SIES

College of Arts, Science & Commerce

RISE WITH EDUCATION

Sion (West), Mumbai – 400022.

Department of Chemistry

Program: M.Sc.

Course: Inorganic Chemistry

Syllabus M.Sc. Semester III & IV

To be implemented from 2018 – 2019

Autonomy

Credit Based Semester and Grading System

SEMESTER III

Contents:		
Paper I	:	**Chemistry of Inorganic Solids**
SIPSCHEI31.1	:	Descriptive Crystal Chemistry
SIPSCHEI31.2	:	Imperfection in crystals and Non-stoichiometry
SIPSCHEI31.3	:	Methods of Preparations
SIPSCHEI31.4	:	Behaviour of Inorganic Solids
Paper II	:	**Bioinorganic and Coordination Chemistry.**
SIPSCHEI32.1	:	Bioinorganic Chemistry
SIPSCHEI32.2	:	Reactivity of Chemical Species – I
SIPSCHEI32.3	:	Reactivity of Chemical Species – II
SIPSCHEI32.4	:	Structure, Bonding, and Stereochemistry of Coordination Compounds
Paper III	:	**Spectral Methods in Inorganic Chemistry**
SIPSCHEI33.1	:	Diffraction Methods – I
SIPSCHEI33.2	:	Diffraction Methods – II
SIPSCHEI33.3	:	Electron Spin Resonance Spectroscopy
SIPSCHEI33.4	:	Mossbauer Spectroscopy
Paper IV	:	**Applied Chemistry (Elective)**
SIPSCHEI34.1	:	Inorganic Materials
SIPSCHEI34.2	:	Nuclear Chemistry and Inorganic Pharmaceuticals
SIPSCHEI34.3	:	Advances in Nanomaterials
SIPSCHEI34.4	:	Some Selected Topics
Practical		
SIPSCHEI3P1	:	Analysis of ores/alloys
SIPSCHEI3P2	:	Solvent Extraction
SIPSCHEI3P3	:	Inorganic Preparations
SIPSCHEI3P4	:	Analysis of the following samples

SEMESTER IV

Contents:		
Paper I	:	**Properties of Inorganic Solids and Group Theory.**
SIPSCHEI41.1	:	Electrical Properties.
SIPSCHEI41.2	:	Magnetic Properties.
SIPSCHEI41.3	:	Thermal and Optical Properties.
SIPSCHEI41.4	:	Applications of group theory to Electronic structures
Paper II	:	**Organometallics and main group Chemistry.**
SIPSCHEI42.1	:	Organometallic Chemistry.
SIPSCHEI42.2	:	Applications of Organometallic Compounds.
SIPSCHEI42.3	:	Inorganic cluster and cage compounds.
SIPSCHEI42.4	:	Inorganic ring and chain compounds
Paper III	:	**Instrumental methods in Inorganic Chemistry.**
SIPSCHEI43.1	:	Spectroscopy.
SIPSCHEI43.2	:	Microscopy of Surfaces – I.
SIPSCHEI43.3	:	Microscopy of Surfaces – II.
SIPSCHEI43.4	:	Thermal Methods.
Paper IV	:	**Intellectual Property Rights and Cheminformatics**
SIPSCHEI44.1	:	Introduction to Intellectual Property.
SIPSCHEI44.2	:	Trade Secrets.
SIPSCHEI44.3	:	Introduction to Cheminformatics.
SIPSCHEI44.4	:	Applications.
Practical		
SIPSCHEI4P1	:	Analysis of ores.
SIPSCHEI4P2	:	Coordination Chemistry.
SIPSCHEI4P3	:	Analysis of the following samples.
SIPSCHEI4P4	:	Spectral interpretation.

Course Code: SIPSCHEI31

Paper I

Chemistry of Inorganic Solids

Credits: 4 Credits (60 Lectures)

COURSE CODE: SIPSCHEIN31 CREDITS: 4 LECTURES: 60

Chemistry of Inorganic Solids		
UNIT- I , 1L/week		
COURSE CODE: SIPSCHEI31.1 **LEARNING OBJECTIVES:** *1) To study the structure of different types of crystals such as oxide, perovskite, spinel, etc.* *2) To study the imperfection in crystals such as Frenkel, Schottky and surface defects.* *3) To study the different methods of synthesis of single crystals, thin film and alloys.* *4) To study the behavior of inorganic solids.*		
1 Chemistry of Inorganic Solids		**15L**
1.1	**Descriptive Crystal Chemistry** **(a) Simple structures** Structures of AB type compounds (PbO and CuO), AB_2 type (β cristobalite, CaC_2 and Cs_2O), A_2B_3 type (Cr_2O_3 and Bi_2O_3), AB_3 (ReO_3, Li_3N), ABO_3 type, relation between ReO_3 and perovskite $BaTiO_3$ and its polymorphic forms, Oxide bronzes, ilmenite structure, AB_2O_4 type, normal, inverse, and random spinel structures. **(b) Linked Polyhedra** (i) Corner sharing: tetrahedral structure (silicates) and octahedral structure (ReO_3) and rotation of ReO_3 resulting in VF_3, RhF_3 and calcite type structures. (ii) Edge sharing: tetrahedral structures (SiS_2) and octahedral structures (BiI_3 and $AlCl_3$). pyrochlores, octahedral tunnel structures and lamellar structures.	
UNIT- II, 1L/week		
COURSE CODE: SIPSCHEI31.2		
2 Imperfection in Crystals and Non-Stoichiometry		**15L**

