K. J. SOMAIYA COLLEGE OF SCIENCE AND COMMERCE

AUTONOMOUS – Affiliated to University of Mumbai

Re-accredited "A' Grade by NAAC

Vidyanagar, Vidyavihar, Mumbai 400077

Syllabus for M.Sc.

Program: M.Sc. Inorganic Chemistry

From the academic year 2020–2021

Preamble of the syllabus

- Master of Science (M.Sc.) in Chemistry is a two-year full-time post-graduation course offered by the Department of Chemistry, K. J. Somaiya College of Science and Commerce (Autonomous).
- In our M.Sc course Sem III and Sem IV students will have specialization in Inorganic Chemistry.
- In semester IV instead of practical students will carry out project work for month duration in college research laboratories.
- Each course is framed to meet the following programme outcomes:

PO1: Cutting-edge Knowledge, fundamental principles of Environmental Science
PO2: Scientific methods, Problem Analysis and critical thinking
PO3: Design/development of solutions
PO4: Conduct investigations of complex Problems,
PO5: Integrating technology tools
PO6: The Graduate and society
PO7: Environment, sustainability and Legitimacy
PO8: Moral values and responsibility
PO9: Individual and team work
PO10: Communication
PO11: competitive exams Entrepreneurship, Project management and finance
PO12: Life-long learning

Programme Specific Outcome (PSO)

PSO (Inorganic): The students will learn solid state chemistry, group theory, bioinorganic chemistry, spectroscopic techniques, industrially important materials, instrumental techniques, Nano chemistry, structure determination, study of different compounds such as coordination compounds, cage and cluster compounds and environment and green chemistry.

M.Sc. – II
Inorganic Chemistry Semester III
Course Code – PSICH 301
Solid State and Group Theory

	Module – I	
1	**Solid state II**	**15 L**
1.1	**Factors influencing the crystal structures**: general formulae, valences, coordination numbers, bonding, ions and ionic radii, ionic structures – general principle, radius ration rule, border line radius ratio and distorted structure, lattice energy of ionic crystal, Kapustinskiis Equation	**05 L**
1.2	**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.	**05 L**
1.3	**Edge sharing:** tetrahedral structures (SiS_2) and octahedral structures (BiI_3 and $AlCl_3$). pyrochlores, octahedral tunnel structures and lamellar structures.	**03 L**
1.4	**Solid state reactions**: General principles and factors influencing reactions of solids, Reactivity of solids.	**02 L**
	Module – II	
2.	**Imperfection in crystals and Non- Stoichiometry**	**15 L**
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 and numerical problems expected); Defects in non-Stoiochiometric Compounds, color centers.	**06 L**
2.2	**Line defects**: Edge and Screw Dislocations, Mechanical Properties and Reactivity of Solids.	**04 L**
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.	**05 L**

	Module– III	
3.	**Inorganic materials I**	**15 L**
3.1	**Methods of Synthesis**: Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples).	**04 L**
3.2	**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 vapor phase: –Epitaxial growth methods.	**04 L**
3.3	**Thin film preparation**: Physical and Chemical methods.	**02 L**
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.	**05 L**
	Module– IV	
4	**Applications of group theory- electronic structures**	**15 L**
4.1	Recapitulation: point groups, character tables	**02 L**
4.2	Molecular Orbital Theory of Inorganic Compounds, Symmetry adapted linear combinations, symmetry aspects of MO theory, sigma and pi- bonding for H_2^+, H_2, AB (LiH), AB_2 (BeH_2), AB_3 (BH_3), AB_4(CH_4)(tetrahedral, square planar), AB_5 (TBP) AB_6 molecule and bond order.	**09 L**
4.3	Molecular orbitals for inorganic cage and cluster compounds such as B_6H_6, metal sandwich compounds such as ferrocene and dibenzene chromium.	**04 L**
	References:	

