University of Mumbai

No. AAMS_UGS/ICC/2024-25/149

CIRCULAR:-

Attention of all the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office Circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the Board of Deans at its meeting held on 3rd September, 2024 **vide** item No. 6.7 (N) have been accepted by the Hon'ble Vice Chancellor as per the power confirmed upon him under section 12(7) of the Maharashtra Public Universities Act, 2016 and that in accordance therewith syllabus for **M.Sc. (Inorganic Chemistry) (Sem – III & IV) for University Department of Chemistry (Autonomous)** as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The Circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
21st September, 2024

(Dr. Prasad Karande)
REGISTRAR

To

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments.

BOD 6.7(N) 03/09/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science,
3) The Chairman, **Board of Studies in Chemistry**
4) The Director, Board of Examinations and Evaluation,
5) The Director, Department of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	**Faculty of Humanities,** **Dean** 1. Prof.Anil Singh Dranilsingh129@gmail.com **Associate Dean** 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, **Dean** 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in **Associate Dean** 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology **Dean** 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in **Associate Dean** 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, **Dean** 1.Dr. Anil K. Singh aksingh@trcl.org.in **Associate Dean** 2.Prin.Chadrashekhar Ashok Chakradeo cachakradeo@gmail.com
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

BOD - 03/9/ 2024
12 (7) of M.P.U.A. 2026
Item No. – 6.7 (N)

As Per NEP 2020

University of Mumbai

Title of the P.G. Program
M.Sc. (Inorganic Chemistry)

Syllabus for

Semester – Sem.- III & IV

Department of Chemistry (Autonomous)

Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O:_____	M.Sc. (Inorganic Chemistry)
2	Scheme of Examination R: _____	NEP 50% Internal 50% External, Semester End Examination Individual Passing in Internal and External Examination
3	Standards of Passing R: _____	40%
4	Credit Structure R: SPA – 25B	Attached herewith
5	Semesters	Sem. III & IV
6	Program Academic Level	6.5
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic Year	2024-25

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the
Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology

Preamble

1) Introduction

This program is designed to provide a comprehensive and in-depth understanding of the fascinating world of Inorganic chemistry. Through a rigorous academic curriculum and hands-on research experience, we aim to nurture the intellectual curiosity and scientific acumen of our students, preparing them for successful careers in various sectors of the chemical sciences. The M.Sc. (Inorganic Chemistry) course is structured to equip students with a strong theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of chemistry. Our esteemed faculty members are experts in their respective fields, with a passion for both teaching and research. They are committed to providing a nurturing learning environment, encouraging open discussions, and fostering collaborative research endeavors. Through their mentorship, students will have the opportunity to engage in cutting-edge research projects, pushing the boundaries of scientific knowledge and contributing to the advancement of the chemical sciences.

We envision our M.Sc. (Inorganic Chemistry) postgraduates act as catalysts for positive change, equipped to drive innovation, shape industries, and address societal challenges through their expertise in chemistry. Whether your passion lies in research, industry, education, or beyond, our program aims to provide the knowledge and skills necessary to excel in your chosen path.

2) Aims and Objectives

The aims and objectives of M.Sc. (Inorganic Chemistry) course are designed to provide students with a well-rounded and advanced education in the field of Inorganic chemistry. These goals focus on equipping students with a deep understanding of chemical principles, fostering research and analytical skills, and preparing them for successful careers in various sectors of the chemical sciences.

The M.Sc. (Inorganic Chemistry) course aims to produce skilled and knowledgeable professionals who can contribute to scientific research, industrial innovation, and the betterment of society through their expertise in Inorganic chemistry.

3) Learning Outcomes

The learning outcomes of the M.Sc. (Inorganic Chemistry) course are designed to equip students with a comprehensive and advanced understanding of the field of chemistry. These learning outcomes reflect the knowledge, skills, and competencies that students are expected to gain upon successful completion of the program.

4) Any other point (if any) : The skills and knowledge acquired during this master's program will make the students well-equipped for diverse roles in academia and industry.