2.1	**Imperfection in Crystals and Non-Stoichiometry** (a) **Point defects**: Point defects in metals and ionic Crystal - Frenkel defect and Schottky defect. Thermodynamics formation of these defects (mathematical derivation to find defect concentration), Defects in Non-Stoichiometric compounds, colour centres. (b) **Line defects**: Edge and Screw Dislocations. Mechanical Properties and Reactivity of Solids. (c) **Surface Defects**: Grain Boundary and Stacking Fault, Dislocation and Grain Boundaries, Vacancies and Interstitial Space in Non-Stoichiometric Crystals, Defect Clusters, Interchangeable Atoms and Extended Atom.	
UNIT III, 1L/week		
COURSE CODE: SIPSCHEI31.3		
3 Methods of Preparations		**15L**
3.1	**Methods of Preparations** **(**a) Methods of Synthesis: Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples). (b) Different methods for single crystal growth: (i) Crystal Growth from Melt: Bridgman and Stockbargar, Czochralski and Vernuil methods. (ii) Crystal growth from liquid solution: Flux growth and temperature gradient methods. (iii) Crystal growth from vapour phase: Epitaxial growth methods. (c) Thin film preparation: Physical and Chemical methods. (d) Solid Solutions: Formation of Substitutional, Interstitial and Complex Solid Solutions, Mechanistic Approach, Study of Solid solutions by X-ray Powder Diffraction and Density Measurement.	
Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI31.4		
4	**Behaviour of Inorganic Solids**	**15L**
4.1	**Behaviour of Inorganic Solids** **(a) Diffusion in Solids:** Fick's Laws of Diffusion, Kirkendall Effect, Wagner mechanism, Diffusion and Ionic Conductivity, Applications of Diffusion in Carburizing and non-Carburizing Processes in Steel Making. **(b) Solid state reactions:** General principles and factors influencing reactions of solids, Reactivity of solids. **(c) Liquid Crystals:** Introduction and classification of thermotropic liquid crystals, Polymorphism in liquid crystal, Properties and applications of liquid crystals.	**15L**

SUGGESTED REFERENCE SIPSCHEI31

1. L. E. Smart and E. A. Moore, Solid State Chemistry-An introduction, 3rd edition, Taylor and Francis, 2005.
2. A.R. West, Solid State Chemistry and Its Applications, John Wiley and sons, 1987.
3. C.N.R. Rao and J. Gopalkrishnan, New Directions in Solid State Chemistry, 2nd Edition, Cambridge University Press. 1997
4. L.V. Azaroff, Introduction to solids, Tata-McGraw Hill Book Co. New Delhi, 1977.
5. D.W. Bruce and Dermont O Hare, Inorganic Chemistry, 2nd Edition, Wiley and sons, New York, 1966.
6. J.M. Hollas, Symmetry in Molecules, Chapman and Hall Ltd., 1972.
7. Rebert L Carter, Molecular Symmetry and Group John Wiley and Sons, New York, 1988.
8. Ulrich Muller, Inorganic structural Chemistry, 2nd edition, John Wiley and Sons, Chichester, 1993.
9. R.N. Kutty and J.A.K. Tareen, Fundamentals of Crystal Chemistry, Universities Press (India) Ltd., 2001.
10. H.V. Keer, Principles of the Solid state, Wiley Eastern Ltd., 1993.Gary L. Miessler and Donald A. Tarr, Inorganic Chemistry, 3rd edition , Pearson Education, Inc., 2004.
11. D.K. Chakrabarty, Solid State Chemistry, New Age International Publishers, 1996.
12. A. Earnshaw, Introduction to Magnetochemistry, Acad. Press, N.Y. (1966).

Course Code: SIPSCHEI32

Paper II

Bioinorganic and Coordination Chemistry

Credits: 4 Credits (60 Lectures)

Bioinorganic and Coordination Chemistry.		
UNIT- I , 1L/week		
COURSE CODE: SIPSCHEI32.1 **LEARNING OBJECTIVES:** *1) To study the principles involved in bioinorganic and coordinate compounds.* *2) To understand the reaction of chemical species.* *3) To study structure, bonding and stereochemistry of coordination compounds using Molecular Orbital Theory and Angular Overlap Model.*		
1 Bioinorganic Chemistry		**15L**
1.1	**Bioinorganic Chemistry** (i) Coordination geometry of the metal ion and functions. (ii) Zinc in biological systems: Carbonic anhydrase, protolytic enzymes, e.g. carboxy peptidase, Zinc finger. (iii) Role of metal ions in biological electron transfer processes: iron sulphur proteins, (iv) Less common ions in biology e.g. Manganese (arginase: structure and reactivity), Nickel (urease : structure and reactivity) (v) Biomineralization.	
UNIT- II, 1L/week		
COURSE CODE: SIPSCHEI32.2		
2 Reactivity of Chemical Species – I		**15L**
2.1	**Reactivity of Chemical Species** **2.2.1** Recapitulation of the definition of Lewis acids and bases, Classification of Lewis acids and bases based on frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases. **2.2.2** Group Characteristic of Lewis acids (Group – 1, 13-17). **2.2.3** Pauling rules to determine the strength of oxoacids, classification and structural anomalies.	

UNIT III, 1L/week		
COURSE CODE: SIPSCHEI32.3		
3 Reactivity of Chemical Species – II		**15L**
3.1	**Reactivity of Chemical Species – II** **3.3.1** Pourbaix Diagrams. **3.3.2** Amphoteric behavior, Periodic trends in amphoteric properties of p-block and d-block elements **3.3.3** Oxoanions and oxocations. **3.3.4** Measures of hardness and softness of acids and bases, Drago-Wayland equation. **3.3.5** Applications of acid-base Chemistry: Super acids and super bases, heterogeneous acid-base reactions.	
Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI32.4		
4 Structure, Bonding, and Stereochemistry of Coordination Compounds		**15L**
4.1	Structure, Bonding, and Stereochemistry of Coordination Compounds (a) Structure and Bonding: i) Molecular Orbital Theory for Complexes with coordination number 4 and 5 for the central ion (sigma as well as pi bonding) (ii) Angular Overlap Model for octahedral and tetrahedral complexes for sigma and pi bond. (b) Stereochemistry of Coordination Compounds: (i) Chirality and Fluxionality of coordination compounds with higher coordination numbers. (ii) Geometries of coordination compounds from coordination number 6 to 9.	

SUGGESTED REFERENCE SIPSCHEI32

1. Gary Wulfsberg, Inorganic Chemistry; Viva Books PA Ltd., New Delhi; 2002.
2. F.A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd edition.
3. James E. Huheey, Inorganic Chemistry, 3rd edition, Harper and Row, Publishers, Asia, Pte Ltd., 1983.
4. W.W. Porterfield, Inorganic Chemistry - A Unified Approach, Academic press (1993).