	Module I/II/III	
1	A. R. West, Solid State Chemistry and its Applications, John Wiley and Sons (Asia) Pvt. Ltd.	
2	L. E. Smart and E. A. Moore, Solid State Chemistry – An Introduction, 3rd Ed., Taylor and Francis, 2005.	
3	S. O. Pillai, Solid State Physics, Fifth Ed., New Age International Publishers, 2002.	
4	Leonid V. Azaroff, Introduction to Solids, Tata-McGraw-Hill Publishing Co. Ltd., New Delhi, 1977.	
5	C. N. R. Rao and J. Gopalakrishnan, New Directions in Solid State Chemistry, Second ed., Cambridge University Press, 1997.	
	Module IV	
1	K.Veera Reddy, Symmetry and Spectroscopy of molecules, 2nded, New Age International publishers.	
2	U.C. Agarwala, H/L/Nigam, S Agarwal, S. S. Kalra, Molecular symmetry in Chemistry via group theory, 2013, Ane Books Pvt. ltd.	
3	H. N. Dass, Symmetry and group theory for chemists, 2004 Asian Books Pvt. Ltd.	
4	F.A. Cotton, Chemical applications of Group Theory, Wiley Student Ed., 2006, John Wiley and Sons, (Asia) Pvt. Ltd.	
5	R. L. Carter, Molecular symmetry and Group theory, Wiley Student Ed., 1996, John Wiley and Sons, (Asia) Pvt. Ltd.	
6	S. Swarnalakshmi, T. Saroja, R.M. Ezhilarisi, A simple approach to Group theory in chemistry, 2008, Universities Press (India) Pvt. Ltd.	
	Inorganic Chemistry Practical **PSICHP301**	
	Inorganic Preparations	
	1. Preparation of $V(oxinate)_3$ 2. Preparation of $Co(\alpha\text{-nitroso-}\beta\text{-naphthol})_3$ 3. Preparation of $Ni(salicylaldoxime)_2$ 4. Hexaamine cobalt (III) chloride 5. Preparation of Trans-bis (glycinato)Cu(II)	
Analysis of Ore/Alloy		
1. Analysis of Zinc Blend:		

	Zn content by complexometric method Fe content by Colorimetric method (azide method). 2. **Analysis of Brass Alloy**: Cu content by iodometric method Zn content by Complexometric method. **3. Analysis of Galena ore:** Pb content as PbCrO4 by gravimetric method using % potassium chromate, Fe content by Colorimetrically using 1, 10 Phenonthroline.	
References:		
1	A. I. Vogel, Quantitative Inorganic Analysis	
2	G. Raj, Advanced Practical Inorganic Chemistry	
3	P. C. Kamboj, University Practical Chemistry	

M.Sc. – II

Inorganic Chemistry Semester III

Course Code –PSICH 302

Coordination Chemistry

	Module I	
1	**Synthesis, Structure, Bonding, and Stereochemistry**	**15 L**
1.1	Synthesis of Coordination Compounds i.Addition Reactions ii.Substitution Reactions iii.Redox Reactions iv.Thermal Dissociation of Solid Complexes v.Reactions in Absence of Oxygen vi.Reactions of Coordination Compounds Vii Trans Effect	**07 L**
1.2	**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	**04 L**
1.3	**Stereochemistry of Coordination Compounds** Chirality and Fluxionality of Coordination Compounds with Higher Coordination Numbers. Geometries of Coordination Compounds with coordination no. 6 to 9.	**04 L**
	Module – II	
2	**Reactivity of Chemical species** Reactivity Matrix of Lewis Acids and Bases	**15 L**
2.1	Acidity and Basicity Parameters	**03 L**
2.2	Measures of hardness and Softness of Acids and Bases;	**03 L**
2.3	Pauling and Drago-Wayland Equation	**04 L**
2.4	Redox Reactions in Aqueous, Non- Aqueous and Solvent Free Media	**02 L**
2.5	Latimer Diagrams	**01 L**
2.6	Pourbaix Diagrams	**01 L**
2.7	Frost diagrams	**01 L**
	Module – III	
3	**Schiffs base ligands and their complexes**	**15 L**

3.1	Introduction Classification of ligands Synthesis and purification Spectroscopic properties Structural properties Bonding to metal Ligand properties and conformational aspects, applications	**08 L**
3.2	**Stability Constants:**	**06 L**
	Methods for Determining Stability Constants of Coordination Compounds such as Potentiometry, Spectroscopic methods viz., Job's method, mole-ratio and slope-ratio methods for determination of stepwise formation constants of metal complexes. Conductometry Polarography (Numerical Problems expected).	
3.3	Stability Constants of Mixed Ligand Complexes.	**01 L**
	Module – IV	
4	**Bioinorganic Chemistry**	**15 L**
4.1	Biological oxygen carriers: hemoglobin, hemerythrin and hemocyanin. Hill equation, Bohr effect and their implications.	**06 L**
4.2	Reactions of dioxygen in biological system with examples of peroxidase, monooxygenase, superoxide dismutase and oxidase reactions.	**04 L**
4.3	Nitrogen fixation-nitrogenase, Hydrogenases.	**01 L**
4.4	Metal ion transport and storage: Ionophores, transferrin and Ferritin.	**02 L**
4.5	Metal ions in medicines, cis-platin and related compounds.	**02 L**
	References:	
	Module I/II/III	
	1 James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993	
	2 Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004	
	3 Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.	
	4 D. Banerjea, Coordination Chemistry, Tata McGraw Hill, New Delhi, 1993.	
	5 Gopalan and Ramalingam, Concise coordination chemistry 2012.	

