Rayat Shikshan Sanstha's

Karmaveer Bhaurao Patil College Vashi, Navi Mumbai

Autonomous College

Syllabus for Approval

M.Sc.-II Inorganic Chemistry

Sr. No.	Heading	Particulars
1	Title of Course	M.Sc.-II Inorganic Chemistry
2	Eligibility for Admission	M.Sc.-I
3	Passing Marks	Minimum 'D' Grade or equivalent minimum marks for passing at the M.Sc.-I level.
4	Ordinances/Regulations (if any)	
5	No. of Years/Semesters	One year/Two semester
6	Level	P.G. Part-II
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic year	2019-2020

AC – 02/03/2019
Item No. 2.10

Rayat Shikshan Sanstha's
KARMAVEER BHAURAO PATIL COLLEGE, VASHI.
NAVI MUMBAI
(**AUTONOMOUS COLLEGE**)
Sector-15- A, Vashi, Navi Mumbai - 400 703

Syllabus for M.Sc.-II Inorganic Chemistry

Program: M.Sc.

Course: M.Sc.-II Inorganic Chemistry

(Choice Based Credit, Grading and Semester System with effect from the academic year 2019-2020)

Scheme of Examination for Each Semester:

Continuous Internal Evaluation: 40 Marks (Common Written Test-20 Marks & 20 Marks For- Seminar, Assignment, Projects, Group discussion, Open book test, online test, Industrial visits etc.)

Semester End Examination: 60 Marks will be as follows -

I.	**Theory:**	
	Each theory paper shall be of two and half hour duration.	
	All questions are compulsory and will have internal options.	
	Q – I	From Unit – I (having internal options.) 12M
	Q – II	From Unit – II (having internal options.) 12M
	Q – III	From Unit – III (having internal options.) 12 M
	Q – IV	From Unit – IV (having internal options.) 12 M
	Q – V	Questions from all the FOUR Units with equal weightage of marks allotted to each unit. 12 M
II.	**Practical**	The External examination per practical course will be conducted as per the following scheme.

Sr. No.	**Particulars of External Practical Examination**	**Marks%**
1	Laboratory Work	80
2	Journal	10
3	Viva	10
	TOTAL	**100**

Choice Based Credit, Grading and Semester System with effect from the academic year 2018-2019

M.Sc.-II Inorganic Chemistry

Semester - III

Course Code	Unit	Topics	Credits	L/Week
PGCHI301	I	Chemistry of Inorganic Solids	4	1
	II	Imperfection in crystals and Non-		1
	III	Methods of Preparations		1
	IV	Behavior of Inorganic Solids		1
PGCHI302	I	Bio-inorganic and Coordination Chemistry	4	1
	II	Reactivity of Chemical Species -		1
	III	Reactivity of Chemical Species -II		1
	IV	Structure, Bonding, and Stereochemistry of Coordination Compounds		1
PGCHI303	I	Diffraction Methods -I	4	1
	II	Diffraction Methods –II		1
	III	Electron Spin Resonance Spectroscopy		1
	IV	Mossbauer Spectroscopy		1
PGCHIEC-I 304	I	Safety in Chemistry Laboratories	4	1
	II	Manufacture and Applications of		1
	III	Inorganic Compounds-I		1
	IV	Metallurgy		1
PGCHIP301 PGCHIP302 PGCHIP303 PGCHIP304	-	Practical Course	8	16

Note: 1. Blue Highlighted Topic / Course has focus on employability/ entrepreneurship/skill development

2. Yellow Highlighted Topic / Course is related to professional ethics, gender, human values, Environment & sustainability

Course Outcomes

PGCHI301	Chemistry of Inorganic Solids	Unit I : Descriptive Crystal Chemistry	1.To predict the structures of AB type compounds illustrating the PbO and CuO.[4] 2.To predict the structures of AB_2 type compounds giving the examples of β -cristobalite, CaC_2 and Cs_2O. [4] 3.To investigate the structures of A_2B_3 type of compounds citing Cr_2O_3 and Bi_2O_3. [5] 4.To investigate the structures of AB_3 type of compounds illustrating ReO_3 and Li3N. [4] 5.To examine the structures of ABO_3 type compounds and deduce relation between ReO_3 and perovskite $BaTiO_3$ and its polymorphmic forms. [4] 6. To account for Oxide bronzes and ilmenite structure. [2] 7. To investigate the structures of AB_2O_4 type normal, inverse, and random spinels. [4] 8. To describe corner sharing illustrating tetrahedral structure in Silicates and octahedral Structure in ReO_3. [3] 9. To discuss the rotation of ReO_3 resulting in VF3, RhF3 and calcite type structures. [2] 10. To explain Edge sharing in tetrahedral structures illustrating in SiS_2 and octahedral structures in BiI3 and $AlCl_3$. [2] 11. Account for pyrochlores, octahedral tunnel structures and lamellar structures. [3]
		Unit II: Imperfection in crystals and Non-Stoichiometry.	1.To discuss Point defects in metals and ionic Crystal stressing on Frenkel defect and Schottky defect. [2] 2.To explain thermodynamically formation of Frenkel defect and Schottky defects. [3] 3.To deduce mathematical expression to find Frenkel and Schottky defect concentration. [5] 4.To discuss defects observed in non-Stoichiometric compounds. [2] 5.To account for color centers in Inorganic solids. [2] 6.To Explain Edge and Screw Dislocations. [2] 7.To know Mechanical Properties and reactivity of Solids. [2] 8.To describe Grain Boundary and Stacking Fault. [2] 9. To identify Dislocation and Grain Boundaries in crystals. [3] 10. To explain vacancies and Interstitial Space in Non-Stoichiometric Crystals. [3] 11. To account for Defects in Clusters. [2] 12. To memorise on Interchangeable Atoms and Extended Atom Defects. [1]
		Unit III: Methods of Preparations	1.To select proper methods like Chemical Method, High Pressure Method, Arc Technique and Skull Method giving examples to prepare inorganic solids. [4] 2.To discuss various methods of crystal growth from its melts citing Bridgman and Stockbargar, Czochralski