5. D.F. Shriver, P.W. Atkins and Tina Overton, Inorganic Chemistry, 5th edition Oxford University.
6. Asim K. Das, Fundamental Concepts of Inorganic Chemistry, (Volumes -I, II and III) CBS Pub. (2000).
7. N.N. Greenwood and A. Earnshaw, Chemistry of Elements, Pergamon, 1984.
8. J.M. Hollas, Symmetry in Chemistry, Chapman and Hall Ltd., NY, 1972.
9. F.A. Cotton, Chemical Applications of Group Theory, 2nd edition, Wiley Eastern Ltd., New Delhi, 1976.
10. C.J. Ballhausen and H.B. Gray, Molecular Orbital Theory McGraw-Hill, New York, 1965.
11. H. Sisler, Chemistry in Non-aqueous Solvents: New York Reinhold Publ. 1965.
12. J.J. Lagowski, The Chemistry of Non-aqueous Solvents, Academic press, New York – London, 1966.
13. C.M. Day and Joel Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
14. L.E. Orgel, An Introduction to Ligand Field Theory, Methuen and Co. Ltd., London, 1960.
15. F. Basolo and R.G. Pearson, Mechanisms of Inorganic Reactions, Wiley, New York, 1967.
16. J.D. Lee, Concise Inorganic Chemistry, 5th edition, Blackwell Science Ltd., 2005.
17. R.H. Crabtree, The Organometallic Chemistry of the Transition Metals, Wiley-Interscience, New York, 1988.
18. G.W. Parshall and S.D. Ittel, Homogeneous Catalysis, 2nd edition, John Wiley and sons, Inc., New York, 1992.
19. Gary O. Spessard and Gary L. Miessler, Organometallic Chemistry, Prentice-Hall, (1997).
20. R.C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2nd ed., New Age International Pvt. Ltd., 2000.
21. B. Douglas, D.H. McDaniel and J.J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons,1983.
22. James E. Huheey, Inorganic Chemistry-Principles of structure and reactivity, edn Harper and Row Publishers (1972).
23. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th

ed., John Wiley, New York, 1999.

24. F.A. Cotton and R.A. Walton, Multiple Bonds between Metal Atoms, 2nd edition, Claranden Press, Oxford, 1993.

25. P.L. Soni, Vandana Soni, Ane Books Pvt., Ltd.

Course Code: SIPSCHEI33

Paper III

Spectral Methods in Inorganic Chemistry

Credits: 4 Credits (60 Lectures)

COURSE CODE: SIPSCHEI33 CREDITS: 4 LECTURES: 60

Spectral Methods in Inorganic Chemistry		
UNIT- I , 1L/week		
COURSE CODE: SIPSCHEI33.1 **LEARNING OBJECTIVES:** *1. To study in detail the different spectral methods in inorganic compounds.* *2. To study the principle undergoing spectroscopic technique like ESR, Mossbauer spectroscopy.*		
1 Diffraction Methods – I		**15L**
1.1	**Diffraction Methods – I** X-Ray Diffraction: Bragg Condition, Miller Indices, Laue Method, Bragg Method, Debye Scherrer Method of X-Ray, Structural Analysis of Crystals.	
UNIT- II, 1L/week		
COURSE CODE: SIPSCHEI33.2.		
2 Diffraction Methods – II		**15L**
2.1	**Diffraction Methods – II** **(a) Electron Diffraction:** Scattering of electrons, Scattering Intensity versus Scattering Angle,	

	Weird Measurement Technique and Elucidation of structures of simple gas phase molecules. **(b) Neutron Diffraction:** Scattering of Neutrons: Scattering of neutrons by Solids and Liquids, Magnetic Scattering, Measurement Technique.	
UNIT III, 1L/week		
COURSE CODE: SIPSCHEI33.3		
3 Electron Spin Resonance Spectroscopy		**15L**
3.1	**Electron Spin Resonance Spectroscopy** (a) Electron behaviour, interaction between electron spin and magnetic field. (b) Instrumentation: Source, sample cavity, magnet and modulation coils, microwave bridge, Sensitivity. (c) Relaxation processes and Line width in ESR transitions: (i) ESR relaxation and chemical bonding. (ii) Interaction between nuclear spin and electron spin (hyperfine coupling). (iii) Spin polarization for atoms and transition metal ions. (iv) Spin-orbit coupling and significance of 'g' tensors. (v) Application to transition metal complexes (having one unpaired electron).	
Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI33.4		
4 Mossbauer Spectroscopy		**15L**
4.1	**Mossbauer Spectroscopy** **4.4.1** Basic principle, recoil energy and Doppler shift. **4.4.2** Instrumentation: sources and absorber, motion devices, detection, reference substances and calibration. **4.4.3** Isomer shift, quadrupole interaction, magnetic interaction, electronegativity and chemical shift. **4.4.4 Applications:** *Iron compounds* - low spin and high spin Fe(II) and Fe(III) compounds and complexes, effect of pi-bonding, mono and polynuclear Iron complexes, spinel oxides and iron-sulphur proteins, *Tin compounds* - tin halides and tin oxides, organotin compounds, *Iodine compounds* - I_2 and alkali metal iodide compounds.	**15L**

SUGGESTED REFERENCE SIPSCHEI33

1. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis Fifth edition, (1996), ELBS Publication. Chapter 2, 3, 11.

2. W.H. Zachariasen. Theory of X-Ray Diffration in Crystals. JohnWiley. New York. 1946.

3. B.D. Cality, Elements of X-Ray Diffraction Procedures. John Wiley and Sons. New York, 1954.

4. R. Reaching, Electron Diffraction, Methuen and Co. London. 1936

5. May and Leopold, An Introduction to Mossbauer Spectroscopy, Plenum, New York, 1971.

6. H.H. Willard, L.L. Merrit, J.A. Dean and F.A. Settle, Instrumental Methods of Analysis, C.B.S. Publishers and Distributors, New Delhi, 1986.

