroscopy, Magnetic moment of lanthanides

**Teaching Methodology**

* Lecturing
* Written Assignments
* Presentations

**Assessment**

**Mid Term (40%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation 20%
* Quiz 20%

**Final Term (60%)**

* Written (Long Questions, Short Questions, MCQs) 60%
* Assignment/Presentation 20%
* Quiz 20%

**Text and Reference books:**

1. Vincent A., *Molecular Symmetry & Group Theory*, 2nd Edition, 2001, John Wiley and Sons.
2. Carter R. L., *Molecular Symmetry & Group Theory*, 2004, John Wiley and Sons.
3. Cotton F. A., *Chemical Applications of Group Theory*, 3rd Edition, 1999, John Wiley and Sons.
4. Catherine E. Housecroft, Alan G. Sharpe, *Inorganic Chemistry*, 5th ed., Pearson, (2018).
5. Miessler, G. L., Fischer P. J., Tarr, D. A., *Inorganic Chemistry*, 5th ed., Pearson, (2014).
6. Weller, M., Overton, Tina., Rourke, J., and Armstrong, F., *Inorganic Chemistry*, 6th ed., Oxford University Press, (2014).
7. Douglas, B., McDanial, D., Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd ed., John-Wiley & Sons, New York, (1994).

**Semester VII Course II**

**Course Title: Inorganic Reaction Mechanism**

**Contact Hours:** **Credit Hours:**

Theory =48 Theory = **3.0**

Practical = 00 Practical = 0.0

Total = 48 Total = **3.0**

 **--------------------------------------------------------------------------------------**

 **Course Objectives**

The objectives of the course are:-

1. To impart in-depth knowledge about inorganic reaction mechanisms.
2. To study the application of inorganic reaction mechanism towards understanding different types of complexes.

**COURSE LEARNING OUTCOMES:**

Upon successful completion of the course, the student will be able to:

1. Drive rate laws using steady state approximation.
2. Understand the substitution reactions in octahedral and square planner complexes.
3. Acquire knowledge of mechanism of electron transfer reaction.
4. Differentiate between the redox reactions oxidative addition and reductive elimination reactions.

**Course outline:**

1. Classification of reaction mechanisms, rate laws, steady state approximation
2. inert and labile complexes
3. Substitution reactions in octahedral complexes and square planar complexes, acid hydrolysis, base hydrolysis, steric effects of inert ligands, nucleophilic reactivity, trans-effect, *cis*-effect, racemization reactions
4. Mechanism of electron transfer reactions. e of drawing instruments and materials.
5. Oxidation reduction reactions of metal ions, outer and inner sphere mechanisms, factors affecting rate of electron transfer reactions, two electrons transfer reactions, complementary or non-complementary electron transfer reactions.
6. Oxidative addition, addition of oxygen, hydrogen, HX, organic halides and bimetallic species Reductive Elimination Reactions.

**Teaching Methodology**

* Lecturing
* Written Assignments/Presentations

**Assessment**

**Mid Term (40%)**

* Written (Long Questions, Short Questions, MCQs) 50%
* Presentation 20%
* Assignments 20%
* Quiz 10%

**Final Term (60%)**

* Written (Long Questions, Short Questions, MCQs) 50%
* Presentation 20%
* Assignments 20%
* Quiz 10%

 **Text and Reference books:**

* + 1. Huheey, J. E., Keiter, E. A., Keiter, R. L.,*Inorganic Chemistry: Principles of Structure and Reactivity*, 4th ed., Prentice Hall, (1997).
		2. Shriver, D.F., Atkins, P.W., *Inorganic Chemistry*, 3rd ed., Oxford University Press, (2001).
		3. Wilkins, R.G.,*Kinetics and Mechanism of Reactions of Transition Metal Complex*, 2nd ed., (Rev.), Wiley-VCH, (1991).
		4. Jolly, W. L., *Modern Inorganic Chemistry*, 2nd ed., McGraw-Hill Company, (1991).
		5. Jordan, R.B.,*Reaction Mechanisms of Inorganic and Organomettalic Systems*, 2nd ed., Oxford University Press, New York, (1998).
		6. Atwood, J. D., *Inorganic and Organometallic Reaction Mechanisms,* 2nd ed., Wiley-VCH, Inc., (1997).
		7. Sharma, S. K., *Inorganic Reaction Mechanisms,* Discovery Publishing House, (2007).

**Inorganic Chemistry**

**Semester VII Course III**

**Course Title: BIOINORGANIC CHEMISTRY**

**Contact Hours:** **Credit Hours:**

Theory =48 Theory = **3.0**

Practical = 00 Practical = 0.0

Total = 48 Total = **3.0**

 **--------------------------------------------------------------------------------------**

 **Course Objectives**

The objectives of the course are:-

**Course Objectives**

1. To impart in-depth knowledge about role of metal ions in biological systems.
2. To study the application of metals in macromolecules, heme containing proteins, enzymes.

**COURSE LEARNING OUTCOMES:**

Upon successful completion of the course, the student will be able to:

1. **Understand** the various roles of metal ions in biology including native metals and the use **of metals as diagnostic and therapeutic agents.**
2. **Understand** the relationship between metal ion properties and structural and functional roles.
3. **Use** of metals in diagnostic & treatment of diseases.

COURSE CONTENTS

* Development and Importance of Bio-Inorganic Chemistry,
* Introduction to Metals of Biological Importance,
* Role of Different Metals in Biological System, Metal Deficiencies and Metal Overload in Biological System, Metalloproteins: Transferrin and Ferritin, Iron Sulphur Proteins, Iron Transport Mechanism,
* Protein Peptides, Metallo-enzymes and Metal activated enzymes, Carbonic anhydrase, Carboxy Peptidase, Alkaline Phosphatase, Chlorin and Porphyrin Metal Complexes, Cytochrome, Myoglobin and Haemoglobin, Haemocyanin, Vitamin B12, Oxygen carriers, Nitrogen Fixation,
* Chelation Therapy and Metallotherapy Photosynthesis.

**Books Recommended**

1. Hay RW “Bio-inorganic Chemistry” (1987) Ellis Horwood Limited
2. Lippard S J and Berg JM “Principles of Bioinorganic Chemistry” University Science Books
3. Das AK “A Text book on Medicinal Aspects of Bio-Inorganic Chemistry” (1909) CBS Publishers and Distributors
4. Cox PA “The Elements on Earth: Inorganic Chemistry in the Environment” (1995) Oxford University Press
5. Hay RW “Bio-inorganic Chemistry” Ellis Harwood Limited (1987)
6. Lippard SJ and Berg JM “Principles of Bioinorganic Chemistry” (1994) University Science Books