			and Vernuil methods of preparation of inorganic solids. [3] 3.To discuss various methods of crystal growth from its liquid solution illustrating Flux growth and temperature gradient methods to prepare inorganic solids. [2] 4.To know the Crystal growth from vapour phase selecting Epitaxial growth methods, physical methods and chemical methods for preparation of Inorganic solids. [2] 5.To know Mechanistic Approach of formation of Substitutional, Interstitial and Complex Solid Solutions. [2] 6.To memorize the Study of Solid solutions by X-ray Powder Diffraction and Density Measurement to prepare inorganic solids. [2]
		Unit IV: Behaviour of Inorganic Solids	1.To State and Explain Fick's Laws of Diffusion. [2] 2.Discuss Kirkendal Effect. [2] 3.Investigate Wagner mechanism. [4] 4.To account for Diffusion and Ionic Conductivity in Inorganic solids. [4] 5.To Discuss applications of Diffusion in Carburizing and non-Carburizing Processes to preparation steel. [2] 6.To underline General principles and factors influencing reactions of solids and Reactivity of solids. [2] 7.To give a brief introduction of liquid crystals. [2] 8.To sort thermotropic liquid crystals. [2] 9.To account for Polymorphism in liquid crystal, their Properties and applications. [2]
PGCHI302	Bioinorganic and Coordination Chemistry	Unit-I Bioinorganic Chemistry	1.To describe coordination geometry of the metal ion in biological systems [2] 2.To illustrate role of metal ions in biological electron transfer processes [3]
		Unit-II Reactivity of Chemical Species -I	1.To classify Lewis acids and bases based on frontier Molecular orbital topology [2] 2.To illustrate Group Characteristic of Lewis acids in periodic table. [3] 3.To determine the strength of oxoacids [2]
		Unit-III Reactivity of Chemical Species -II	1.To compare Pourbaix diagrams of different chemical species. [5] 2. To recite amphoteric behaviour, Periodic trends in amphoteric properties of p-block and d-block elements [2] 3.To calculate hardness and Softness of Acids and Bases [3] 4.To describe heterogeneous acid-base reactions. [2]
		Unit-IV Structure, Bonding, and Stereochemistry of	1.To apply Molecular Orbital Theory for Complexes with Coordination Number 4 and 5 for the central ion. [5] 2.To apply Angular Overlap Model for octahedral and tetrahedral complexes for sigma and pi bond. [3] 3.To describe chirality and Fluxionality of Coordination Compounds with Higher Coordination Numbers [2]

		Coordination Compounds	
PGCHI303	Spectral Methods in Inorganic Chemistry	Unit-I Diffraction Methods -I	1. To describe Bragg Condition; Miller Indices. [2] 2. To apply Laue Method to find orientation of large single crystals in inorganic solids [3] 3. To analyse X-Ray Structural Crystals by Scherrer Method. [4]
		Unit-II Diffraction Methods -II	1. To describe Scattering of electrons. [2] 2. To compare Scattering Intensity versus Scattering Angle [5] 3. To Elucidate Structures of Simple gas Phase Molecules. [2]
		Unit-III Electron Spin Resonance Spectroscopy	1. To interpret spectra Electron Spin Resonance of given inorganic species. [3] 2. To describe Basic principle, Instrumentation of Mossbauer Spectroscopy [2] 3. To compare interaction between nuclear spin and electron spin [3]
		Unit-IV Mössbauer Spectroscopy	1. To describe Basic principle, recoil energy and Doppler shift. [2] 2. To summarize Isomer shift, quadrupole interaction, magnetic interaction, electronegativity and chemical shift. [2] 3. To interpret Mossbauer Spectroscopy of inorganic species. [3]
PGCHIEC-I 304	Applied Chemistry (Elective)	Unit-I Electron Spin Resonance Spectroscopy	1. To summarize handling of Hazardous Materials, Toxic Materials, Explosives and Inflammable Materials. [2] 2. To illustrate types of fire extinguishers [3] 3. To propose ideas for recycling & recovery of metals used in the laboratory. [6]
		Unit-II Manufacture and Applications of Inorganic Compounds -I	1. To summarize industrial preparation of Lime, Chlorine and Caustic soda, Ceramics and refractory materials [2] 2. To summarize industrial preparation of Cement [2] 3. To Discuss inorganic explosives in details [2] 4. To propose idea for synthesis of industrially important chemicals at small scale. [6]
		Unit-III Manufacture and Applications of Inorganic Compounds -II	1. To summarize industrial preparation of Fertilizers and micronutrients [2] 2. To formulate micronutrients that will minimize pollution from agri-fertilizers. [3] 3. To summarize industrial preparation of Glass Paints and Pigments [2]