5) Credit Structure of the M.Sc. (Inorganic Chemistry) (Sem I, II, III & IV) (Table as per पपपपपपपप-1 with sign of HOD and Dean)

R _____

Post Graduate Program: M.Sc. (Inorganic Chemistry) पपपपपपपप-1

Year	Level	Sem	Major				RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandatory			Electives					
1	6.0	Sem I	3*4+ 2=14			4	4		-	22	PG Diploma (after 3 Years Degree)
			Physical Chemistry-I (55711)	TH	4	Analytical Chemistry-I (55751) **(OR)** Applied Industrial Chemistry-I (55752)	Research Methodology (55791)				
			Inorganic Chemistry-I (55721)	TH	4						
			Organic Chemistry-I (55731)	TH	4						
			Chemistry Practical-I (55792)	PR	2						
		Sem II	3*4+ 2=14			4	-	4 (55793)	-	22	
			Physical Chemistry-II (55712)	TH	4	Analytical Chemistry-II (55771) **(OR)** Applied Industrial Chemistry-II (55772)					
			Inorganic Chemistry-II (55722)	TH	4						
			Organic Chemistry-II (55732)	TH	4						
			Chemistry Practical-II (55794)	PR	2						
Cum. Cr. For PG Diploma			28			8	4	4		44	
Exit Option: PG Diploma (44 credits) after Three Year UG Degree											

R: SPA – 25B

Year	Level	Sem (2yr)	Major				RM	OJT/FP	RP	Cum. Cr.	Degree
2	6.5	Sem III	3*4+ 2=14			4	-	-	(CHEM 626) 4	22	PG Degree after 3-yr UG or PG Degree after 4-yr UG
			Solid State Chemistry-I (CHEM 621)	TH	4	Advances in Inorganic Chemistry (CHEM 62511) OR Applied Inorganic Chemistry-I (CHEM 62512)					
			Coordination and Bio-Inorganic Chemistry (CHEM 622)	TH	4						
			Instrumental Methods and Spectroscopy(CHEM 623)	TH	4						
			Inorganic Chemistry Practical (CHEM 624)	PR	2						
		Sem IV	3*4=12			4	-	-	(CHEM 631) 6	22	
			Solid State Chemistry-II (CHEM 627)	TH	4	Intellectual Property right and Chemoinformatics(CHEM 63011) **(OR)** Applied Inorganic Chemistry-II (CHEM 63012)					
			Organometallic Chemistry and Catalysis (CHEM 628)	TH	4						
			Instrumental Methods, Spectroscopy and Group Theory (CHEM 629)	TH	4						
Cum. Cr. For 1 Yr PG Degree			26			8			10	44	
Cum. Cr. For 2 Yr PG Degree			54			16	4	4	10	88	

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Department of Chemistry(Autonomous)
UNIVERSITY OF MUMBAI

Syllabus for M.Sc. (InorganicChemistry)
Semester III and IV

Choice-Based Credit System
Under New Education Policy (NEP) 2020
(To be implemented from the academic year, 2024-2025)

PROGRAM OUTLINE 2023-2024

YEAR		COURSE CODE	COURSE TITLE	CREDITS
M.Sc. Sem-III	Mandatory Course-I	621	Solid State Chemistry-I	04
	Mandatory Course-II	622	Coordination and Bio-Inorganic Chemistry	04
	Mandatory Course-III	626	Instrumental Methods and Spectroscopy	04
	Mandatory Course Practical	624	Inorganic Chemistry Practical	02
	Elective 1	62511	Advances in Inorganic Chemistry	04
	Elective 2	62512	Applied Inorganic Chemistry-I	04
	Research Project	626	Research Project	04
M.Sc. Sem-IV	Mandatory Course-I	627	Solid State Chemistry-II	04
	Mandatory Course-II	628	Organometallic Chemistry and Catalysis	04
	Mandatory Course-III	629	Instrumental Methods, Spectroscopy and Group Theory	04
	Elective 1	63011	Intellectual Property Right and Chemoinformatics	04
	Elective 2	63012	Applied Inorganic Chemistry-II	04
	Research Project	631	Research Project	06

PROGRAMME SPECIFIC OUTCOME (PSOs)

1. Gain knowledge of the advanced concepts in the branch of chemistry, identify and accomplish a solution to problems encountered in the field of research and analysis.

2. Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.

3. Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.

4. Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques implemented in the industry.

5. Use the subject knowledge, communication, and ICT skills to become an effective team leader/team member in the interdisciplinary fields.

6. Understand, Manage, and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

7. Exhibit professional work ethics and norms of scientific development.

Syllabus for
M.Sc. (Inorganic Chemistry)
(Sem. III & IV)

Semester – III

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Paper-I	Course Code: CHEM 621 Course Title:- SOLID STATE CHEMISTRY-I			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. To gain knowledge about the different types of arrangement of atoms in the crystal structure of inorganic materials.
2. To understand the various methods of synthesis of inorganic materials, growth of single crystals and thin films formation.
3. To know the in-depth information and applications of solid solutions and liquid crystal.
4. To get information about the various types of crystal defects and their effect on electrical, optical and magnetic properties of the solid materials.

