S. P. MANDALI'S
RAMNARAIN RUIA AUTONOMOUS COLLEGE

Syllabus for SEMESTER III and IV Program:
M.Sc. Course: Inorganic Chemistry

Credit based semester and grading system with effect from the academic year 2024-2025

SEMESTER III

Course Code	Unit	Topic	Credits
DSC - I		**SOLID STATE CHEMISTRY**	
	I	Descriptive Crystal Chemistry	3
	II	Imperfection in crystals and non-stoichiometry	
	III	Methods of Preparations	
		PRACTICAL	1
DSC - II		**ADVANCE INSTRUMENTAL TECHNIQUES**	
	I	Spectral Methods	3
	II	Radioanalytical and Thermal Methods	
	III	Electroanalytical Methods	
		PRACTICAL	1
DSC – III		**COORDINATION CHEMISTRY**	
	I	Reactivity of Chemical Species –I	3
	II	Reactivity of Chemical Species –II	
	III	Synthesis, Structure & Bonding, and Stereochemistry	
		PRACTICAL	1
EC-I		**ENVIRONMENTAL CHEMISTRY**	
	I	Air Pollution	3
	II	Water Quality Standards	
	III	Other Types of Pollution	
		PRACTICAL	1
		PHARMACEUTICAL AND COSMETIC CHEMISTRY	
EC-II	I	Pharmaceutical Legislation	3
	II	Drugs	
	III	Cosmetics and Perfumes	
		PRACTICAL	1
		RESEARCH PROJECT / ON JOB TRAINING	8

SEMESTER IV

Course Code	Unit	Topic	Credits
DSC - I		**SOLID STATE CHEMISTRY**	
	I	Inorganic Materials Properties – I (Electrical and Thermal Properties)	3
	II	Inorganic Materials Properties – II (Magnetic and Optical Properties)	
	III	Molecular Spectroscopy	
		PRACTICAL	1
DSC - II		**ORGANOMETALLIC AND MAIN GROUP CHEMISTRY**	
	I	Clusters and The Isolobal Analogy	3
	II	Applications of Organometallic Chemistry to Organic Synthesis	
	III	Inorganic Cluster and Cage compounds	
		PRACTICAL	1
EC – I		**ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS**	
	I	Effluent Treatment	3
	II	Solid Waste Management	
	III	Industrial materials	
		PRACTICAL	1
		SELECTED TOPICS IN ANALYTICAL CHEMISTRY	
EC – II	I	Chemistry of Fuels & Agrochemicals	3
	II	Green Chemistry	
	III	Metallurgy	
		PRACTICAL	1
		RESEARCH PROJECT	10

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SEMESTER – III

DSC I

Credits 3

DSC – I SOLID STATE CHEMISTRY

Course Objectives:

- Initially, the learner is introduced to structures of some compounds of the type AB, AB_2, AB_3 along with oxides ABO_3 and AB_2O_4 and how these polyhedra are linked through corner, edge or face is discussed.

- Hereafter, the difference between the perfect and imperfect crystals and the Classification of proposed schemes for defects and importance of thermodynamics in the formation of defects is brought to the notice of the learner.

- Along with the above concepts, the learner understands the methods of synthesis of inorganic materials with special emphasis of growing of single crystals from different phases of matters, thin film preparation and solid solutions.

Course outcomes:

At the end of this semester, the learner is expected to:	
CO 1	Predict the structures of some known type of compounds based on their stoichiometry like AB, AB_2 etc.
CO 2	Classify the oxides based on structure whether inverse, normal or random and how the polyhedra forms by sharing its corner, edge or face.
CO 3	Have a clear distinction between Perfect and imperfect crystals and how these defects lead to change the properties of solids.
CO 4	Be well versed with the methods available to synthesize the inorganic solids based on the compositions.
CO 5	Identify the importance of Single Crystal and its method of preparation.

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SEMESTER – III

DSC I

Credits 3

DSC – I SOLID STATE CHEMISTRY

Unit	Topics	Lecture
I	**Descriptive Crystal Chemistry**	**(15)**
	1.1 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 polymorphmic forms, Oxide bronzes, ilmenite structure, **AB_2O_4** type, normal, inverse, and random spinel Structures. **1.2 Linked Polyhedra:** **1.2.1** 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. **1.2.2** Edge sharing: tetrahedral structures (SiS_2) and octahedral structures (BiI_3 and $AlCl_3$). pyrochlores, octahedral tunnel structures and lamellar structures.	
II	**Imperfection in crystals and non-stoichiometry**	**(15)**
	2.1 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. **2.2 Line defects**: Edge and Screw Dislocations. Mechanical Properties and Reactivity of Solids. **2.3 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 Defects.	
III	**Methods of Preparations**	**(15)**
	3.1 Methods of Synthesis: Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples). **3.2 Different methods for single crystal growth:** **3.2.1** Crystal Growth from Melt: Bridgman and Stockbargar, Czochralski and Vernuil	

	methods. **3.2.2** Crystal growth from liquid solution: Flux growth and temperature gradient methods **3.2.3** Crystal growth from vapor phase: Epitaxial growth methods. **3.3 Thin film preparation**: Physical and Chemical methods. **3.4 Solid Solutions:** Formation of Substitutional, Interstitial and Complex Solid Solutions; Mechanistic Approach; Study of Solid solutions by X-ray Powder Diffraction and Density Measurement.	