		Unit-IV Metallurgy	1. To illustrate, summarize occurrence, extraction and metallurgy of different inorganic ores [2] 2. To summarize physical and chemical properties and applications of these metals [2] 3. To illustrate uses of different Compounds of metals, alloys. [2]
PGCHIEC-II304	Applied Chemistry (Elective)	Unit-I Inorganic Materials	1. To summarize classification, manufacture and applications of (i) Inorganic fibres, and (ii) Inorganic fillers. [2] 2. To illustrate Preparation, properties and uses of industrially important chemicals [2]
		Unit-II Nuclear Chemistry and Inorganic Pharmaceuticals	1. To summarize separation of fission products from spent fuel rods by PUREX process. [2] 2. To illustrate Radiopharmaceuticals containing Tc and Bi, contrast agents for X-ray and NMR imaging agents. [3] 3. To summarize properties and uses of protectives, adsorbents, antimicrobial agents, astringents etc. [2]
		Unit-III Advances in Nanomaterials and Inorganic Photochemistry	1. To summarize types of nanomaterials nanotubes, nanorods. [2] 2. To discuss optical properties of metal and semiconductor nanoparticles. [3] 3. To describe various methods for growth of semiconductors. [2] 4. To survey use of nanomaterials in electronics, energy, automobiles, sports [6]
		Unit-IV Inorganic Photochemistry and stability Constants	1. To summarize transition between energy states, decay process, photophysical pathways [2] 2. To recite examples of main photochemical processes: non-redox processes [2] 3. To rewrite mechanism and salient features of photosynthesis reaction [2]
PGCHIP301	Analysis of ores/alloys		1. To perform analysis of different ores and alloys to find out contents. [5]
PGCHIP302	Solvent Extraction		1. To Separate different mixtures of inorganic cations using solvent extraction technique [4]
PGCHIP303	Inorganic Preparations		1. To prepare different Inorganic complexes. [4]
PGCHIP304	Analysis of the samples		1. To analyse different commercial samples by various methods. [4]

***Note: [1]: Remembering, [2]: Understanding, [3]: Applying, [4]: Analysing, [5]: Evaluating, [6]: Creating**

M.Sc. INORGANIC CHEMISTRY

SEMESTER III

Course Code	Unit	Topics
		(Numericals and word problems wherever possible**.)**
PGCHI 301		**1. Chemistry of Inorganic Solids**
	I	**1.1 Descriptive Crystal Chemistry(15 L)**
		(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 polymorphmic 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
	II	**1.2 Imperfection in crystals and Non-Stoichiometry (15 Lectures)** **(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-Stoiochiometric 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 Defects.
		1.3 Methods of Preparations (15 Lectures)
		(a) Methods of Synthesis: Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples).
	III	**(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 vapor 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.
	IV	**1.4 Behavior of Inorganic Solids (15 Lectures)** **(a) Diffusion in Solids**: Fick's Laws of Diffusion; Kirkendal 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.
		REFERENCE BOOKS 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 & sons, 1987. 3. C.N.R. Rao and J.Gopalkrishnan New Directons in Solid State Chemistry, 2nd Ed., Combridge University Press. 1997 4. L.V. Azaroff, Introductionn 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. 6. J.M. Hollas, Symmetry in Molecuies, Chapman adn Hall Ltd.,1972. 7. Reboert L carter, Molecular Symmeetry and Group Hohn 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.Chakraborty, Solid State Chemistry, New Age International Publishers, 1996. 12. A. Earnshaw, Introduction to Magnetochemistry, Acad. Press,N.Y. (1966)
		2. Bioinorgnic and Coordination Chemistry.
PGCHI 302	**I**	**2.1 Bioinorganic Chemistry(15 Lectures)** (i)Coordination geometry of the metal ion and functions. (ii)Zn 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. Mn (arginase; structure and reactivity), Ni (urease ; structure and reactivity) (v) Biomineralization
	II	**2.2 Reactivity of Chemical Species -I (15Lectures)** 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 (Gp-1,13-17). 2.2.3 Pauling rules to determine the strength of oxoacids; classification and Structural anomalies.
	III	**2.3 Reactivity of Chemical Species -II (15Lectures)** **2.3.1 Pourbaix Diagrams.** 2.3.2Amphoteric behavior, Periodic trends in amphoteric properties of p-block and d-block elements 2.3.3 Oxoanions and Oxocations. 2.3.4 Measures of hardness and Softness of Acids and Bases, Drago-wayland equations 2.3.5 Applications of acid-base Chemistry: Super acids and Super bases, heterogeneous acid-base reactions.
	IV	**2.4 Structure, Bonding, and Stereochemistry of Coordination Compounds (15 Lectures)** **(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.
		REFERENCES: 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 &