Course Outcomes:

1. Learners will be able to study the crystal structure of various stoichiometric inorganic compounds *via* unit cell and linked polyhedral approach.
2. Learners will be able to understand various synthetic approaches for synthesizing inorganic materials, growing single crystal and thin films.
3. Learners will be able to understand the conditions for obtaining solid solutions and liquid crystals for numerous industrial and commercial applications.
4. Learners will be able to study various defects in crystals and their influence on crystal properties.

Paper-I
Course Code: CHEM 621
Course Title: SOLID STATE CHEMISTRY-I

Unit-I **[15L]**

(a) Crystal Chemistry:

Recapitulation of common structures (AB and AB_2). Structures of the compounds of different types: AB (PbO and CuO), AB_2 (β-crystabalite, CaC_2 and Cs_2O), A_2B_3 (Cr_2O_3 and Bi_2O_3), AB_3 (ReO_3 and Li_3N), ABO_3 (perovskite, $BaTiO_3$), oxide bronzes, ilmenite structure, AB_2O_4 (normal and inverse and random spinel structures).

(b) Linked polyhedra:

Factors affecting linking of polyhedra, Corner sharing: tetrahedral structure (silicates) and octahedral structure (ReO_3), Edge sharing: tetrahedral structure (SiS_2) and octahedral structures of BiI_3 and $AlCl_3$, etc.

Unit-II **[15L]**

(a) Synthesis of Inorganic Materials: Aspects of inorganic synthesis, choosing a method; Preparation methods: (i) Chemical method (Introduction to ceramic, sol-gel and precursor methods, Topochemical redox reactions, Ion exchange reactions), (ii) High pressure methods, (iii) Arc technique and (iv) Skull melting.

(b) Different methods for single crystal growth:

(i) Crystal growth from solution and flux (Flux growth technique).

(ii) Crystal growth from melt- Bridgman and Stockbargar method, Czochralski technique, Kyropoulos method, Vernuil technique and Zone refining technique.

(iii) Crystal growth from vapor phase: Epitaxial growth methods, chemical vapour transport.

(c) Thin Film Preparation: (i) Chemical and electrochemical methods,

(ii) Physical methods.

Unit-III **[15L]**

(a) Solid Solutions: Formation of substitutional, interstitial and complex solid solutions, study of solid solutions by X-ray powder diffraction and by density measurement.

(b) Liquid Crystals: Introduction and classification of liquid crystals, microscopic and optical properties of nematic, smectic and cholesteric liquid crystals, applications of liquid crystals, inorganic liquid crystals.

Unit-IV **[15]**

Crystal defects and non-stoichiometry:

Perfect and imperfect crystals;

Types of defects:

(i) **Point defects**- Vacancy, Self interstitial, Schottky defect, Frenkel defect, thermodynamics of formation of these defects (mathematical derivations to find defect concentration and numerical problems expected), defects in non-stoichiometric compounds: Metal excess defects, Metal deficient defects.

(ii) **Line defects**- Edge dislocation and Screw dislocation

(iii) **Plane defects-** Grain boundaries and Stacking faults

Defect clusters, interchanged atoms; Extended atom defects-crystallographic shear structures, subgrain boundaries and antiphase domains.

Reference books:

Unit-I:

1. U. Muller, *Inorganic structural chemistry*, 2nd edition, Wiley (2007).
2. A. F. Wells, *Structural inorganic chemistry*, 5th edition, Clarendon press, Oxford (1984).
3. A. R. West, *Solid state chemistry and its chemical applications*, 2nd edition, Wiley (2014).

Unit-II:

1. A. R. West, *Solid state chemistry and its chemical applications*, John Wiley & Sons, (1984).
2. Lesley E. Smart and Elaine A. Moore, *Solid state chemistry – An introduction*, 3rd Ed., Taylor and Francis, (2005).
3. C. N. R. Rao and J. Gopalakrishnan, *New directions in solid state chemistry*, Cambridge university press, (1986).

Unit-III:

1. A. R. West, *Solid state chemistry and its chemical applications*, 2nd edition, Wiley (2014).
2. C. N. R. Rao and J. Gopalakrishnan, *New directions in solid state chemistry*, Cambridge university press, (1986).