7. P.J. Horne, Nuclear Magnetic Resonance. Oxford University Press, Oxford, 1995.

8. Reverts John D., Nuclear Magnetic Resonance, McGraw Hill, NewYork, 1959.

9. H. Kambe and P.D.Garn. Thermal Analysis, Kondansha Ltd. Toyo, 1974.

10. G.W. Ewing, Instrumental Methods, Of Analysis, 4th Ed. McFraw Hill Ltd., 1970.

11. N.H. Ring, Inorganic Polymers, Academic Press, New York, 1978

12. H.G. Heal, The Inorganic Heterocyclic Chemistry of Sulphur, Nitrogen and Phosphorous, Academic Press, New York, 1980.

13. G.T. Seaborg, Man-made Transuranic Elements Preitce- Hall, 1963.

14. M.T.R. Series, The Superheavy Elements.

15. Haissilsky, Nuclear Chemistry and its Application, 1962.

16. S. Glasstone, Sourcebook of Aomic Energy, East-West Publisher, 1969.

17. D. Harvey, Modern Analytical Chemistry, The McGraw-Hill Pub,1st Edition(2000);

18. John H. Block, E.B. Roche, T.P.Soine and Charles O.Wilson, Inorganic Medicinal and Pharmaceutical Chemistry, Lea and Febiger, 1974.

19. R. S. Drago, Physical Methods in Inorganic Chemistry, John-Wiley Pub.,1975

20. M. Drescher an G. Jeschke, (Eds), EPR Spetroscopy: Applications in Chemistry and Biology, Springer-Verlag Berlin, Heidelberg 2012

21. Graham Smith; David Keeble. Introduction to Modern EPR Spectroscopy CRC Press 2013.

(((22. C.N.R. Rao, Chemical Applications of Infrared Spectroscopy Academic Pess, N.Y.(1963

23. K. Veera Reddy, Symmetry and Spectroscopy,

24. Paul Gabbott Principles and Applications of Thermal Analysis Wiley-Blackwell; edition (2007)

25. Richard Vernon Parish, NMR, NQR, EPR, and Mössbauer spectroscopy in inorganic chemistry, Publisher, E. Horwood, (1990)

Course Code: SIPSCHEI34

Paper IV

Applied Chemistry (Elective)

Credits: 4 Credits (60 Lectures)

COURSE CODE: SIPSCHEI34 CREDITS: 4 LECTURES: 60

Applied Chemistry (Elective)		
UNIT- I , 1L/week		
COURSE CODE: SIPSCHEI34.1 **LEARNING OBJECTIVES:** *1) To study the Classification, synthesis and application of magnetic material.* *2) To study the nuclear phenomenon involve in fusion by using the PUREX process, radiopharmaceuticals and their applications.* *3) To study the different advances made in Nanomaterials.* 4) *To study some selective topics involving supramolecular chemistry and intercalation compounds.*		
1 Inorganic Materials		**15L**
1.1	**Inorganic Materials** (a) Classification, manufacture and applications of (i) Inorganic fibers (ii) Biofibers and (iii) Inorganic fillers. Study of (i) Condensed phosphates and (ii) Coordination polymers. (b) Preparation, properties and uses of industrially important chemicals – potassium permanganate, sodium thiosulphate, bleaching powder, hydrogen peroxide, potassium dichromate.	
UNIT- II, 1L/week		

COURSE CODE: SIPSCHEI34.2		
2 Nuclear Chemistry and Inorganic Pharmaceuticals		**15L**
2.1	**Nuclear Chemistry and Inorganic Pharmaceuticals** **(a) Nuclear Chemistry :** Introduction to of nuclear fuels and separation of fission products from Spent fuel rods by PUREX process. Super heavy element, discovery, Preparation, position in the periodic table. **(b) Inorganic Pharmaceuticals :** Radiopharmaceuticals containing Technetium and Bismuth, contrast agents for X-ray and NMR imaging. Gastrointestinal agents viz. (i) Antacids (Aluminium hydroxide, Milk of magnesia, Sodium bicarbonate and (ii) Cathartics (Magnesium sulphate and Sodium phosphate). Topical agents viz. (iii) Protectives and adsorbents (Talc, Calamine), (iv) Antimicrobial agents (Potassium permanganate, Tincture iodine, Boric acid) and astringents (Potash alum).	
UNIT III, 1L/week		
COURSE CODE: SIPSCHEI34.2		
3 Advances in Nanomaterials		**15L**
3.1	**(a) Types of nanomaterials:** e.g. nanotubes, nanorods, solid spheres, core-shell in a nanoparticles, mesoporous materials, isolation of nanomaterials. **(b) Some important properties of nanomaterials:** optical properties of metal and semiconductor nanoparticles, magnetic properties. **(c) Some special nanomaterials: Carbon nanotubes:** Types, synthesis using various methods, growth mechanism and electronic structure. Porous silicon: Preparation and mechanism of porous silicon formation, Factors affecting porous structure and properties of porous silicon. Aerogels: Types of aerogels, properties and applications of aerogels. **(d)** Applications of nanomaterials in electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defense. Environmental effects of nanotechnology.	
Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI34.4		
4 Some Selected Topics		**15L**

4.1	**Some Selected Topics:** i) Isopoly and Heteropoly acids. ii) Supramolecular chemistry. iii) Inorganic pesticides. iv) Intercalation compounds.	**15L**

SUGGESTED REFERENCE SIPSCHEI34

1. G.M. Masters, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt. Ltd. New Delhi, 1995.

2. Sulabha K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007.

3. K. R. Mahadik and B. S. Kuchekar, Concise Inorganic Pharmaceutical Chemistry, Nirali Prakashan, Pune.

4. D. A. Skoog, D. M. West, and F. J. Holler, Fundamentals of Analytical Chemistry, 7th Edition, (printed in India in 2001), ISBN Publication.