		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 & 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 & 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 & Sons,1983. 22. James E.Huheey, Inoganic Chemistry-Principles of structure and reactivity, edn Harper & 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 MetalAtoms, 2nd edition, claranden Press, Oxford, 1993. 25. P.L. Soni, Vandana Soni ,Ane Books Pvt.,Ltd
		3. Spectral Methods in Inorganic Chemistry
	I	**3.1 Diffraction Methods -I (15 Lectures)** X-Ray Diffraction: Bragg Condition; Miller

PGCHI 303		Indices; Laue Method; Bragg Method; Debye Scherrer Method of X-Ray Structural Analysis of Crystals.
	II	**3.2 Diffraction Methods -II** **(15 Lectures)** **(a) Electron Diffraction:** Scattering of electrons, Scattering Intensity versus Scattering Angle, Weirl Measurement Technique, 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.
	III	**3.3 Electron Spin Resonance Spectroscopy (15 Lectures)**
		(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 gtensors, (v) Application to transition metal complexes (having one unpaired electron)
	IV	**3.4 Mossbauer Spectroscopy** **(15 Lectures)**
		Mössbauer Spectroscopy: 3.4.1 Basic principle, recoil energy and Doppler shift. 3.4.2 Instrumentation: sources and absorber; motion devices, detection, reference substances and calibration, 3.4.3 Isomer shift, quadrupole interaction, magnetic interaction, electronegativity and chemical shift. 3.4.4 Applications: *Iron compounds*- low spin and high spin Fe(II) and Fe(III) compounds and complexes, effect of pi-bonding, mono and poly nuclear 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.
		REFERENCES: 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)
		4. Applied Chemistry(Elective)
		4.1 Safety in Chemistry Laboratories (15 Lectures) 4.1.1 Handling of Hazardous Materials 4.1.2 Toxic Materials (Various types of toxins and their effects on humans)

PGCHIEC-I 304	**I**	4.1.3 Explosives and Inflammable Materials 4.1.4 Types of fire extinguishers(chemical reaction) 4.1.5 Bioactive materials. 4.1.6 Recycling& recovery of metals with reference to Silver, lead, cobalt, Nickel and chromium 4.1.7 Laboratory Wastes Disposal Management in Chemical Laboratories .
	ll	**4.2 Manufacture and Applications of Inorganic Compounds-I(15Lectures)** 4.2.1 Lime, Chlorine and Caustic soda, 4.2.2 Ceramics and refractory materials 4.2.3 Cement 4.2.4 Inorganic explosives (mercury fulminate, Lead azide)
	III	**4.3 Manufacture and Applications of Inorganic Compounds-II (15 Lectures)** 4.3.1 Fertilizers and micronutrients 4.3.2 Glass 4.3.3 Paints and Pigments
	IV	**4.4 Metallurgy (15 Lectures)** 4.4.1 Occurrence, extraction and metallurgy of Zirconium, Hafnium, Niobium, Tantalum Platinum and Palladium metals. 4.4.2 Physical and chemical properties and applications of these metals, 4.4.3 Compounds of these metals, alloys and their uses.
		REFERENCES: 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, 19 . 4. D. A. Skoog, D. M. West, and F. J. Holler, Fundamentals of Analytical Chemistry, 7 th Edition, (printed in India in 2001), ISBN Publication. 5. B. Douglas, D.H. McDaniel and J. J. Alexander, Concepts and Models of Inorganic Chmistry, 2nd edition, John Wiley & Sons, 1983.
	I	4.1 Inorganic Materials (15 Lectures) Elective (a) Classification, manufacture and applications of (i) Inorganic fibers, and (ii) 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.

PGCHIEC-II 304		
	II	**4.2 Nuclear Chemistry and Inorganic Pharmaceuticals (15 Lectures)** **(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 Tc and Bi, contrast agents for X-ray and NMR imaging. Gasrtrointestinal agents viz. (i) antacids(aluminium hydroxide, milk of magnesia, sodium bicarbonate and (ii) Cathartics (magnesium sulphate and sodium phosphate). Topical agents viz.(i) protectives and adsorbents(talc, calamine), (ii) antimicrobial agents(potassium permanganate, tincture iodine, boric acid) and astringents(potash alum) .
	III **IV**	4.3 Advances in Nanomaterials and Inorganic Photochemistry: (15 Lectures) (a) Types of nanomaterials, e.g. nanotubes, nanorods, solid spheres, core-shell Nanoparticles, mesoporous materials; isolation of nano materials (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, electronic structure; Porous silicon: Preparation and mechanism of porous silicon formation, Factors affecting porous structure, properties of porous silicon; Aerogels: Types of aerogels, Properties and applications of aerogels. (d) Applications of nanomaterials in lectronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defense. Environmental effects of nanotechnology **4.4 Inorganic Photochemistry and stability Constants. (15 Lectures)** Transition between energy states, decay process, photophysical pathways (fluorescence and phosphorescence), Jablonski diagram, photochemical pathways (unimolecular or intramolecular process and bimolecular or intermolecular process), quantum yield,Kasha's rule and Stoke shifts, identification of excited states, examples of main photochemical processes: non-redox processes(photoisomerization, photodissociation, photosubstitution), photoredox processes : general aspects and mechanism. Photosynthesis reactions (mechanism and salient features of photosynthesis reaction (I and II), light harvesting, solar energy conversion, metal ion sensors, chemosensors, artificial photosynthesis