Reference Books:

1. A.F. Wells, Structural Inorganic Chemistry, 4th Edition, Clarendon Press-Oxford University Press, 1975.
2. Ulrich Muller, Inorganic Structural Chemistry, 2nd Edition, John Wiley & Sons Ltd, 2006.
3. Anthony R. West, Solid State Chemistry and its Applications, Student Edition, 2nd Edition, John Wiley & Sons Ltd, 2014.
4. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry Introduction, 3rd Edition, Taylor & Francis Group, LLC, 2005.
5. Richard J. D. Tilley, Understanding Solids: the Science of Materials, John Wiley & Sons Ltd, 2004.
6. Richard J. D. Tilley, Crystals and Crystal Structures, John Wiley & Sons Ltd, 2006.
7. William D. Callister, David G. Rethwisch, Materials Science and Engineering - An Introduction, John Wiley & Sons Ltd, 2014.

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SEMESTER – III

DSC II

Credits 3

DSC – II ADVANCE INSTRUMENTAL TECHNIQUES

Course Objectives:

- The learner should know the recent developments in this fields which will enable them to attain industrial readiness.
- The learner is introduced to the surface analytical techniques, electron spectroscopy and NQR is introduced in the first unit.
- The second unit focuses on thermal methods and radiochemical methods.
- The third unit deals with electroanalytical methods with special reference to voltammetry. Voltammetry includes various types. As a whole this unit four encompasses the methods, instrumentation, various types of microelectrodes and their working.
- Apart from the general coverage, importance is given to the study of organic systems by electrochemical methods. Modern techniques used for chemical analysis and mechanistic studies are introduced so that real world analysis problems can be investigated.
- Focus will be on analytical applications of these techniques and utilizing the correct technique for solving specific analysis problems.

Course outcomes:

At the end of this semester, the learner is expected to:	
CO 1	Understand the basic working principles and applications of surface analytical techniques (such as SIMS, PIXE), electron spectroscopy and Nuclear quadrupole resonance.
CO 2	Know the essential principles underlying the applications of thermal methods and radiochemical methods
CO 3	Develop a working knowledge of various methods used in Voltammetry.
CO 4	Explain anodic, cathodic and adsorptive stripping methods in voltammetry.
CO 5	Select a suitable method of voltammetry for the analysis of a particular sample

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SEMESTER – III

DSC II

Credits 3

DSC – II ADVANCE INSTRUMENTAL TECHNIQUES

Unit	Topics	Lecture
I	**Spectral Methods**	**(15)**
	1.1. Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis. **1.2.** Principle, instrumentation and applications of the following: i) Secondary Ion mass spectroscopy ii) Particle-Induced X-Ray Emission. **1.3.** Electron Spectroscopy**:** principles, instrumentation and applications of the following ESCA (XPS), AUGER, UPS **1.4.** Nuclear Quadrupole Resonance (NQR), ENDOR, ELDOR.	
II	**Radioanalytical and Thermal Methods**	**(15)**
	2.1 Enthalpimetric methods and thermometric titrations. **2.2** Thermal analysis- Principle, Interfacing, instrumentation and Applications of Simultaneous Thermal Analysis- TG-DTA and TG-DSC **2.3** Evolved gas analysis- TG-MS and TG-FTIR **2.4** Activation analysis- NAA, radiometric titrations and radio-release methods Radiometric titrations and Applications **2.5** Auto, X-ray and Gamma Radiography.	
III	**Electroanalytical Methods**	**(15)**
	3.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography, Differential double Pulse Polarography **3.2** Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry. **3.1.1** Potential Step method- Chronoamperometry **3.1.2** Stripping Voltammetry- anodic, cathodic, and adsorption **3.1.3** Chemically and electrolytically modified electrodes and ultra- microelectrodes in voltammetry **3.3** Applications of electrochemical methods in Organic synthesis	

Reference Books:

1. D. A. Skoog, F. J. Holler and J. A. Niemann, Principles of Instrumental Analysis, 5th Edition, 2004.
2. H. H. Willard, L. L. Merritt Jr., J. A. Dean and F. A. Settle Jr., Instrumental Methods of Analysis, 7th Edition, CBS 1986.
3. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill, 1987.
4. G. D. Christian, Analytical Chemistry, 4th Edition, John Wiley, New York, 1986.
5. D. A. Skoog, D. M. West and F. J. Holler Holt- Saunders, Fundamentals of Analytical Chemistry, 6th Edition, 1992.
6. A. J. Bard and Marcel Dekker, Electroanalytical Chemistry, New York, (A series of volumes).
7. J. J. Lingane, Electroanalytical Chemistry, 2nd Edition, Interscience, New York, 1958.
8. A. M. Bond, Marcel Dekker, Modern Polarographic Methods in Analytical Chemistry, New York, 1980.
9. Kamla Zutski, Introduction to polarography and allied techniques, 2006.
10. John C. Vickerman and Ian S. Gilmore, Surface Analysis –The Principal Techniques, 2nd Edition, John Wiley & Sons, Ltd., 2009.

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SEMESTER – III

DSC III

Credits 3

DSC – III COORDINATION CHEMISTRY

Course Objectives:

- The first objective is to study the reactivity of Lewis acids and bases, classification based on the Frontier Molecular Orbital (FMO) method and determination of the strength of oxoacids based on Pauling's rule.
- The second objective is to study the relative stabilities of different oxidation states in aqueous solution for individual elements. Parameters governing the potential and pH under which species are stable in water are also studied.
- The third objective of is to enhance the learner's knowledge of thermodynamic and kinetic stabilities of complexes as an aid in devising methods for the synthesis of coordination compounds and/or understanding synthetic reactions.
- It further includes the bonding and stereochemistry of coordination compounds.