5. B. Douglas, D.H. McDaniel and J.J. Alexander, Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons, 1983.

Course Code: SIPSCHEI3P1

Practical Paper I

Analysis of ores/alloys

COURSE CODE: SIPSCHEI3P1 CREDITS: 2

Course Code: SIPSCHEI3P1 (4L/Week)	
1	1. **Analysis of Brass alloy:** (i) Cu content by iodometric method, (ii) Zn content by complexometric method. **2. Analysis of Mangelium alloy:** (i) Al content by gravimetric method as basic succinate. (ii) Mg content by complexometric method. **3. Analysis of Bronze alloy:**

	(i) Cu content by complexometric method. (ii) Sn content by gravimetric method. **4. Analysis of steel nickel alloy:** (i) Ni content by homogeneous precipitation method.

Course Code: SIPSCHEI3P2

Practical Paper II

Solvent Extraction

COURSE CODE: SIPSCHEI3P2 CREDITS: 2

Course Code: SIPSCHEI3P2 (4L/Week)	
1	1. Separation of Mn and Fe using isoamyl alcohol and estimation of Mn. 2. Separation of Co and Ni using n-butyl alcohol and estimation of Co. 3. Separation of Al and Fe using ethyl acetate determination of Fe by redox titration. 4. Separation of Fe and Mo using isoamyl alcohol and estimation of Mo. 5. Separation of Cu and Fe using n-butyl acetate and estimation of Cu.

Course Code: SIPSCHEI3P3

Practical Paper III

Inorganic Preparations

COURSE CODE: SIPSCHEI3P3 CREDITS: 2

Inorganic Preparations (4L/Week)	
1	1. Preparation of $V(oxinate)_3$ 2. Preparation of Sn(IV) Iodide 3. Preparation of Co(α-nitroso-β-naphthol)$_3$ 4. Preparation of $Ni(salicylaldoxime)_2$ 5. Preparation of Hexamine cobalt (III) chloride 6. Preparation of Trans-bis(glycinato) copper(II)

Course Code: SIPSCHEI3P4

Practical Paper IV

Analysis of the following samples

COURSE CODE: SIPSCHEI3P4 CREDITS: 2

Course Code: SIPSCHEI3P4 (4L/Week)	
1	1. Calcium tablet for its calcium content by complexometric titration. 2. Bleaching powder for its available chlorine content by iodometric method. 3. Iron tablet for its iron content colorimetry by 1,10-phenanthroline method. 4. Nycil powder for its Zinc content complexometrically.

Reference books for practical's

1. A. I. Vogel, *Quantitative Inorganic Analysis.*

2. J. D. Woolins, *Inorganic Experiments.*

3. Palmer, *Inorganic Preparations.*

4. Gurdeep Raj, *Advanced Practical Inorganic Chemistry*

5. James E. House, Inorganic chemistry, Academic press, 2nd edition, (2013).

SEMESTER IV

Course Code: SIPSCHEI41

Paper I

Properties of Inorganic Solids and Group Theory

Credits: 4 Credits (60 Lectures)

COURSE CODE: SIPSCHEI41 CREDITS: 4 LECTURES: 60

Properties of Inorganic Solids and Group Theory.		
UNIT- I, 1L/week		
COURSE CODE: SIPSCHEI41.1 **LEARNING OBJECTIVES:** 1) *To study the properties of Inorganic solid, electrical properties like Thomson and Seebeck effect and their applications.* 2) *To study the magnetic behavior of substance and mechanism of ferromagnetic and antiferromagnetic ordering, hard and soft magnets.* 3) *To study the thermal properties of material like ceramics, polymers and optical properties of laser, phosphor.* 4) *To understand the principle involved in group theory and their application to tetrahedral molecules, Ligand field theory.*		
1 Electrical Properties		**15L**
1.1	**Electrical Properties** (a) Electrical properties of solids: (i) Conductivity: Solid Electrolytes, Fast Ion Conductors, Mechanism of Conductivity, Hopping Conduction. (b) Other Electrical Properties: Thomson and Seebeck effects, Thermocouples and their Applications, Hall Effect, Dielectric, Ferroelectric, Piezoelectric and Pyrroelectric Materials and their Inter-relationships and Applications.	
UNIT- II, 1L/week		
COURSE CODE: SIPSCHEI41.2		
2 Magnetic Properties.		**15L**

2.1	**Magnetic Properties.** Behaviour of substances in magnetic field, mechanism of ferromagnetic and antiferromagnetic ordering, superexchange, hysteresis, hard and soft magnets, structures and magnetic Properties of Metals and Alloys, Transition metal oxides, Spinels, garnets, Ilmenites, Perovskite and Magneto plumbites, Application in transformer cores, information storage, magnetic bubble memory devices and as permanent magnets.	
UNIT III, 1L/week		
COURSE CODE: SIPSCHEI41.3		
3 Thermal and Optical Properties		**15L**
3.1	**Thermal and Optical Properties** **a) Thermal Properties:** Introduction, Heat Capacity and its Temperature Dependence, Thermal Expansion of Metals, Ceramics and Polymers and Thermal Stresses. **b) Optical properties:** Colour Centres and Birefringence, Luminescent and Phosphor Materials, Coordinate Model, Phosphor Model, Anti Stokes Phosphor, Ruby Laser, Neodymium Laser.	**15L**
Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI41.4		
4 Applications of group theory to Electronic structures		**15L**
4.1	**Applications of group theory to Electronic structures** (a) Recapitulation of Points groups and Character tables. (b) Transformation Properties of Atomic Orbitals. (c) Sigma and pi- molecular orbitals for AB_4 (tetrahedral) and AB_6 (octahedral) molecules. (d) Ligand Field Theory : Electronic structures of free atoms and ions, Splitting of levels and terms in a chemical environment, Construction of energy level diagrams, Direct product, Correlation diagrams for d^2 ions in octahedral and tetrahedral ligand field, Methods of Ascending and Descending Symmetry, Hole formalism.	**15L**

SUGGESTED REFERENCE SIPSCHEI41

1. Leslie E. Smart and E. A. Moore, Solid State Chemistry-An introduction, 3rd edition, Taylor and Francis, 2005.

2. A.R. West, Solid State Chemistry and Its Applications, John Wiley and sons, 1987.

3. C.N.R. Rao and J. Gopal krishnan New Directons in Solid State Chemistry, 2nd Ed., Cambridge University Press. 1997

4. L.V. Azaroff, Introduction to solids, Tata-McGraw Hill Book Ce. New Dehli, 1977.

5. D.W. Bruce and Dermont O Hare, Inorganic Chemistry, 2nd Ed. Wiely and sons, New York, 1966.

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7. Rebert L carter, Molecular Symmetry and Group John Wiley and Sons, New York, 1988.