		REFERENCES: 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, 19 . 4. D. A. Skoog, D. M. West, and F. J. Holler, Fundamentals of Analytical Chemistry, 7 th Edition, (printed in India in 2001), ISBN Publication. 5. B.Douglas, D.H. McDaniel and J.J.Alexander, Concepts and Models of Inorganic Chmistry, 2nd edition, John Wiley & Sons, 1983. 5. J.R. Gispert, Coordination Chemistry, Wiley-VCH 2008.

PRACTICALS
SEMESTER-III Inorganic Chemistry -II

PGCHIP301: Analysis of ores/alloys

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.

PGCHIP302: Solvent Extraction

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 U and Fe using 8-hydroxyquinoline in chloroform and estimation of U
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

PGCHIP303: Inorganic Preparations

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. Hexaamine cobalt (III) chloride
6. Preparation of Trans-bis (glycinato) Cu(II)

PGCHIP304: Analysis of the following samples

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-phenonthroline method.
4. Calcium tablet for its calcium content by complexometric titration.
5. Bleaching powder for its available chlorine content by iodometric method.
6. Iron tablet for its iron content colorimetry by 1,10-phenonthroline method.
7. Nycil powder for its Zn content complexometrically.

Reference books for practicals

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).

Choice Based Credit, Grading and Semester System with effect from the academic year 2018-2019

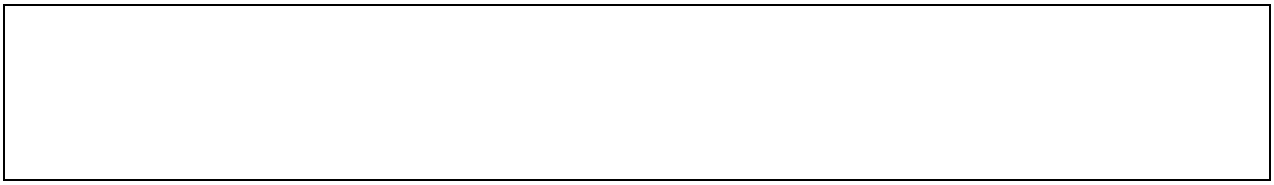
M.Sc.-II Inorganic Chemistry

Semester – IV

Course Code	Unit	Topics	Credits	L/Week
PGCHI401	I	ELECTRICAL PROPERTIES	4	1
	II	MAGNETIC PROPERTIES		1
	III	THERMAL AND OPTICAL PROPERTIES		1
	IV	APPLICATIONS OF GROUP THEORY TO -ELECTRONIC STRUCTURES		1
PGCHI402	I	ORGANOMETALLIC CHEMISTRY	4	1
	II	APPLICATIONS OF ORGANOMETALLIC		1
	III	COMPOUNDS		1
	IV	INORGANIC CLUSTER AND CAGE COMPOUNDS		1
PGCHI403	I	SPECTROSCOPY	4	1
	II	MICROSCOPY OF SURFACE CHEMISTRY-I		1
	III	MICROSCOPY OF SURFACE CHEMISTRY-II		1
	IV	THERMAL METHODS		1
PGCHIEC-II 404	I	PRINT, DIGITAL, JOURNALS, INFORMATION TECHNOLOGY AND LIBRARY RESOURCES	4	1
	II	DATA ANALYSIS		1
	III	METHODS OF SCIENTIFIC RESEARCH AND WRITING		1
	IV	SCIENTIFIC PAPERS		1
PGCHIP401 PGCHIP402 PGCHIP403 PGCHIP404	-	PRACTICAL COURSE	8	16

Note: 1. Blue Highlighted Topic / Course has focus on employability/ entrepreneurship/skill development

2. Yellow Highlighted Topic / Course is related to professional ethics, gender, human values, Environment & sustainability