		Module IV	
	1	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993	
	2	Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.	
	3	B. E. Douglas and H. McDaniel, Concepts and models in Inorganic chemistry, 3rd Ed., John Wiley& Sons, Inc., New York, (1994).	
	4	H. J. Emeleus and A. G. Sharpe, Modern aspects of inorganic chemistry, 4th Ed., ELBS &Routledge and Kegan Paul, (1973).	
	5	Gopalan and Ramalingam, Concise coordination chemistry 2012.	
	Inorganic Chemistry Practical PSICHP302		
	Coordination Chemistry		
	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 CFSE values of hexa-aqua complexes of Ti^{3+} and Cr^{3+}. 4. Determination of Racah parameters for complex $[Ni(H_2O)_6]^{2+}$ and $[Ni(en)_3]^{2+}$ 5. Determination of Stability constant of $[Fe(SCN)]^{2+}$ by slope ratio method.		
	References:		
	1	A. I. Vogel, Quantitative Inorganic Analysis	
	2	G. Raj, Advanced Practical Inorganic Chemistry	
	3	P. C. Kamboj, University Practical Chemistry	

	M.Sc. – II Inorganic Chemistry Semester III Course Code - PSAIPCH 303 Advanced Instrumental Techniques and Surface Characterization Chemistry	
	Advanced Instrumental Technique	
1	**Module I: Mossbauer and Raman spectroscopy**	**15 L**
1.1	**Mossbauer's spectroscopy**: Principle, recoilless emission absorption of gamma rays, experimental methods, instrumentation- drive mechanism, sources, detectors, absorbers effect, calibration of instrument, isomer shift, hyperfine structure (quadruple interactions), magnetic hyperfine interaction, applications, purity and characterization, detection of structurally different atoms in polynuclear compounds of Iron and Tin	**07 L**
1.2	**Raman Spectroscopy:** Theory of excitation of Raman spectra, mechanism of Raman and Rayleigh scattering, comparison of Raman and Infra-red spectra. Intensity of normal Raman peaks, instrumentation, organic and inorganic applications, surface enhanced Raman spectroscopy, resonant Raman spectroscopy, Non-linear Raman spectroscopy.	**08 L**
2	**Module II: ESR and Hyphenated techniques**	**15 L**
2.1	**ESR:** Principle, instrumentation, spin-spin splitting, qualitative and multiple resonance (ENDOR, ELDOR) spin labelling, metallic complexes, applications.	**07 L**
2.2	**Hyphenated techniques**: Need for hyphenation, possible hyphenation, interfacing devices and applications of GC-MS, GC-IR, MS-MS, LC-MS, LC-IR, LC-NMR.	**08 L**
3	**Module III:X-ray spectroscopy and thermal methods**	**15 L**
3.1	**X-ray spectroscopy**: Principles, instrumentation and applications of X-ray fluorescence, X-ray absorption and X-ray diffraction spectroscopy.	**07 L**
3.2	**Thermal methods**: Principle, instrumentation and applications of: differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermometric titrations, thermo mechanical analysis (TMA), simultaneous thermal analysis (STA), evolved gas analysis (EGA), application in material science.	**08 L**

4	**Module IV: Surface Characterizationby spectroscopy and microscopy**	**15 L**
4.1	Introduction to study of surfaces, definition of a solid surfaces, types of surface measurements, general techniques in surface spectroscopy, surface spectroscopic methods, sampling surfaces, surface contaminants.	**02 L**
4.2	X-ray photoelectron spectroscopy (XPS)	**02 L**
4.3	Auger electron spectroscopy	**02 L**
4.4	Basic principle, Instrumentation and applications of Electron microprobe, SEM,TEM and AFM	**09 L**
	References: Module I/II/III/IV 1. Analytical Chemistry, G. D. Christian, 5th Ed. John Wiley, New York (2000) 2. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders 9th Edition (2016) 3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 8th Edition(1998) 4. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr, 7th Ed CBS (1986) 5. Introduction to instrumental analysis, R. D. Braun, McGraw Hill (1987) 6. Wilson and Wilson's Comprehensive Analytical Chemistry, Ed. G. Svehla. (A series of Volumes) 7. Treatise on Analytical Chemistry, Eds I. M. Kolthoff and Others, Interscience Pub. (A series of volumes) 8. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger PublishingCompany, (A series of volumes) 9. Spectroscopy by H Kaur, Prgati prakashan, 2016. 10. Instrumental methods of Analysis by Chatwal and Anand, S Chand, 2015.	
	Inorganic Chemistry **Practical PSICHP303**	
1	To interpret the IR spectrum of acetylacetone and copper acetylacetonate complex.	
2	To interpret the IR spectrum of dimethylglyoxime and Ni(II)-DMG complex and calculate force constant of M-N bond .	
3	To interpret the IR spectrum of hexamine cobalt (III) chloride complex.	