8. Ulrich Muller, Inorganic structural Chemistry, 2nd edition, John Wiley and Sons, Chichester, 1993.

9. R.N. Kutty and J.A.K. Tareen, Fundamentals of Crystal Chemistry, Universities Press (India) Ltd., 2001.

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11. D.K. Chakraborty, Solid State Chemistry, New Age International Publishers, 1996.

12. 12. A. Earnshaw, Introduction to Magnetochemistry, Acad. Press, N.Y. (1966)

Course Code: SIPSCHEI42

Paper II

Organometallics and main group Chemistry

Credits: 4 Credits (60 Lectures)

COURSE CODE: SIPSCHEI42 CREDITS: 4 LECTURES: 60

Organometallics and main group Chemistry		
UNIT- I , 1L/week		
COURSE CODE: SIPSCHEI42.1 **LEARNING OBJECTIVES:** *1) To study the chemistry of organometallic and main group element with its application.* *2) To understand the concept of inorganic cluster cage compounds.* 3) *To study inorganic ring and chain compounds.*		
1 Organometallic Chemistry		**15L**
1.1	**Organometallic Chemistry** (a) Metal-Metal Bonding and Metal Clusters. (b) Electron Count and Structures of Clusters. (c) Isolobal Analogy. (d) Organo Palladium and Organo Platinum Complexes (preparations, properties and applications).	**15L**
UNIT- II, 1L/week		
COURSE CODE: SIPSCHEI42.2		
2 Applications of Organometallic Compounds		**15L**
2.1	**Applications of Organometallic Compounds** **(a)** Catalysis-Homogenous and Heterogenous Catalysis: Comparison, Fundamental Reaction Steps. **(b)** Organometallics as Catalysts in Organic Reactions: (i) Hydrosilylation (ii) Hydroboration (iii) Water gas Shifts reaction (iv) Wacker process(oxidation of alkenes) (v) Alcohol carbonylation.	**15L**

	(c) Coupling reactions: (i) Heck reaction (ii) Suzuki reaction.	
UNIT III, 1L/week		
COURSE CODE: SIPSCHEI42.3		
3 Inorganic cluster and cage compounds		**15L**
3.1	**Inorganic cluster and cage compounds** (i) Introduction (ii) Bonding in boranes (iii) Heteroboranes (iv) Carboranes (v) Cluster compounds (vi) Electron precise compounds and their relation to clusters.	
Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI42.4		
4 Inorganic ring and chain compounds		**15L**
4.1	**Inorganic ring and chain compounds** (a) Silicates, polysilicates and aluminosilicates. (b) Phosphazenes and phosphazene polymers. (c) Polyanionic and polycationic compounds.	

SUGGESTED REFERENCE SIPSCHEI42

1. Gary Wulfsberg, Inorganic Chemistry; Viva Books PA Ltd., New Delhi; 2002.
2. F.A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd edition.
3. James E. Huheey, Inorganic Chemistry, 3rd edition, Harper and Row,Publishers, Asia, Pte Ltd.,1983.
4. W.W. Porterfield, Inorganic Chemistry-An Unified Approach, Academic press(1993);
5. D.F. Shriver, P.W. Atkins and C.H. Langford, Inorganic Chemistry,3rd edition Oxford University Press, 1999.
6. Asim K. Das, Fundamental Concepts of Inorganic Chemistry,(Volumes-I,II and III)CBS Pub.(2000)
7. N.N. Greenwood and A. Earnshaw, Chemistry of Elements, Pergamon, 1984.
8. J.M.Hollas, Symmetry in Chemistry, Chapmanad Hall Ltd., NY, 1972.

9. F.A.Cotton, Chemical Applications of Group Theory, 2nd edition, Wiley Eastern Ltd., New Delhi, 1976.

10. C.J. Ballhausen and H.B.Gray, Molecular Orbital Theory, McGraw-Hill, New York, 1965.

11. H. Sisler, Chemistry in Non-aqueous Solvents: New York Reinhold Publ. 1965.

12. J.J. Lagowski, The Chemistry of Non-aqueous Solvents, Academic press, New york and London.

13. C.M. Day and Joel Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt.Ltd., 1985.

14. L.E.Orgel, An Introduction to Ligand Field Theory, Methuen and Co.Ltd., London, 1960.

15. F.Basolo and R.G. Pearson, Mechanisms of Inorganic Reactions, Wiley, New York, 1967.

16. J.D.Lee, Concise Inorganic Chemistry, 5th ed., Blackwell ScienceLtd., 2005.

17. R.H. Crabtree, The Organometallic Chemistry of the Transition Metals, Wiley-Interscience, New york, 1988.

18. G.W.Parshall and S.D.Ittel, Homogeneous Catalysis, 2nd edition,John Wiley and sons, Inc., New York, 1992.

19. Gary O. Spessard and Gary L.Miessler, Organometallic Chemistry,Prentice-Hall, (1997).

20. R.C.Mehrotra and A.Singh, Organometallic Chemistry-A UnifiedApproach, 2nd ed., New Age International Pvt.Ltd., 2000.

21. B.Douglas, D.H. McDaniel and J.J.Alexander, Concepts and Models of Inorganic Chmistry, 2nd edition, John Wiley and Sons,1983.

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23. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann,Advanced Inorganic Chemistry, 6th ed., John Wiley, New York,1999.

24. F.A. Cotton and R.A.Walton, Multiple Bonds between MetalAtoms, 2nd edition, Claranden Press, Oxford, 1993.

25. P.L. Soni, Vandana Soni, Ane Books Pvt.,Ltd

Course Code: SIPSCHEI43

Paper III

Instrumental methods in Inorganic Chemistry.