Course Outcomes

PGCHI401	Properties of Inorganic Solids and Group Theory	Unit I: Electrical properties.	1. To discuss conductivity of Solid Electrolytes. [2] 2. To account for Fast Ion Conductors. [2] 3. To investigate the Mechanism of Conductivity and to identify Hopping Conduction. [3] 4. To demonstrate Thomson and Seebeck Effects. [2] 5. To describe Thermocouples and memorize their Applications. [2] 6. To investigate Hall Effect. [3] 7. To interpret Dielectric, Ferroelectric, Piezoelectric and Pyrroelectric Materials and deduce their Inter-relationships. [3] 8. To compile the applications of Dielectric, Ferroelectric, Piezoelectric and Pyrroelectric Materials. [2]
		Unit II : Magnetic Properties	1. To investigate the behaviour of substances in magnetic field. [3] 2. To observe the mechanism of ferromagnetic and antiferromagnetic ordering and identify super exchange phenomenon. [3] 3. To interpret Magnetic Hysteresis loop in inorganic solids. [2] 4. To compare Hard and soft magnets giving examples. [2] 5. To predict structures and to interpret magnetic Properties of Metals and Alloys. [3] 6. To predict structures and to interpret magnetic Properties of Transition metal Oxides; Spinels; garnets, Ilmenites; Perovskite and Magneto plumbites. [3] 7. To discuss the applications of inorganic solids in transformer cores, information storage, magnetic bubble memory devices and as permanent magnets. [3]
		Unit III: Thermal and Optical Properties.	1. To know brief about thermal and optical properties of inorganic solids. [2] 2. To discuss Heat Capacitiy and deduce its Temperature Dependance. [2] 3. To explain thermal expansion of metals. [2] 4. To account for Ceramics, Polymers and Thermal Stresses. [2] 5. To Discuss Color centres and Birefringence [2] 6. To account for Luminescent and Phosphor Materials. [2] 7. To interpret Coordinate Model and Phosphor Model of inorganic solids. [2] 8. To know Anti Stokes Phosphor of inorganic solids [2] 9. To explain briefly Ruby Laser and Neodymium Laser. [2]
		Unit IV: Applications of group theory to	1. To identify Points groups and to design Character tables. [2] 2. To illustrate Transformation Properties of Atomic

		-Electronic structures	Orbitals. [2] 3. To discuss Sigma and pi- molecular orbitals illustrating for AB_4 (tetrahedral) and AB_6 (octahedral) molecules. [2] 4. To outline Ligand Field Theory. [2] 5. To predict Electronic structures of free atoms and ions based on Ligand field theory. [2] 6. To determine splitting of levels and to identify terms in a chemical environment on the basis of Ligand Field Theory. [2] 7. To construct energy level diagrams, Direct product and Correlation diagrams for d^2 ions in octahedral and tetrahedral ligand field. [3] 8. To investigate Methods of Ascending and Descending Symmetry. [3] 9. To explain briefly Hole formalism. [2]
PGCHI402	Organometallics and main group Chemistry	Unit-I Organometallic Chemistry	1. To summarize Metal-Metal Bonding and Metal Clusters. [2] 2. To apply theory of Electron Count and deduce stability Structures of Clusters [3] 3. To illustrate preparations, properties and applications of Organo Palladium and Organo Platinum Complexes. [2]
		Unit-II Applications of Organometallic Compounds	1. To compare Homogenous and Heterogeneous Catalysis [3] 2. To summarize catalytic activity in organic Reactions [2]
		Unit-III Inorganic cluster and cage compounds	1. To illustrate Bonding in boranes, Heteroboranes, Carboranes. [2] 2. To recite properties, structures and stability of boranes, Heteroboranes, Carboranes. [2] 3. To summarize electron precise compounds [2]
		Unit-IV Inorganic ring and chain compounds	1. To illustrate Bonding in Silicates, aluminosilicates, Phosphazenes, polycationic compounds [2] 2. To recite properties, structures and stability of Silicates, aluminosilicates, Phosphazenes, polycationic compounds. [2]
PGCHI403	Instrumental methods in Inorganic Chemistry	Unit-I Spectroscopy	1. To calculate Fundamental modes of vibrations. [3] 2. To summarize selection rules of IR & Raman spectra, IR absorption bands of metal - donor atom [2] 3. To analyze effect of complexation on the IR spectrum of ligands formations [2] 4. To elucidate structures of molecules on the basis of IR & Raman [2] 5. To determine the Symmetry Types of the Normal Modes of vibrations. [2] 6. To interpret of IR and Raman Spectra for molecules using group theory criterion. [2]

		Unit-II Microscopy of Surface Chemistry-I	1. To summarize surface spectroscopy, Microscopy, problems of surface, analysis, distinction of surface species, sputter etching [2] 2. To summarize theory, instrumentation involved in Ion Scattering Spectra, Secondary Ion Mass Spectroscopy, Auger Emission Spectroscopy[2]
		Unit-III Microscopy of Surface Chemistry-II	1. To summarize Instrumentation and applications of ESCA, SEM, AFM & TEM [2]
		Unit-IV Thermal Methods	1. To apply thermal characterization to polymers, quantitative analysis of mixture of oxalates. [3] 2. To apply principles of DSC and DTA in determination of thermodynamic parameters such as heat capacity and standard enthalpy of formation of the compounds. [3] 3. To summarize basic principles of instrumentation and applications to other thermal methods like Thermomechanical analysis. [2]
PGCHIEC-I 404	Research methodology	Unit: I	1. To understand various terminologies like Journal abbreviations, abstracts, current titles, reviews etc. [2] 2. To recite various terms like Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. [2] 3. To deduce information related given subject from digital sources available online. [2]
		Unit II: Data analysis	1. To apply scientific methods and design experiments. [3] 2. To analyse and present data of studied material using various calculative methods, tools and software. [4]
		Unit III: methods of scientific research and writing scientific papers	1. To analyse and write literature surveys and reviews, organize a poster display and give an oral presentation. [4] 2. To publish scientific work done by using ethics and avoiding plagiarism. [6]
		Unit IV: chemical safety & ethical handling of chemicals	1. To describe Safe working procedure in laboratories, safe storage and use of hazardous chemicals. [2] 2. To work safely with substances that pose hazards, flammable or explosive hazards. [2] 3. To demonstrate disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals[2] 4. To identify, verify and segregate laboratory waste and perform proper disposal of chemicals[2]
PGCHIP401	Analysis of ores/alloys		1. To perform analysis of different ores and alloys to find out contents. [2]
PGCHIP402	Solvent		1. To Separate different mixtures of inorganic cations using solvent extraction technique [2]