Course outcomes:

At the end of this semester, the learner is expected to:	
CO 1	Illustrate the reactivity of Lewis acids and bases and Classification based on Frontier Molecular Orbital concept.
CO 2	Know the different features of groups from 13-17 with respect to the acidity.
CO 3	Predict the strength, hardness and softness of acids and bases. Be well versed with the Latimer, Pourbaix and Frost diagrams.
CO 4	Know the different routes of synthesizing coordination complexes. Differentiating between sigma and pi bonding of coordination complexes and geometries of tetrahedral and octahedral.
CO 5	Rationalize the chiral and fluxional behavior of coordination complexes.

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SEMESTER – III

DSC III

Credits 3

DSC – III COORDINATION CHEMISTRY

Unit	Topics	Lecture
I	**Reactivity of Chemical Species –I**	**(15)**
	1.1 Recapitulation of the definition of Lewis acids and bases, **1.2** Classification of Lewis acids and bases based on frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases. **1.3** Group Characteristic of Lewis acids (Group -1, 13 - 17). **1.4** Pauling rules to determine the strength of oxoacids; classification and Structural anomalies.	
II	**Reactivity of Chemical Species –II**	**(15)**
	2.1 Pourbaix Diagrams. **2.1.1** Amphoteric behavior, Periodic trends in amphoteric properties of p-block and d-block elements **2.1.2** Measures of hardness and Softness of Acids and Bases **2.1.3** Applications of acid-base Chemistry: Super acids and Super bases, heterogeneous acid-base reactions. **2.1.4** Pauling and Drago-Wayland Equation **2.2** Latimer Diagrams **2.3** Frost diagrams	
III	**Synthesis, Structure and Bonding, and Stereochemistry**	**(15)**
	3.1 Synthesis of Coordination Compounds Addition Reactions, Substitution Reactions, Redox Reactions, Thermal Dissociation of Solid Complexes, Reactions in Absence of Oxygen, Reactions of Coordination Compounds, Trans Effect. **3.2 Structure and Bonding.** **3.2.1** Molecular Orbital Theory for Complexes with Coordination Number 4 and 5 for the central ion (sigma as well as Pi bonding) **3.2.2** Angular Overlap Model for octahedral and tetrahedral complexes for sigma and pi bond. **3.3 Stereochemistry of Coordination Compounds.**	

	3.3.1 Chirality and Fluxionality of Coordination Compounds with Higher Coordination Numbers. **3.3.2** Geometries of Coordination compounds from Coordination number 6 to 9.	

Reference Books:

1. Gary Wulfsberg, Inorganic Chemistry, Viva Books PA Ltd., New Delhi, 2002.
2. James E. House, Inorganic Chemistry, 2nd Edition, Elsevier, 2013.
3. W. W. Porterfield, Inorganic Chemistry-An Unified Approach, Academic press, 1993.
4. D. F. Shriver, P. W. Atkins and C.H. Langford, Inorganic Chemistry, 3rd edition Oxford University Press, 1999.
5. Asim K. Das, Fundamental Concepts of Inorganic Chemistry, (Volumes-I, II and III) CBS Publication, 2000.
6. F. Basolo and R. G. Pearson, Mechanisms of Inorganic Reactions, Wiley, New York, 1967.
7. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, Blackwell Science Ltd., 2005.
8. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th ed., John Wiley, New York, 1999.
9. Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry, 2nd Edition, Pearson Education Limited, 2005.

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SEMESTER – III
EC I

Credits 3

EC – I ENVIRONMENTAL CHEMISTRY

Course outcomes:

After completion of this course, the learner will be able to	
CO 1	List the major sources of different types of pollutants.
CO 2	Classify the different types of pollutants.
CO 3	Estimate the pollutants present in air.
CO 4	Outline the role of pollution control boards in monitoring and controlling pollution.
CO 5	Apply the methods learned in sampling of these pollutants to procure a sample for analysis.
CO 6	Indicate appropriate measures to reduce/or minimize the effects of these pollutants on environment.
CO 7	Evaluate the quality of potable water based on the guidelines laid down by the regulatory bodies.

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SEMESTER – III
EC I

Credits 3

EC – I ENVIRONMENTAL CHEMISTRY

Unit	Topics	Lecture
I	**Air Pollution**	**(15)**
	1.1 Sources, classification, pollutants and permissible limits. (2L) **1.2** Sampling methods for air, flew gas, Industrial Exhaust, stag samples etc. (2L) **1.3** Importance of automobile exhaust control and its limits New BS VI regulations. (2L) **1.4** Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors. SPM analysis on ESP (3L) **1.5** Carbon credit and global issues related to air pollution. (3L) **1.6** Greenhouse gases and their substitutes. (1L) **1.7** Environmental Legislation: role of pollution control boards, article 48A and 51A, Motor Vehicle Act and method of analysis with respect to PUC. (2L)	
II	**Water Quality Standards**	**(15)**
	2.1 Water: quality and requirements of potable water, direct and indirect pollutants for potable water reservoirs, quality of potable water from natural sources. (4L) **2.2.** Bore well water quality and analytical parameters. Quality of bottled mineral water (3L) **2.3**. Process of purification of bore well water to bottled mineral water. (2L) **2.4** Regulatory requirements for packaged drinking water (4L)	
III	**Other Types of Pollution**	**(15)**
	3.1 Soil pollution and Soil Analysis: sources of soil pollution and their control, sampling of soil, determination of water holding capacity, determination total nitrogen, ammonia and nitrates, fertility of soil and effect of pollution on it, synthetic fertilizers and their long-term effect on soil quality. (6L) **3.2 Noise Pollution:** sources, effects, methods of measurements and control measures. (2L) **3.3 Thermal Pollution:** definition, source, impact, control measures, working of cooling	

	towers and cooling ponds, involved economy (3L) **3.4 Radioactive pollutants:** source, exposure hazards, precautions in handling and safety, long term effects. (2L) **3.5 Environmental Audits:** concept of audit, authorities, evaluation methodology, benefits and certification. (2L)	