4	To interpret the given electronic spectrum of hexamine cobalt (III) chloride complex.	
5	To interpret the IR and NMR spectrum of cinnamaldehyde thiosemicarbazone ligand.	
6	To interpret the given IR and electronic spectrum of o-hydroxybenzylidine ligand and its copper (II) complex.	
	References:	
	1. A. I. Vogel, Quantitative Inorganic Analysis	
	2. G. Raj, Advanced Practical Inorganic Chemistry	
	3.P. C. Kamboj, University Practical Chemistry	

	M.Sc. – II Chemistry Semester III: Course Code - PSAIPCH 304 Nano Chemistry and Some Important Industrial Materials	
1	**Module I: Nano chemistry 1:**	**15 L**
1.1	Introduction, comparison between bulk and nano materials. Types of nano materials-zero, one, three dimensional nanomaterials.	**02 L**
1.2	Synthesis of nanomaterials: Physical methods, Chemical methods and biological methods.	**06 L**
1.3	Properties of nano material with respect to Au, $CdSe_2$, Silica, PolydimehtylSiloxane-mechanical, structural, melting, electrical, optical and magnetic properties.	**07 L**
2	**Module II: Nano chemistry 2:**	**15 L**
2.1	Some important nanomaterials- carbon nanotubes, porous silicon, mesoporous materials, aerogels, ordered porous materials, self-Assembled nano materials and core shell particles.	**09 L**
2.2	Applications of nanomaterials in electronics, energy, automobiles, sports, textiles, cosmetics, domestic appliances, biotechnology, medical fields and space and research. Environmental effects of nanotechnology.	**06 L**
3	**Module III: Paints, pesticides and detergents**	**15 L**
3.1	**Paints:** Introduction, determination of volatile and non-volatile components, water content of paints, flash point, separation of pigments, binders and thinners of different types, identification and analysis of different types of pigments, organic and inorganic pigments, white tinted and coloured pigments.	**06 L**
3.2	**Pesticides**: Introduction, definition, classification, biodegradation and determination of pesticides. pesticide residue analysis, extraction and cleavage of various type of pesticides, use of instrumental method like GLC, TLC, etc.	**06 L**
3.3	**Detergents**: classification, general scheme of analysis, quantitative method of analysis, active ingredient and equivalent combined SO_3 analysis.	**03 L**

4	**Module IV: Petrochemical, explosives, glass and alloys**	**15L**
4.1	**Petrochemical analysis:** Introduction, definition-fuels, calorific values of fuel, composition and properties of fuels, analysis of petrochemicals, distillation range, moisture content, flash point, fire point, sulphur and carbon residue, doctor test.	**04 L**
4.2	**Explosives:** definition, heat of explosion, qualitative tests for explosives, quantitative methods for explosive mixtures.	**04 L**
4.3	**Alloys**: definition, analysis of copper based alloys, aluminum and stainless steel.	**03 L**
4.4	**Glass**: analysis of different types of glass, soda lime glass, lead glass and borate glass.	**04 L**
	References: Module I/II/III/IV	

1. Analytical Chemistry, G. D. Christian, 5th Ed. John Wiley, New York (2000)
2. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt-Saunders 9th Edition (2016)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 8th Edition(1998)
4. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F.A. Settle Jr, 7th Ed CBS (1986)
5. Introduction to instrumental analysis, R. D. Braun, McGraw Hill (1987)
6. Wilson and Wilson's Comprehensive Analytical Chemistry, Ed. G. Svehla. (A series of Volumes)
7. Treatise on Analytical Chemistry, Eds I. M. Kolthoff and Others, Interscience Pub. (A series of volumes)
8. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger PublishingCompany, (A series of volumes)
9. Spectroscopy by H Kaur, Prgati prakashan, 2016.
10. Instrumental methods of Analysis by Chatwal and Anand, S Chand, 2015.
11. Concepts of nanochemistry by Cadmitri and others, Wiley publications.
12. Nanotechnology by Sulbha Kulkarni, CRC press, 4th edition, 2010