	Extraction		
PGCHIP403	Inorganic Preparations		1.To prepare different Inorganic complexes. [2]
PGCHIP404	Project Evaluation & Spectral Interpretation		1.To perform research project having different methods studied at theory classes and interpret spectra and present it in a proper format. [6]

***Note: [1]: Remembering, [2]: Understanding, [3]: Applying, [4]: Analysing, [5]: Evaluating, [6]: Creating**

SEMESTER IV
Choice Based Credit, Grading and Semester System with effect from the academic year 2018-2019

M.Sc.-II Inorganic Chemistry

Course Code	Unit	Topics
	I	(Numericals and word problems wherever possible.**)** **1 Properties of Inorganic Solids and Group Theory.**
		1.1 Electrical Properties- (15 Lectures)
PGCHI 401		**(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
	II	**1.2 Magnetic Properties. (15 Lectures)** (a) Behavior 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; Transition metal Oxides; Spinels; garnets, Ilmenites; Perovskite and Magneto plumbites, Application in transformer cores, information storage, magnetic bubble memory devices and as permanent magnets.
	III	**1.3 Thermal and Optical Properties (15 Lectures)** **a) Thermal Properties:** Introduction, Heat Capacitiy and its Temperature Dependance; Thermal Expansion of Metals; Ceramics and Polymers and Thermal Stresses. **(b) Optical properties:** Color Centres and Birefringence; Luminescent and Phosphor Materials; Coordinate Model; Phosphor Model; Anti Stokes Phosphor; Ruby Laser; Neodymium Laser

	IV	**1.4 Applications of group theory to -Electronic structures (15Lectures)** (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.
		REFERENCE BOOKS 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 & sons, 1987. 3. C.N.R. Rao and J.Gopalkrishnan New Directons in Solid State Chemistry, 2nd Ed., Combridge University Press. 1997 4. L.V. Azaroff, Introductionn 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. 6. J.M. Hollas, Symmetry in Molecuies, Chapman adn Hall Ltd.,1972. 7. Reboert L carter, Molecular Symmeetry and Group Hohn 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.Chakraborty, Solid State Chemistry, New Age International Publishers, 1996. 12. 12. A. Earnshaw, Introduction to Magnetochemistry, Acad. Press,N.Y. (1966)
	I	**2 Organometallics and main group Chemistry (15 Lectures)** **2.1 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.)
		2.2 Applications of Organometallic Compounds (15 Lectures)

PGCHI 402	**II**	(a) Catalysis-Homogenous and Heterogenous Catalysis: comparison, Fundamental Reaction Steps. (b) Organometallics as Catalysts in Organic Reactions: i)Hydrosilation, (ii)Hydroborationn. (iii) Water gas Shifts Reaction (iv) Wacker process (Oxidation of alkenes) (v)Alcohol corbonylation (c)Coupling reactions: (i) Heck's reaction (ii) Suzuki reaction
	III	**2.3 Inorganic cluster and cage compounds (15 Lectures)** (i) Introduction, (ii) Bonding in boranes, (iii) Heteroboranes, (iv) Carboranes, (v) cluster compounds, (vi) electron precise compounds and their relation to clusters.
	IV	**2.4 Inorganic ring and chain compounds (15 Lectures)** (a) Silicates, polysilicates and aluminosilicates, (b) Phosphazenes, phosphazene polymers (c) Polyanionic and polycationic compounds
		REFERENCES: 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 & 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 &

		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 & 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 & Sons,1983. 22. James E.Huheey, Inoganic Chemistry-Principles of structure and reactivity, edn Harper & 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 MetalAtoms, 2nd edition, claranden Press, Oxford, 1993. 25. P.L. Soni, Vandana Soni ,Ane Books Pvt.,Ltd
PGCHI 403	**I**	**3 Instrumental methods in Inorganic Chemistry .** **3.1 Spectroscopy (15 Lectures)** **(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_{42-} . **(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. (c) 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
	II	**3.2 Microscopy of Surface Chemistry-I (15 Lectures)** 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),
	III	**3.3 Microscopy of Surface Chemistry-II (15 Lectures)** ESCA, Scanning Electron Microscopy (SEM),Atomic force microscopy (AFM) and transmission electron microscopy (TEM): Instrumentation and applications.
	IV	**3.4 Thermal Methods (15 Lectures)** 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, M.P. and B.P. 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).
		REFERENCES: 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	

PAPER – IV: PGCHEC-l 404 (Elective-I)