Reference Books:

1. A. K. De, Environmental Chemistry, 2nd Edition. Wiley (1989).
2. S. M. Khopkar, Environmental Pollution Analysis, John Wiely (1993).
3. Sharad Gokhale, Air Pollution Sampling and Analysis, IIT Guwahati, May (2009).
4. S. M. Khopkar, Environmental Pollution Analysis, New Age International publication (2011).
5. Seonard Ciacere, Water And Water Pollution (hand book) Ed.,Vol I to IV, Marcel Dekker inc. New.York(1972).
6. Arvindkumar, Water pollution, APH publishing (2004)
7. Simon Parsons, Bruce Jefferson, Introduction to Potable Water Treatment Processes, Paperback publication.
8. Guidelines for drinking-water quality, third edition, (incorporating first and second addenda). WHO report.
9. S.G. Misra and Dinesh Mani, Soil pollution, APH Publishing Corporation, (2009).
10. Abrahim Mirsal, Soil Pollution: origin, monitoring and remediation, Springer (2010).
11. Donald F Anthrop, Noise Pollution, Lexington Books, (1973)
12. N. Birsen, Kairat K. Kadyrzhanov, Environmental Protection Against Radioactive Pollution Springer publication, (2003).

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SEMESTER – III
EC II

Credits 3

EC – II PHARMACEUTICAL AND COSMETIC CHEMISTRY

Course Outcomes:

After completion of this course, the learners will be able to,	
CO 1	Categorize the different types of drugs and dosage forms.
CO 2	Outline the role of FDA in pharmaceutical industry.
CO 3	Make use of the different methods learned to estimate the amount of drug present in a sample.
CO 4	Apply the concept of impurity profiling, stability studies, limit tests, bioavailability and bioequivalence while ensuring the uniformity in standards of quality, efficacy & safety of pharmaceutical products.
CO 5	Evaluate the quality of the cosmetic products by carrying out their analysis using the methods learned.

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SEMESTER – III
EC II

Credits 3

EC – II PHARMACEUTICAL AND COSMETIC CHEMISTRY

Unit	Topics	Lecture
I	**Pharmaceutical Legislation**	**(15)**
	1.1 General idea regarding the Pharmaceutical Industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries. (04L) **1.2** Sources of impurities in pharmaceutical products and raw materials. (01L) **1.3** Standardization of finished products and their characteristics, official methods of quality control. (01L) **1.4. Pharmaceutical Legislation:** Introduction to drug acts, drug rules (schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration. (05L) **1.5. Introduction to Intellectual Property Rights (IPR):** Introduction and Types of IPR- Patent, copyright, designs, Trademarks, Trade secrets, Geographical indications. **Patents:** History of Indian patenting system, WIPO, PCT system, criteria for patenting an invention, Routes & Procedure to file patents in India, Basic and associated right of owners, Infringements of patents rights & offences. (04L) **(Discussion on case studies involving IPR is expected).**	
II	**Drugs**	**(15)**
	2.1 Introduction to drug design: Stages of drug discovery and development. Various approaches used in drug design. Lipinski rule of 5, Physicochemical parameters used in quantitative structure activity relationship (QSAR), such as partition coefficient, Hammet's electronic parameter, Taft's steric parameter and Hansch's analysis. Pharmacophore modelling and docking techniques. (04L) **2.2.** Pharmacopoeias: Introduction to IP, BP, USP (2L)	

	2.3. Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, assays involving chromatographic separations, assays of enzyme containing substances, biological and microbiological assays and tests. (03L) **2.4.** Limit tests, solubility tests, disintegration tests, stability studies (2L) **2.5.** Bioequivalence and bioavailability studies. (2L) **2.6.** Impurity profile of drugs (1L) **2.7.** Polymers in pharmaceuticals and novel drug delivery systems. (1L)	
III	**Cosmetics and Perfumes**	**(15)**
	3.1 Cosmetics: Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis. (01L) **3.1.1 Deodorants and antiperspirants:** Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methanamine, phenolsulphonates and urea. (02L) **3.1.2 Face powder:** Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total). (02L) **3.1.3 Hair tonic:** 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers). (02L) **3.1.4 Creams and Lotions:** Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) (02L) **3.1.5 Lipsticks:** General analysis, determination of - nonvolatile matter, lakes and fillers, trichloroethylene-acetone soluble contents. (02L) **3.2 Perfumery:** Introduction – Definition of perfumes, deters, ottos and aromatic waters. Classification of perfumes. (01L) **3.2.1** Essential oils: Introduction, Production (Raw materials, processing, purification and isolation of essential oils), reconstitution of oil. Study of various physical & chemicals properties of essential oil. (01L) **3.2.2** Methods of preparation & manufacture of perfumes: Including (natural & synthetic) general operation flow sheets, statistics. (01L) **3.2.3** Analysis & standardization of perfumes: Includes analysis of essential oils and various physicochemical tests & parameters used for analysis of various perfumes. (01L)	

References:

1. Kenneth Antonio Connors, Text book of Pharmaceutical Analysis, Wiley, (2001).
2. Indian Pharmacopeia, Volume I and II.
3. M L Mehra, The Handbook of Drug Laws, University Book Agency, Ahmedabad, (1997).
4. Takeru Higuchi, Chemical Analysis of Drugs, Interscience Publishers, (1995).
5. Foster Dee Snell et al, Encyclopedia of Industrial Chemical Analysis, Interscience Publishers, (1967).
6. Official methods of analysis of AOAC international,18th edition 2005, AOAC international.
7. Vivien Irish, Intellectual Property Rights for Engineers, 2nd Edition, British Library, (2008).
8. David I. Bainbridge, Intellectual Property, 8th Edition, Pearson, (2010).
9. Stephen Elias and Richard Stim, Patent Copyright & Trade Mark, 8th Edition, Nolo and Richard, (2013).
10. Harry's Cosmetology, 7th Ed, Longman Scientific Co.
11. Edward Sagarin, Cosmetic Technology, Interscience Publishers, (1957).
12. Edgar George Thommsen, Francis Chilson, Modern Cosmetics, Drug and Cosmetic Industry, (1947).
13. Government of India Publications of Food, Drug and Cosmetic Act and Rules.
14. Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, (1995).

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SEMESTER – III

PRACTICAL

	Analysis of Alloy		**Credit**
DSC-I	**1.**	Analysis of Brass alloy: i) Cu content by iodometric method, ii) Zn content by complexometric method.	**1**
	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: Ni content by homogeneous precipitation method.	
	Solvent Extraction		
DSC-II	**1.**	Separation of Co and Ni using n-butyl alcohol and estimation of Co	**1**
	2.	Separation of Mn and Fe using isoamyl alcohol and estimation of Mn	
	3.	Separation of Cu and Fe using n-butyl acetate and estimation of Cu	
	Inorganic Preparations		
DSC-III	**1.**	Preparation of $Ni(salicylaldoxime)_2$	**1**
	2.	Hexaamine cobalt (III) chloride	
	3.	Preparation of Trans-bis (glycinato) Cu(II)	
EC-I	**Pharmaceutical & Cosmetic Chemistry**		**1**
	1.	Determination of Silica by molybdenum blue method.	
	2.	Estimation of copper by extractive photometry.	
	3.	Separation of Ni(II) and Co(II) using anion exchanger column.	
	4.	Analysis of mixture of carbonate and bicarbonate using pH metry.	
	5.	Analysis of detergents: Oxygen releasing capacity, alkalinity, active anionic matter.	

	6.	Determination of dissolved oxygen in water sample with nitrite as impurity by Winkler's (Azide modification) method.	
EC-II		**Environmental & certain industrially important materials**	
	1.	Determination of partition coefficient of medicinal compounds by shake flask method.	
	2.	Limit test for chloride, sulphate, Iron and lead.	
	3.	Determination of neutralizing capacity of aluminum hydroxide gel / Analysis of Whitefield's ointment.	
	4.	Simultaneous estimation of Ibuprofen and Paracetamol by UV spectroscopy.	
	5.	Determination of water by Karl Fischer method-Rifamycin sodium.	
	6.	Identification of components of essential oils by GCMS.	
	7.	Estimation of drugs by non-aqueous titration: Pyridoxine hydrochloride, Mebendazole.	
	8.	Estimation of Aspirin by conductometry.	
	9.	Estimation of Ca in Ca-pantothenate/calcium lactate tablets**.**	

References for Practical:

1. G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989.
2. R Gopalan, V Ramalingam, Concise Coordination Chemistry, Vikas Publishing House Pvt. Ltd. 2000.
3. H N Patel, S P Turakhia, S S Kelkar, S R Puniyani, Post Graduate Practical Chemistry Part I, Himalaya Publishing House, 5th Edition, 2008.

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SEMESTER – IV

DSC I

Credits 3

PAPER – I SOLID STATE CHEMISTRY AND SPECTROSCOPY

Course Objectives:

- The primary objective of this paper is to study the electrical properties of inorganic solids with emphasis on Thomson and Seebeck effect which throw light on development of electric potential across a temperature gradient.
- The second objective is to study magnetic behavior of inorganic materials in presence and absence of applied magnetic fields.
- This also includes the structural and magnetic behavior of alloys, hardness and softness of magnets of different inorganic materials. The study of transition metal oxides and their applications in different electronic fields such as Bubble memory for data storage devices has been explored. A thorough discussion on the basic principles and applications of Molecular spectroscopy at the advanced level supplements the objectives.

Course Outcomes:

After completion of this course, the learners will be able to,	
CO 1	Understand the electrical properties of inorganic solids and how these materials can be used as superconductors.
CO 2	Learn the importance of inorganic materials in making batteries and sensors. Know how hopping model is used to describe carrier transport in a disordered semiconductor or in amorphous solid.
CO 3	Know transition metal oxides such as spinels, garnets and the strength of magnets. Understand the thermal properties and optical behavior of inorganic solids. Know the different models available to understand optical properties of inorganic solids
CO 4	Comprehend the general principles and theory of spectroscopy.
CO 5	Grasp the specialties and applications of various types of spectroscopic methods