Credits: 4 Credits (60 Lectures)

COURSE CODE: SIPSCHEI43 CREDITS: 4 LECTURES: 60

Instrumental methods in Inorganic Chemistry.		
UNIT- I , 1L/week		
COURSE CODE: SIPSCHEI43.1 **LEARNING OBJECTIVES:** *1) To introduce the basics of Infrared spectroscopy, Raman spectroscopy, NMR spectroscopy.* *2) To interpret IR and Raman Spectra of molecules.* *3) To study surface spectroscopy, microscopy and understand problems of surface analysis* *4) To study the application of TGA, DSC, DTA, TMA, EGA (Evolved gas analyser) thermomechanical analysis.*		
1 Spectroscopy		**15L**
1.1	**Spectroscopy** **(a) Infrared spectroscopy:** Fundamental modes of vibrations, selection rules, IR absorption bands of metal - donor atom, effect of complexation on the IR spectrum of ligands formations on the IR of ligands like NH_3, CN^-, CO, olefins (C=C) and $C_2O_4^{2-}$. **(b) Raman spectroscopy:** Raman spectroscopy for diatomic molecules. Determination of molecular structures like diatomic and triatomic molecules. **(c) Applications of Group theory in Infrared and Raman spectroscopy.** Molecular Vibrations: Introduction; The Symmetry of Normal Vibrations; Determining the Symmetry Types of the Normal Modes; symmetry based Selection Rules of IR and Raman; Interpretation of IR and Raman Spectra for molecules such as H_2O, BF_3, N_2F_2, NH_3 and CH_4. **(d) Nuclear Magnetic Resonance Spectroscopy :** Introduction to basic principles and instrumentation. Use of ^1H, ^{19}F, ^{31}P, ^{11}B NMR spectra in structural elucidation of inorganic compounds; Spectra of paramagnetic materials: Contact shift, application of contact shift, lanthanide shift reagent.	

UNIT- II, 1L/week		
COURSE CODE: SIPSCHEI43.2		
2 Microscopy of Surfaces – I		**15L**
2.1	**Microscopy of Surface – I:** Introduction to surface spectroscopy, microscopy, problems of surface analysis, distinction of surface species, sputter etching and depth profile and chemical imaging, instrumentations, Ion Scattering Spectra (ISS), Secondary Ion Mass Spectroscopy (SIMS),Auger Emission Spectroscopy (AES).	
UNIT III, 1L/week		
COURSE CODE: SIPSCHEI43.3		
3 Microscopy of Surfaces – II		**15L**
3.1	**Microscopy of Surface – II:** ESCA, Scanning Electron Microscopy (SEM), Atomic force microscopy (AFM) and transmission electron microscopy (TEM): Instrumentation and applications.	
Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI43.4		
4 Thermal Methods		**15L**
4.1	**Thermal Methods:** **3.4.1** Application of TGA in Thermal characterization of polymers, quantitative analysis of mixture of oxalates, moisture content in coal, study of oxidation state of alloys etc. **3.4.2** Application of DSC and DTA in determination of thermodynamic parameters such as heat capacity and standard enthalpy of formation of the compounds, investigation of phase transitions, thermal stability of polymeric materials, purity of pharmaceuticals samples, Melting point of organic compounds etc. **3.4.3** Basic principle, instrumentation and applications to other thermal methods like Thermomechanical analysis (TMA) and evolved gas analysis (EGA).	**15L**

SUGGESTED REFERENCE SIPSCHEI43

1. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis Fifth edition, (1996),ELBS Publication. Chapter 2, 3, 11.
2. W.H. Zachariasen. Theory of X-Ray Diffraction in Crystals. John Wiley. New York. 1946.
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4. R. Reaching, Electron Diffraction, Methuen and Co. London. 1936

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15. Haissilsky, Nuclear Chemistry and its Application, 1962.

16. S. Glasstone, Sourcebook of Aomic Energy, East-West Publisher, 1969.

17. D.Harvey,Modern Analytical Chemistry, The McGraw-Hill Pub,1st Edition(2000);

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19. R. S. Drago, Physical Methods in Inorganic Chemistry, John-Wiley Pub., 1975

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22. C.N.R. Rao, Chemical Applications of Infrared Spectroscopy Academic Press, N.Y. (1963

23. K. Veera Reddy, Symmetry and Spectroscopy,

24. Paul Gabbott Principles and Applications of Thermal Analysis Wiley-Blackwell; edition (2007)

25. Richard Vernon Parish, NMR, NQR, EPR, and Mössbauer spectroscopy in inorganic chemistry, Publisher, E.Horwood, (1990).

Course Code: SIPSCHEI44

Paper IV Applied Chemistry (Elective)

Credits: 4 Credits (60 Lectures)

COURSE CODE: SIPSCHEI44 CREDITS: 4 LECTURES: 60

INTELLECTUAL PROPERTY RIGHTS AND CHEMINFORMATICS		
UNIT- I , 1L/week		
COURSE CODE: SIPSCHEI44.1 **LEARNING OBJECTIVES:** *1) To understand the concept of 'IP', Industrial designs, copy rights, Trader Marks* *2) To Study Trade secrets Economic value of Zp* *3) To understand the Genre of 'Cheminformatics' representation of molecule chemical reaction.* 4) *To Study the application of linear free energy relationship, quantitative structure, drug design.*		
1 INTELLECTUAL PROPERTY RIGHTS and CHEMINFORMATICS		**15L**
1.1	**Introduction to Intellectual Property:** **1.1.1** Introduction to Intellectual Property. **1.1.2** Historical perspective, Different types of IP, Importance of protecting IP. **1.1.3** Patents. **1.1.4** Historical perspective, basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India. **1.1.5** Industrial Designs: Definition, How to obtain, features, International design registration. **1.1.6 Copyrights:** Introduction, How to obtain, Differences from Patents. **1.1.7 Trade Marks:** Introduction, How to obtain, Different types of marks - Collective marks, certification marks, service marks, trade names etc. **1.1.8 Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India. Recycling and recovery of metals with reference to silver, lead, cobalt, nickel and chromium, Laboratory Wastes Disposal Management in Chemical Laboratories.	