Applied Nanotechnology

UNIT-I	**Introduction to Nanotechnology**	**15**
	Introduction – Quantum wire, quantum well, quantum dot, nanotubes, Properties of nanomaterials Synthesis techniques – Chemical precipitation and Co-precipitation, Sol-gel, CVD, Microwave heating, Sonochemical, Electrochemical, Photochemical methods. Nanomaterial characterization techniques – Diffraction methods, FTIR, UV-Visible, TGA, DTA, DSC.	
UNIT-II	**Carbon Nanostructures**	**15**
	Introduction, carbon molecules, allotropes of carbon, Graphite, Diamonds, Fullerenes, Carbon anions, carbon clusters, carbon nanotubes, Synthetic methods of different allotropes of carbon. Applications of carbon materials on nanotechnology.	
UNIT-III	**Biomedical applications of Nanotechnology**	**15**
	Introduction, biological sciences, photodynamic therapy in targeted drugs, advances in manufacturing, biomedical sensor and biosensors, quantum dot technology in cancer treatment, nanoparticles as a drug carrier	
UNIT-IV	**Environmental impacts of nanotechnology**	**15**
	Introduction, engineered nonmaterial in the body, routes of entry, toxic mechanisms, environmental implications of nanoparticles, toxicological health effects, relevant parameters in nanoparticle toxicology, integrated concept of risk assessment of nanoparticles	

REFERENCES:

1. Introduction to nanoscience and nano technology by, T.Pradeep.
2. Fundamentals of nano technology by, Gabbor L., J.Dutta.,J.Moore.
3. Text book of nanoscience and nano technology, James Murday.

4. Basics of Nanotechnology, H. G. Rubhan.

5. Nanotubes and Nanowires, A. Govindaraj and C. N. R. Rao

6. Essentials of Inorganic Materials Synthesis, C.N.R. Rao, Kanishka Biswas

COURSE CODE: PGCHIEC-II 404 (Elective-II)

PAPER - IV: RESEARCH METHODOLOGY

Unit 1: [15L]

Print: [5L]

Primary, Secondary and Tertiary sources.

Journals:

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: [5L]

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: [5L]

The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.

Unit II: DATA ANALYSIS [15L]

The Investigative Approach:

Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.

Analysis and Presentation of Data:

Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of

multiple linear regression analysis.

Unit III: METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS [15L]

Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.

Writing Scientific Papers:

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.

Unit IV: CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS

[15L]

Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below .atmospheric pressur, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

REFERENCES:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in Chemistry,* 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data Analysis for Chemistry* Oxford University Press.
3. Topping, J., (1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill, London.
4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters 3-5
5. Levie, R. De. (2001) *How to use Excel in Analytical Chemistryand in general scientific data analysis* Cambridge Universty Press.
6. Chemical Safety matters - IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

PAPER – IV: PGCHEC-l 404 (Elective-I)

Applied Nanotechnology

UNIT-I	**Introduction to Nanotechnology**	**15**
	Introduction – Quantum wire, quantum well, quantum dot, nanotubes, Properties of nanomaterials Synthesis techniques – Chemical precipitation and Co-precipitation, Sol-gel, CVD, Microwave heating, Sonochemical, Electrochemical, Photochemical methods. Nanomaterial characterization techniques – Diffraction methods, FTIR, UV-Visible, TGA, DTA, DSC.	
UNIT-II	**Carbon Nanostructures**	**15**
	Introduction, carbon molecules, allotropes of carbon, Graphite, Diamonds, Fullerenes, Carbon anions, carbon clusters, carbon nanotubes, Synthetic methods of different allotropes of carbon. Applications of carbon materials on nanotechnology.	
UNIT-III	**Biomedical applications of Nanotechnology**	**15**
	Introduction, biological sciences, photodynamic therapy in targeted drugs, advances in manufacturing, biomedical sensor and biosensors, quantum dot technology in cancer treatment, nanoparticles as a drug carrier	
UNIT-IV	**Environmental impacts of nanotechnology**	**15**
	Introduction, engineered nonmaterial in the body, routes of entry, toxic mechanisms, environmental implications of nanoparticles, toxicological health effects, relevant parameters in nanoparticle toxicology, integrated concept of risk assessment of nanoparticles	

REFERENCES:

1. Introduction to nanoscience and nano technology by, T.Pradeep.
2. Fundamentals of nano technology by, Gabbor L., J.Dutta.,J.Moore.

3. Text book of nanoscience and nano technology, James Murday.

4. Basics of Nanotechnology, H. G. Rubhan.

5. Nanotubes and Nanowires, A. Govindaraj and C. N. R. Rao

6. Essentials of Inorganic Materials Synthesis, C.N.R. Rao, Kanishka Biswas

PRACTICALS
SEMESTER-IV

PGCHIP401: Analysis of Ores

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.
2. Analysis of Zinc blend ore:
   (i) Zn content by complexometric method,
   (ii) Fe content by colorimetric method (Azide method).
3. Analysis of Haematite ore :
   (i) Fe content by complexometric method,
   (ii) Acid insoluble residue by gravimetric method.

PGCHIP402: 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 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 $[Ni(en)_3]^{2+}$

PGCHIP403: Analysis of the following samples

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. .

PGCHIP404: Project Evaluation & Spectral interpretation

Reference books for Practicals	
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).

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