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SEMESTER – IV

DSC I

Credits 3

PAPER – I SOLID STATE CHEMISTRY AND SPECTROSCOPY

Unit	Topics	Lecture
I	**Inorganic Materials Properties – I (Electrical and Thermal Properties)**	**(15)**
	1.1 Electrical properties of solids: Conductivity: Solid Electrolytes; Fast Ion Conductors; Mechanism of Conductivity; Hopping Conduction. **1.2 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. **1.3 Thermal Properties:** Introduction, Heat Capacity and its Temperature Dependence; Thermal Expansion of Metals; Ceramics and Polymers and Thermal Stresses.	
II	**Inorganic Materials Properties – II (Magnetic and Optical Properties)**	**(15)**
	2.1 Magnetic properties: Behaviour of substances in magnetic field, mechanism of ferromagnetic and antiferromagnetic ordering, super exchange, Hysteresis, Hard and soft magnets, structures and magnetic Properties of Metals and Alloys. **2.2 Transition metal Oxides:** Spinels, garnets, Ilmenites, Perovskite and Magneto plumbites, Application in transformer cores, information storage, magnetic bubble memory devices and as permanent magnets. **2.3 Optical properties:** Color Centers and Birefringence; Luminescent and Phosphor Materials, Coordinate Model, Phosphor Model, Anti Stokes Phosphor; Ruby Laser and Neodymium Laser	
III	**Molecular Spectroscopy**	**(15)**
	3.1 Rotational spectroscopy: Einstein coefficients, classification of poly atomic Molecules spherical top, symmetric top and asymmetric top molecules, rotational Spectra of polyatomic molecules Stark modulated microwave Spectrometer. **3.2 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 $C_2O_4^{2-}$	

	3.3 Raman Spectroscopy-Classical theory of molecular polarizability, pure rotational, vibrational and vibration-rotation spectra of diatomic and polyatomic molecules polarization and depolarization of Raman lines correlation between IR and Raman spectroscopy Instrumentation.	

Reference Books:

1. Anthony R. West, Solid State Chemistry and its Applications, Student Edition, 2nd Edition, John Wiley & Sons Ltd, 2014.
2. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry Introduction, 3rd Edition, Taylor & Francis Group, LLC, 2005.
3. Richard J. D. Tilley, Understanding Solids: the Science of Materials, John Wiley & Sons Ltd, 2004.
4. Richard J. D. Tilley, Crystals and Crystal Structures, John Wiley & Sons Ltd, 2006.
5. William D. Callister, Jr. and David G. Rethwisch, Materials Science and Engineering - An Introduction, John Wiley & Sons Ltd, 2014.
6. Colin N. Banwell and Elaine M. McCash, Fundamentals of molecular spectroscopy, 4th Edition.
7. G. Aruldas, Molecular structure and spectroscopy, 2nd Edition.
8. H.S. Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd., 2003
9. R.S. Drago, Physical Methods for Chemists, 2nd Edition, Saunders College Publishing 1992.
10. P.W, Physical Chemistry, Oxford University Press, 6th Edition, 1998.

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SEMESTER – IV

DSC II

Credits 3

DSC – II ORGANOMETALLIC AND MAIN GROUP CHEMISTRY

Course Objectives:

- This course aims to study large clusters which have been researched upon with the objective of developing catalysts that may duplicate or improve upon the properties of previously known heterogeneous catalysts. This also includes the concept of isolabilty which shows similarities between organometallic chemistry and organic chemistry. Such similarities can be envisioned on a broader scale by considering frontier orbital of the isolobal molecular fragments of which organometallic compounds are composed.
- Further, the study of various industrial applications of organometallic compounds using as catalyst is brought about in this course. This course also throws light on appropriate pairing of palladium with suitable ligands and their applications in certain industrially important coupling reactions.
- The structure, bonding and classification of inorganic clusters and cage compounds is also discussed in detail in this course. Before considering organometallic clusters, we will find it useful to examine the capacity of boron to form clusters.

Course Outcomes:

After completion of this course, the learners will be able to,	
CO 1	Be well versed with the Synthesis of various palladium Coupling complexes
CO 2	Its properties along with applications
CO 3	Know the Homogenous and heterogeneous catalytic applications of organometallic compounds in various industrial fields
CO 4	Understand the Bonding, electron count of metal clusters
CO 5	Understand the Chemistry of cage and cluster compound

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SEMESTER – IV

DSC II

Credits 3

DSC – II ORGANOMETALLIC AND MAIN GROUP CHEMISTRY

Unit	Topics	Lecture
I	**Clusters and The Isolobal Analogy**	**(15)**
	1.1 Metal Cluster 1.1.1 Carbonyl Cluster 1.1.1.1 Low Nuclearity Carbonyl Cluster (LNCC) 1.1.1.2 High Nuclearity Carbonyl Cluster (HNCC) 1.1.1.3 Electron Counting for LNCC and HNCC 1.1.1.4 Capping Rules: Limitation and Exceptions 1.1.1.5 Synthesis and reactions of Metal Carbonyl clusters 1.1.1.6 Wade's Rule **1.2** Halide type Clusters **1.3** Total Valence Electron Counts in d-block organometallic clusters **1.4** Chevrel Phases **1.5** Zintl Ions **1.6** Concept of Isolobality and Isolobal Analogies	
II	**Applications of Organometallic Chemistry to Organic Synthesis**	**(15)**
	2.1 Alkene Metathesis 2.1.1 Synthesis of Grub's and Schrock Catalysts 2.1.2 Mechanism of Metathesis: Ring Opening Metathesis, Ring Closing Metathesis, Cross Metathesis **2.2** Palladium Catalyzed C-C and C-N Cross Coupling Reactions 2.2.1 Discovery and Industrial application of Cross Coupling Reactions 2.2.2 The Heck Reaction 2.2.3 Suzuki-Miyaura Coupling 2.2.4 Sonogashira Coupling 2.2.5 Stille Coupling 2.2.6 Negishi Coupling	