	Inorganic Chemistry **Practical PSICH304**	
	Analysis of commercial samples	
1	Electral powder for sodium content by flame photometrically	
2	Sea water for percentage of salinity by Volhard's method	
3	Fertilizers for potassium content by flame photometrically	
4	Cement for its Iron content by redox titration	
5	Bleaching powder for its available chlorine content by iodometric method	
6	Nycil powder for zinc content by complexometrically	
7	Preparation of ZnO and Ag metal nanoparticles.	
8	Determination of Na in cold drinks and fruit juices using flame photometric techniques.	
	References:	
	1.A. I. Vogel, Quantitative Inorganic Analysis	
	2.G. Raj, Advanced Practical Inorganic Chemistry	
	3.P. C. Kamboj, University Practical Chemistry	

M.Sc. – II

Inorganic Chemistry Semester IV

Course Code –– PSICH 401

Inorganic Materials & Group Theory

	Module I	
1	**Inorganic Materials II**	**15 L**
1.1	**Diffusion in Solids**: Fick's Laws of Diffusion (numerical problems expected); Kirkendall Effect; Diffusion and Applications of Diffusion in Carburizing and non-Carburizing Processes in Steel Making, Impurity diffusion into silicon wafers for integrated circuits.	**06 L**
1.2	**Liquid Crystals**: Introduction and classification of thermotropic liquid crystals, Polymorphism in liquid crystal, Properties and applications of liquid crystals, growth of silicon single crystal.	**05 L**
1.3	**Optical properties:** Color Centres and Birefringence; Luminescent and Phosphor Materials; Coordinate Model; Phosphor Model; Anti Stokes Phosphor.	**04 L**
	Module – II	
2	**Mechanical properties of solid materials**:	**15 L**
2.1	Stress and strain in metals- Engineering stress and engineering strain, shear stress and shear strain, the tensile test and engineering stress - strain diagram, modulus of elasticity, yield strength.	**05 L**
2.2	Hardness and hardness testing, plastic deformations of metal single crystals, plastic deformation of polycrystalline metals, solid solution strengthening of metals.	**05 L**
2.3	Fracture of metals-ductile and brittle fracture, toughness and impact testing, fatigue of metals, the creep test, creep-rupture test.	**05 L**
	Module – III	
3	**Properties of Inorganic Materials**	**15 L**
3.1	**Magnetic Properties**: Theory of magnetism, diamagnetism, paramagnetism, ferromagnetism and antiferromagnetism, Curie and Curie-Weiss laws, Faraday's method of determination of magnetic susceptibility.	**05 L**

	Structure and Properties of (i) Metals and Alloys (ii) Transition Metal Oxides; (iii) Spinels; (iv) Ilmenites; (v)Perovskiteand (vi) Magnetoplumbites.	**05 L**
3.2	(b) **Thermal Properties**:Introduction, Heat Capacitiyand its Temperature Dependance; Thermal Expansion of Metals; Ceramics and Polymers and Thermal Stresses.	**02 L**
3.3	**Electrical properties**: Conductivity: Solid Electrolytes; Fast Ion Conductors; Mechanism of Conductivity; Hopping Conduction. Other Electrical Properties: Thomson and Seebeck Effects; Thermocouples and their Applications; Hall Effect; Dielectric, Ferroelectric, Piezoelectric and Pyroelectric Materials and their Inter-relationships and Applications.	**03 L**
	Module – IV	
4	**Application of Group Theory-Spectral properties**	**15 L**
4.1	Ligand Field Theory: Electronic structures of Free Atoms and Ions; Splitting of Levels and Terms in a Chemical Environment; Construction of Energy Level Diagrams.	**05 L**
4.2	Correlation Diagrams for d^2 ions in octahedral and tetrahedral ligand field; Method of Descending Symmetry; Hole Formalism.	**03 L**
4.3	Molecular Vibrations: The Symmetry of Normal Vibrations; Determining the Symmetry Types of the Normal Modes; Selection Rules for Fundamental Vibrational Transitions (IR and Raman) and Interpretation of IR and Raman Spectra e.g. H_2O, CO_2, HF, H_2; comparison of IR and Raman selection rules.	**07 L**
	References:	
	Module I/II/III	
	1 A. R. West, Solid State Chemistry and its Applications, John Wiley and Sons (Asia) Pvt. Ltd.	
	2 L. E. Smart and E. A. Moore, Solid State Chemistry – An Introduction, 3rd Ed., Taylor and Francis, 2005.	