UNIT- II, 1L/week		
COURSE CODE: SIPSCHEI44.2		
2 Trade Secrets		**15L**
2.1	**Manufacture and Applications of Inorganic Compounds – I** **Trade Secrets:** Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection. **IP Infringement issue and enforcement:** Role of Judiciary, Role of law enforcement agencies - Police, Customs etc. **Economic Value of Intellectual Property:** Intangible assets and their valuation, Intellectual Property in the Indian context - Various Laws in India Licensing and Technology transfer. **Different International agreements:** **(a) World Trade Organization (WTO):** (i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade Related Services (GATS) Madrid Protocol. (iii) Berne Convention (iv) Budapest Treaty **(b) Paris Convention**, **WIPO** and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.	
UNIT III, 1L/week		
COURSE CODE: SIPSCHEI44.3		
3 Introduction to Cheminformatics		**15L**
3.1	**Introduction to Cheminformatics:** History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modelling and structure elucidation. **Representation of molecules and chemical reactions:** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Mol files and Sd files, Libraries and toolkits, Different electronic effects, Reaction classification. **Searching Chemical Structures:** Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	

Unit – IV, 1L/week		
COURSE CODE: SIPSCHEI44.4		
4 Applications		**15L**
4.1	Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure - Property Relations, Descriptor Analysis, Model Building, Modelling Toxicity, Structure - Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-based and Structure based Drug design, Application of Cheminformatics in Drug Design.	

SUGGESTED REFERENCE SIPSCHEI44

1. Andrew R. Leach and Valerie J. Gillet (2007) *An Introduction to Cheminformatics.* Springer: The Netherlands.

2. Gasteiger, J. and Engel, T. (2003) *Chemoinformatics: A textbook*. Wiley–VCH

3. Gupta, S. P. *QSAR and Molecular Modelling.* Springer-Anamaya Pub.: New Delhi.

Course Code: SIPSCHEI4P1

Practical Paper I

Analysis of ores

COURSE CODE: SIPSCHEI4P1 CREDITS: 2

Course Code: SIPSCHEI4P1 (4L/Week)	
1	1. Analysis of galena ore: (i) Pb content as $PbCrO_4$ by gravimetric method using 5% potassium chromate. (ii) Fe content by colorimetrically using 1,10-phenanthroline. 2. Analysis of Zinc blend ore: (i) Zn content by complexometric method. (ii) Fe content by colorimetric method (Azide method). 3. Analysis of Pyrolusite ore: (i) Mn content by complexometric method. (ii) Acid insoluble residue by gravimetric method.

Course Code: SIPSCHEI4P2

Practical Paper II

Coordination Chemistry

COURSE CODE: SIPSCHEI4P2 CREDITS: 2

Course Code: SIPSCHEI4P2	
LEARNING OBJECTIVES 1. *To learn to calibrate volumetric apparatus.* 2. *To learn to perform experiments that has specific aims with correct techniques.* 3. *To develop skills of observation, recording and analyzing data.* 4. *To learn to present the experimental work in a systematic manner.* 5. *To understand miscibility concept of various organic compounds.*	
Course Code: SIPSCHEI4P2 (4L/Week)	
1	1. Determination of Stability constant of $[Zn(NH_3)_4]^{2+}$ by potentiometry 2. Determination of Stability constant of $[Ag(en)]^{+}$ by potentiometry 3. Determination of Stability constant of $[Fe(SCN)]^{2+}$ by slope ratio method 4. Determination of CFSE values of hexa-aqua complexes of Ti^{3+} and Cr^{3+}. 5. Determination of Racah parameters for complex $[Ni(H_2O)_6]^{2+}$ and $[Ni(en)_3]^{2+}$

Course Code: SIPSCHEI4P3

Practical Paper III

Analysis of the following samples

COURSE CODE: SIPSCHEI4P3 CREDITS: 2

Course Code: SIPSCHEI4P3 (4L/Week)	
1	1. Electral powder for Na/K content flame photometrically. 2. Fasting salt for chloride content conductometrically. 3. Sea water for percentage salinity by Volhard's method. 4. Soil for mixed oxide content by gravimetric method. 5. Fertilizer for potassium content by flame photometry.

Course Code: SIPSCHEI4P4

Paper IV

Spectral interpretation

COURSE CODE: SIPSCHEI4P4 CREDITS: 2

Course Code: SIPSCHEI4P4 (4L/Week)	
1	Spectral interpretation

SUGGESTED REFERENCE SIPSCHEI4P4

1. A. I. Vogel, *Quantitative Inorganic Analysis.*
2. J. D. Woolins, *Inorganic Experiments.*
3. Palmer, *Inorganic Preparations.*
4. G. Raj, Advanced *Practical Inorganic Chemistry.*
5. J. E. House, Inorganic chemistry, Academic press, 2nd edition, (2013).

MODALITY OF ASSESSMENT

1. The candidate is expected to submit a journal certified by the Head of the Department /institution at the time of the practical examination.
2. A candidate will not be allowed to appear for the practical examination unless he/she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.
3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

Scheme of examination for M.Sc. Inorganic Chemistry Semester III and IV.

Internal Theory examination (40 Marks)

One seminar based on curriculum / publication of a research paper/ presentation of a research paper in seminar or conference (to be assessed by teacher of the institution teaching PG learners).

a) Selection of the topic, introduction, write up, references ……. 20 marks

b) Presentation ……. 20 marks

There will not be any internal examination for practical.

External Theory Examination (60 Marks)

Paper	Time allotted in hours	Maximum marks
I	2.5	60
II	2.5	60
III	2.5	60
IV	2.5	60

It is recommended that a total of five questions be set, based on the syllabus with due weightage to the number of lectures allotted per topic. The candidates are expected to answer all five questions. Question 5 will be based on all four units and the remaining questions will be based on each unit.

Semester End Practical Examination (50 Marks)

Laboratory Work : 40 Marks

Journal : 05 Marks

Viva : 05 Marks

The practical examination will be held for two days as described below. The candidates will be examined practically and orally on each day.

Paper	Experiments	Time duration in hours	Maximum marks

I	**1**	**3.5**	**50**
II	**1**	**3.5**	**50**
III	**1**	**3.5**	**50**
IV	**1**	**3.5**	**50**

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