	2.2.7 Buchwald-Hartwig C-N Cross Coupling **2.3** Methanol Carbonylation and Alkenes Oxidation: The Monsanto Process and The Wacker Process **2.4** Fischer- Tropsch Synthesis, Hydrosilylation of Alkenes, Hydroformylation using Cobalt Catalyst, Water gas Shifts Reaction, Carbonylation of Alcohol	
III	**Inorganic Cluster and Cage compounds**	**(15)**
	3.1 Boranes **3.1.1** Introduction **3.1.2** Method for Classifying Structures **3.1.3** Wade's rules and its Origin **3.1.4** Structural correlations and Bonding **3.1.5** Synthesis of higher boranes **3.1.6** Characteristic reactions of boranes **3.2** Carboranes **3.2.1** Introduction **3.2.2** Method for Classifying Structures **3.2.3** Wade's rules **3.2.4** Synthesis of Carboranes **3.3** Heteroboranes **3.3.1** Introduction **3.3.2** Method for Classifying Structures **3.4** Metallaboranes and Metallacarboranes **3.4.1** Introduction **3.4.2** Method for Classifying Structures **3.5** Polyhedral Skeletal Electron Pair approach or Mingo's Rules **3.6** Electron precise compounds and their relation to clusters	

Reference Books:

1. B D Gupta and A J Elias, Basic Organometallic Chemistry- Concept, Synthesis and Applications, 2nd Edition, University Press, 2013**.**
2. Gary O. Spessard and Gary L. Miessler, Organometallic Chemistry, Oxford University Press, 2nd Edition, 2010.
3. Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry, 2nd Edition, Pearson Education Limited, 2005.
4. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th ed., John Wiley, New York, 1999.
5. D. F. Shriver, P. W. Atkins and C.H. Langford, Inorganic Chemistry, 3rd edition Oxford University Press, 1999.
6. J. D. Lee, Concise Inorganic Chemistry, 5th Edition, Blackwell Science Ltd., 2005.
7. James E. House, Inorganic Chemistry, 2nd Edition, Elsevier, 2013.
8. Robert H. Crabtree, The Organometallic Chemistry of The Transition Metals, 4th Edition, John Wiley & Sons Ltd, 2005.

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M.SC. INORGANIC CHEMISTRY

SEMESTER – IV

EC I

Credits 3

EC – I ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS

Course Outcomes:

After completion of this course, the learner will be able to,	
CO 1	Elaborate on the various physical, chemical and biological processes which are used in CETP to remove the contaminants from wastewater.
CO 2	Apply the concept of recycling, reuse & reclamation in managing solid waste in real life.
CO 3	Classify the different types of plastics.
CO 4	Outline the importance of additives in plastic.
CO 5	Estimate the amount of metallic impurities in plastics.
CO 6	Describe the composition of paints.
CO 7	Make use of the methodologies learned to carry out the analysis of each and every component present in paints.

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SEMESTER – IV

EC I

Credits 3

EC – I ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS

Unit	Topics	Lecture
I	**Effluent Treatment**	**(15)**
	1.1. Effluent treatment: primary secondary and tertiary (2L) **1.2** Plant general construction and process flow charts(3L) **1.3** Treatment and disposal of sewage. (3L) **1.4.** Effluent parameters for metallurgical industry Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent. (2L) **1.5** Recycle and reuse of process and treated (effluent) water. (2L) **1.6** Recovery of metals from effluent, modern methods – electrodialysis, electrodeposition and Ion Exchange etc.(3L)	
II	**Solid Waste Management**	**(15)**
	2.1. Solid waste types and characteristic (2L) **2.2.** Solid waste management: objectives, concept of recycle, reuse and recovery (3L) **2.3.** Methods of solid waste disposal. (2L) **2.4.** Treatment and disposal of sludge / dry cake (3L) **2.5** Managing non-decomposable solid wastes (2L) **2.6** Bio- medical waste: Introduction, Classification and methods of disposal (3L)	
III	**Industrial materials**	**(15)**
	3.1. Plastics & Polymers: Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride, ethylene, acrylic and cellulosic plastics. (03L) **3.1.2** Metallic impurities in plastic and their determination (02L) **3.1.3** Impact of plastic on environment as pollutant. (01L) **3.1.4.** Recycling of plastic: International universal recycling codes and symbols for identification. Biodegradable plastics and alternatives. (02L)	

	3.2 Paints and pigments: Types of paints and pigments, determination of volatile and non - volatile components, Flash point (significance and method of determination), separation and analysis of pigments, binders and thinners. (03L) **3.2.1.** Role of Organo silicones in paints and their impact on environment. (01L) **3.3. Soaps and Detergents:** Classification and composition with role of ingredients, properties, qualitative and quantitative analysis of ingredients of detergents- alkalinity, anionic matter and oxygen releasing capacity. Environmental hazards of common detergent chemicals. Biodegradable detergents. (03L)	

Reference Books:

1. H.R.Singh, Environmental Biology, S.Chand& Company Ltd.
2. P.S.Sindhu, Environmental Chemistry, New age international (P) limited Publishers.
3. Balram Pani, Textbook of Environmental Chemistry, I.K. International Publishing House Pvt.Ltd (2007).
4. Sameer.K.Banerji , Environmental Chemistry, 2nd edition, Prentice Hall of India Private Limited.
5. K Sasikumar and Sanoop Gopi Krishna, Solid waste management, PHI publication (2009).
6. Surendrakumar, Solid waste management, Northen Book Center (2009).
7. G. S. Sodhi , Fundamental Concepts of Environmental Chemistry,2nd edition, Alpha Science, (2005).