	3	S. O. Pillai, Solid State Physics, Fifth Ed., New Age International Publishers, 2002.	
	4	Leonid V. Azaroff, Introduction to Solids, Tata-McGraw-Hill Publishing Co. Ltd., New Delhi, 1977.	
	5.	C. N. R. Rao and J. Gopalakrishnan, New Directions in Solid State Chemistry, Second ed., Cambridge University Press, 1997.	
	Module IV		
1	K.Veera Reddy, Symmetry and Spectroscopy of molecules, 2nd ed, New Age International Publishers.		
2	U.C. Agarwala, H/L/Nigam, S Agarwal, S. S. Kalra, Molecular symmetry in Chemistry via group theory, 2013,Ane Books Pvt.ltd.		
3	H. N. Dass, symmetry and group theory for chemists, 2004 Asian Books Pvt. Ltd.		
4	F.A. Cotton, Chemical applications of Group Theory, Wiley Student Ed., 2006,John Wiley and Sons, (Asia) Pvt. Ltd.		
5	R. L. Carter, Molecular symmetry and Group theory, Wiley Student Ed., 1996,JohnWiley and Sons, (Asia) Pvt. Ltd.		
6	S. Swarnalakshmi, T. Saroja, R.M. Ezhilarisi, A simple approach to Group theory in chemistry, 2008, Universities Press (India) Pvt. Ltd.		

M.Sc. – II

Inorganic Chemistry Semester IV

Course Code –– PSICH 402

Applications of Inorganic Compounds and Nuclear Chemistry

	Module I	
1	**Preparation, properties and uses of Industrially important chemicals**	**15 L**
1.1	Lime, Chlorine and Caustic soda, Cement Inorganic explosives (mercury fulminate, Lead azide); Fertilizers and micronutrients Glass	**09 L**
1.2	Potassium permanganate, Sodium thiosulphate, Bleaching powder, Hydrogen peroxide, Potassium dichromate.	**06 L**
	Module – II	
2	**Metallurgy**	**15 L**
2.1	Occurrence, extraction and metallurgy of Zirconium, Hafnium, Niobium, Tantalum, Platinum and Palladium metals.	**09 L**
2.2	Physical and chemical properties, applications and compounds of these metals.	**06 L**
	Module - III	
3	**Chemistry of Non Heme proteins**	**15 L**
3.1	Coordination geometry of the metal ion and functions.	**03 L**
3.2	Zn in biological systems: Carbonic anhydrase, protolytic enzymes, e.g. carboxypeptidase, Zinc finger.	**03 L**
3.3	Role of metal ions in biological electron transfer processes Copper containing proteins and enzymes.	**05 L**

3.4	Less common ions in biology e.g. Co, Ni, V Metallothioneins, Biomineralization	**04 L**
	Module – IV	
4	**Nuclear Chemistry and Inorganic Pharmaceuticals**	**15 L**
4.1	Introduction 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.	**08 L**
4.2	Inorganic Pharmaceuticals: Compounds of iron, calcium and lithium, gold antiarthritic drugs, anticancer drugs, radiopharmaceuticals containing Tc, Ga and Xe isotopes, contrast agents for X-ray and NMR imaging.	**07 L**

References:

Module I

1. B. K. Sharma, Industrial Chemistry, Goel Publishing House, 2001.
2. Satyaprakash, Malik, Tuli, Advance Inorganic Chemistry, S. Chand Publication, 2015.
3. James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993
4. Gary wulfsberg, Inorganic chemistry, viva books, 2010.
5. Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004
6. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., Calcutta, 2001.
7. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
8. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, New York, 1978.
9. George A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., New York, 1997.

Module II

1. James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993.

2	Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.	
3	R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., Calcutta, 2001.	
4	R. C. Mehrotra, A. Singh, Organometallic Chemistry: A unified approach- 2nd Edition, New Age International Publication, 2006.	
	Module III	
1	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993.	
2	Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004	
3	Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.	
4	D. Banerjea, Coordination Chemistry, Tata McGraw Hill, New Delhi, 1993.	
5	Gopalan and Ramalingam, Concise coordination chemistry 2012.	

	Module IV	
1	G. T. Seaberg, Man-made Transuranic Elements Prentice- Hall, 1963.	
2	M.T. R. Series, The Superheavy Elements.	
3	Haissilsky, Nuclear Chemistry and its Applications, 1962.	
4	H. J. Arnikar, Nuclear Chemistry, 1984.	
5	A.V.R. Reddy, D. D. Sood, Nuclear Chemistry, IANCAS Publishers.	