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M.SC. INORGANIC CHEMISTRY

SEMESTER – IV

EC II

Credits 3

EC – II SELECTED TOPICS IN ANALYTICAL CHEMISTRY

Course Outcomes:

After the completion of this course, the learner will be able to:	
CO 1	Recommend methods for the biodegradation of insecticides and pesticides.
CO 2	Judge the quality of the detergents by making use of the various methods which are used in industries for carrying out their analysis.
CO 3	Enlist properties of an ideal fuel.
CO 4	Determine the calorific value of fuels using the methodologies learned.
CO 5	Acquire awareness of the principles of green chemistry.
CO 6	Plan out the synthesis of a sample by incorporating benign and environmentally safe solvents.
CO 7	Develop an understanding of zone refining and vacuum fusion and extraction techniques.
CO 8	Classify the kinds of elements that can be purified by the process of zone refining.
CO 9	Suggest a method for analyzing different elements present in ores & alloys.

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M.SC. INORGANIC CHEMISTRY

SEMESTER – IV

EC II

Credits 3

EC – II SELECTED TOPICS IN ANALYTICAL CHEMISTRY

Unit	Topics	Lecture
I	**Chemistry of Fuels & Agrochemicals**	**(15)**
	1.1. Petrochemical products: Crude oils, fuels, and calorific values, fractional distillation process and fractions, properties of fuel, composition of fuel, flashpoint, fire point, corrosion test, carbon residue and impact on environment. (05L) **1.2. Insecticides and Pesticides:** Definition, classification, and determination as pollutant. Biodegradation of insecticides and pesticides. (05L). **1.3. Fertilizers:** Introduction, Types - Nitrogen, Phosphorous, Potash and compound fertilizers, Analysis of fertilizers for its constituents, Impact of fertilizers on environment, Biofertilizers. (05L)	
II	**Green Chemistry**	**(15)**
	3.1 Principle and concepts of green chemistry: Sustainable development and green chemistry, Atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity (4L) **3.2** Organic solvents: environmentally benign solutions, solvent free systems, supercritical fluids (only introduction) Ionic liquids as catalysts and solvents (4L) **3.3** Emerging green technologies, photochemical reactions (advantages and Challenges) examples, Chemistry using microwaves, sonochemistry, electrochemical synthesis (4L) **3.4** Designing Greener processes: Inherently safer designs (ISD), Process intensification (PI) in-process monitoring. (3L)	
III	**Metallurgy**	**(15)**
	3.1. Ores and minerals: Hydrometallurgy, Pyrometallurgy, Electrometallurgy. (One example in case for extraction of metals is to be discussed). Pollution due to metallurgical processes. (3L) **3.2.** Chemical analysis of ores for principal constituents: Galena, Pyrolusite, Bauxite, Hematite, Monazite (4L) **3.3 Alloys:** definition, analysis of Cupronickel, Magnelium, Steel and Stainless Steel, Bronze,	

	Gun metal. (4L) **3.4 Techniques of purification:** Zone refining, analysis of high purity materials like silicon, vacuum fusion and extraction techniques. (4L).	

Reference Books:

1. Green chemistry An Introductory text, Mzike Lancaster, Royal Society of Chemistry (2002).
2. K. G. Das, Dekker, Pesticide Analysis, (1981).
3. S. L Chpra, J.S Kanwar, Analytical, Agricultural Chemistry Kalyani publication.
4. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau of Mines, (1979).
5. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).
6. Zone refining and allied techniques, Norman L. Parr, G. Newnes Technology &Engineering (1960).

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M.SC. INORGANIC CHEMISTRY

SEMESTER – IV

PRACTICAL

DSC-I	**Analysis of Ores**		**Credit**
	1.	Analysis of galena ore: i) Pb content as PbCrO4 by gravimetric method using 5% potassium chromate ii) Fe content by colorimetrically using 1, 10- phenonthroline	**1**
	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	
DSC-II	**Coordination Chemistry**		
	1.	Determination of Stability constant of $[Zn(NH_3)_4]^{2+}$ by potentiometry.	**1**
	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 $[Ni(en)_3]^{2+}$	
EC-I	**Environmental & certain industrially important materials**		**1**
	1.	Determination of Silica by molybdenum blue method.	
	2.	Estimation of copper by extractive photometry.	
	3.	Separation of Ni(II) and Co(II) using anion exchanger column.	
	4.	Analysis of mixture of carbonate and bicarbonate using pH metry.	
	5.	Analysis of detergents: Oxygen releasing capacity, alkalinity, active anionic matter.	
	6.	Determination of dissolved oxygen in water sample with nitrite as impurity by Winkler's (Azide modification) method.	

EC-II	**Selected topics in Analytical Chemistry**		
	1.	Determination of calorific value, cloud point and pour point of fuels.	**1**
	2.	Analysis of pesticides by HPLC.	
	3.	Analysis of fertilizers for the essential components present.	
	4.	Microwave assisted synthesis of industrially important material.	
	5.	Analysis of Bauxite and Monazite.	
	6.	Analysis of Cupronickel alloy by electrogravimetry.	

References for Practical:

1. G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989.
2. R Gopalan, V Ramalingam, Concise Coordination Chemistry, Vikas Publishing House Pvt. Ltd. 2000.
3. H N Patel, S P Turakhia, S S Kelkar, S R Puniyani, Post Graduate Practical Chemistry Part I, Himalaya Publishing House, 5th Edition, 2008.