M.Sc. – II

Inorganic Chemistry Semester IV

Course Code –– PSICH 403

Applications of Inorganic Spectroscopy

	Module I	
1	**Vibrational Spectroscopy & Diffraction Methods**	**15 L**
1.1	Symmetry and shapes of AB_2, AB_3, AB_4, AB_5 and AB_6 molecules. Mode of bonding of ambidentate ligands, ethylenediamine and diketonato complex. Applications of resonance Raman spectroscopy for the study of active sites of metalloproteins, metal-nitrogen, metal-sulphur.	**07 L**
1.2	**Electron Diffraction:** Scattering intensity vs. scattering angle, wierl equation, measurement technique, elucidation of structure of simple gas phase molecule, Low energy electron diffraction and structure of surface.	**04 L**
1.3	**Neutron Diffraction:** Scattering of neutron by solids and liquids, maganetic scattering, Measurement technique, Elucidation of structure of magnetically ordered unit cell.	**04 L**
	Module – II	
2	**Electronic Spectroscopy:**	**15 L**
2.1	**Atomic Spectroscopy:** Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali atoms.	**04 L**
2.2	**Molecular Spectroscopy:** Energy level, molecular orbitals, vibronic transition, vibrational progressions and geometry of the excited states. Franck-Condon Principle, electronic spectra of polyatomic molecule, emission spectra, radiative and non radiative decay, internal conversion, spectra of transition metal complexes, charge transfer spectra.	**07 L**
2.3	**Photoelectron Spectroscopy:**	**04 L**

	Basic principles, photo-electric effect, ionization process, koopman theorem,photoelectron spectra of simple molecules, ESCA, chemical information from ESCA.	
	Module – III	
3	**NMR, NQR and ESR spectroscopy of Inorganic compounds**	**15 L**
3.1	**Nuclear Magnetic Resonance:** The contact and pseudocontact shifts, Factors affecting nuclear relaxation, NMR of metal nuclides with emphasis on ^{195}Pt and ^{119}Sn spectra, Measurements of paramagnetic susceptibilities of coordination compounds.	**07 L**
3.2	**Nuclear Quadrupole Resonance Spectroscopy :** Quadrupole nuclei, quadrupole moments, electric fields gradient, coupling constant, splitting, application.	**05 L**
3.3	**Electron Spin Resonance:** Application of ESR and magnetic susceptibility studies of metal complexes: interpretation of ESR spectra of Cu(II) complexes (octahedral, square planar and tetragonal complexes) and susceptibility results for the same.	**03 L**
	Module – IV	
4	**Inorganic Photochemistry and Spectroscopic Method**	**15 L**
4.1	Inorganic Photochemistry: Luminescence: Fluorescence and Phosphorescence of Transition and Inner Transition Elements. Prompt and Delayed Reactions	**05 L**
4.2	Spectroscopic methods viz., Job's method, mole-ratio and slope-ratio methods for determination of stepwise formation constants of metal complexes.	**05 L**
4.3	Interpretation of electronic spectra for octahedral (Ni(II) and Cr(III)) and square planar complexes for d8 ions [Ni(II), Pd(II), Pt(II)], IR and Raman spectroscopy with reference to metal- nitrogen, metal-oxygen and metal-sulfur bonds.	**05 L**

References:	
	Module I/II/III
1	Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination compounds
2	C. N. Banwell, Fundamental of molecular spectroscopy, Tata McGraw-Hill Education, 1994
3	R. S. Drago, Physical methods in inorganic chemistry
4	Syamal and Dutta, Elements of magnetochemistry.
5	Hammer, Inorganic spectroscopy.
	Module IV
1	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry– Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993
2	Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.
3	D. Banerjea, Coordination Chemistry, Tata McGraw Hill, New Delhi, 1993.

	M.Sc. – II **Chemistry Semester IV** **Course Code - PSCH 404** **Environmental and Green Chemistry**	
	Environmental chemistry	
	Module I: Air and Water Pollution	**15 L**
1	**Air pollution:**	**07 L**
1.1	Natural and anthropogenic sources of pollution, primary and secondary pollutants, transport and diffusion of pollutants, gas laws governing the behaviour of the pollutants in the atmosphere.	**03 L**
1.2	Sampling and analysis of: particulate matter, aerosols, SO_2, H_2O, NO_x, CO, NH_3, organic vapours.	**03 L**
1.3	Effect of pollutants on human beings, plants, animals, materials and on climates.	**01 L**
	Water pollution:	**08 L**
1.4	Sources of water pollution, basic chemistry of water pollutants, effects and control.	**02 L**
1.5	Determination of water pollution parameters and their significance.	**01 L**
1.6	Physical parameters: colour, pH, Temperature, odour, turbidity, density, TOS, TSS,TDS.	**02 L**
1.7	Chemical parameters- acidity, alkalinity, hardness, DO, COD, BOD, TOC, THOD, MPN, biological parameters.	**02 L**
1.8	Heavy metal pollutants like Hg, Pb, Cd, As, Cu, Cr with respect to their sources, Distribution, speciation, toxic effect, control, treatment.	**02 L**
	Module II: Pollution control technology	**15 L**
	Air pollution control technologies: methods to control air pollution in the environment, Limestone injection and fluidised bed combustion, desulphurisation, catalytic convertor and control of vehicular emission, gravity setting chamber, fabric filters.	**05 L**
2.1	**Solid Waste disposal**: solid waste disposal methods- open dumps, ocean dumping, land-fills, incineration, recycling and reuse, organic pollutants and hazardous waste disposal and management, non-destructive solid waste, biomedical waste.	**05 L**

2.2	**Sewage and wastewater treatment system**: primary, secondary and tertiary treatments, measurements of treatment efficiencies. biological treatments- aerobic versus anaerobic treatments, bioaugmentation and biostimulation, biofilms in treatments.	**05 L**
	Module III: Non renewable energy sources	**15 L**
3.1	Concept and demand of energy, Growing energy needs, Renewable and non renewable sources of energy.	**02 L**
3.2	Use of alternate energy sources, Wind energy, Solar energy, Nuclear energy, Tidal energy. Water as a source of energy.	**06 L**
3.3	Biofuels production, use and sustainability, use and over exploitation of energy sources and associated problems	**04 L**
3.4	Role of an individual in conservation of natural resources. Equitable use resources for sustainable lifestyles	**03 L**
	Module IV: Environmental policies, Regulation, Assessment and Green Chemistry	**15 L**
4.1	Important environmental laws in India: Article 48A, Article 51 A, and other laws for environmental management. Role of HOEF and pollution control boards in pollution control- role of international environmental agency- UNEP, GEF, UNFCCC and IPCC.	**03 L**
4.2	Environmental impact assessment (EIM): need of EIA, scope, objectives, types of environmental impacts, steps involved in conducting the EIA studies, techniques- Ad-hoc method, checklist method, overlay mapping method, merits and demerits of EIA studies.	**04 L**
4.3	Environmental audit: types, objectives, benefits, practice and procedures.	**03 L**
4.4	Principle and concept of green chemistry, environmental benign solutions, solvent free systems, SCF, ionic liquids as catalysts and solvents, photochemical reactions, chemistry using microwave, sonochemistry, electrochemical synthesis, Designing greener processes- inherently safer designs (ISD), process intensification (PI) in process monitoring. Porous phase reactions, heterogeneous catalysis, bio-catalysis, greener methods.	**05 L**
	References: Module I/II/III/IV 1. Environmental Pollution Analysis, S. M. khopkar, New Age International publication (2011). 2. Water and water pollution (hand book) Ed., Seonard'lCiacere, Vol I to IV, Marcel Dekker inc. N.Y.(1972) 3. Water pollution, Arvindkumar, APH publishing (2004) 4. Introduction to Potable Water Treatment Processes	

Simon Parsons, Bruce Jefferson, Paperback publication.
5. Guidelines for drinking-water quality, third edition, (incorporating first and second addenda). WHO report.
6. Solid waste management, K Sasikumar and Sanoop Gopi Krishna PHI publication (2009)
7. Solid waste management, Surendra kumar, Northern Book Center (2009)
8. Handbook of chemical technology and pollution control 3rd Edn Martin Hocking AP Publication (2005).
9. Fundamental Concepts of Environmental Chemistry, Second Edition G. S. Sodhi , Alpha Science, 2005
10. Chemical analysis of metals ; Sampling and analysis of metal bearing ores: American Society for Testing and Materials 1980 - Technology & Engineering
11. 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.
12. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).

Zone refining and allied techniques, Norman L. Parr, G. Newnes Technology & Engineering (1960).

Project and Dissertation

In semester IV the student will not have any practical courses instead students will be undertaking project work of duration 4 months in the college laboratories.

Project work goals:

- The students will learn the skills required to succeed in industry or professional school.
- The students will learn and will be exposed to a breadth of experimental techniques using modern instrumentation.
- The student will learn the laboratory skills needed to design, safely conduct and interpret chemical research.
- The student will acquire a foundation of chemistry of sufficient breadth and depth to enable them to understand and critically interpret the primary chemical literature.
- The student will develop the ability to effectively communicate scientific information and research results in written and oral formats.
- The student will learn professionalism, including the ability to work in teams and apply basic ethical principles.