Unit-IV

1. A. R. West, *Solid state chemistry and its chemical applications*, John Wiley & Sons, (1984).
2. H. V. Keer, *Principles of the solid state*, Wiley Eastern Ltd, (1994).
3. Lesley E. Smart and Elaine A. Moore, *Solid state chemistry – An introduction*, 3rd Ed. Taylor and Francis, (2005).

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Paper-II	Course Code: CHEM622 Course Title:- COORDINATION AND BIO-INORGANIC CHEMISTRY			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. To gain knowledge about the various states existing in materials and to understand types of decay process and photo physical pathways.
2. To understand and characterize magnetism in transition metal complexes and lanthanides.
3. To understand the influence of geometry on the electronic spectra of first transition metal complexes.
4. To understand the role of transition metal based enzymes and proteins in the living system.

Course Outcomes:

1. Learners will be able to study the transition between the states and decay process that leads to fluorescence and phosphorescence.
2. Learners will be able to understand the theory of magnetism in transition and lanthanides complexes along with the methods for determining the magnetic moments.
3. Learners will be able to interpret the electronic spectra of different metal complexes.
4. Learners will be able to study the role of various transition metal enzymes in biological systems.

Paper-II
Course Code: CHEM622
Course Title:- COORDINATION AND BIO-INORGANIC CHEMISTRY

Unit-I: INORGANIC PHOTOCHEMISTRY [15L]

Transitions 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).

Unit-II: MAGNETIC PROPERTIES OF METAL COMPLEXES [15L]

Origin of magnetism, classification of substances according to the magnetic properties: diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism and ferrimagnetism. magnetic moment from magnetic susceptibility, Curie equation and Curie temperature, Curie-Weiss law, Neel temperature, thermal energy and magnetic property, magnetic moment for different multiplet width, temperature independent paramagnetism, magnetic susceptibility and spin only formula, spin and orbital contribution to magnetic moment, spin cross-over.

Magnetic properties of first transition series metal ions and lanthanide, diamagnetic correction using Pascal constants and calculation of magnetic moment. Methods of determination of magnetic susceptibility.

Unit-III: ELECTRONIC SPECTRA OF COMPLEXES [15L]

Determination of spectral terms for ground state and excited state using pigeon hole diagram, energy of terms, Hund's rules, spin orbit (L-S) coupling , selection rules and intensities, crystal field splitting of the terms in ligand field, construction of Orgel diagram and Tanabe Sugano diagram. Calculation of crystal field parameters (10Dq, B',β, β^o) from electronic absorption spectra of octahedral complexes (d^1-d^9) Comparing the spectra of octahedral, tetrahedral and square planar complexes of Nickel(II).

Unit-IV: BIOINORGANIC CHEMISTRY [15L]

Molybdenum enzyme: reaction mechanism for xanthine oxidase, reaction cycle of sulfite oxidase; Zn in biological systems: Carbonic anhydrase, protolytic enzymes, e.g. carboxy peptidase, Zinc finger. Role of metal ions in biological electron transfer processes. Copper containing proteins and enzymes.Less common ions in biology e.g. V, Co, Ni. Metallothionines, Biomineralization.

Reference books:

Unit-I:

1. J. R. Gispert, *Coordination Chemistry*, Wiley-VCH (2008).
2. D. Banerjea, *Coordination chemistry*, 3rd edition, Asian Books Pvt. Ltd. (2009).
3. R. Gopalan and V. Ramalingam, *Concise coordination chemistry*, Vikas Publising House Pvt. Ltd. (2007).
4. Gary Wulfsberg, *Inorganic chemistry*, Viva Books Pvt,. Ltd. (2002).
5. B. Douglas, D. McDaniel and J. Alexander, *Concepts and models of inorganic chemistry*, 3rd editions, John Wiley & Sons, Inc.(2001).

Unit-II:

1. R. A. Dutta & A. Syamal, *Elements of magnetochemistry*, 2nd edition, Affiliated East-West Press Pvt. Ltd. (1993).
2. D. Banerjea, *Coordination chemistry*, 3rd edition, Asian Books Pvt. Ltd. (2009).
3. R. Gopalan and V. Ramalingam, *Concise coordination chemistry*, Vikas Publising House Pvt. Ltd. (2007).

Unit-III:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorganic chemistry- Principles of structure and reactivity*, 4th edition, Pearson (2006).
2. A. B. P. Lever, *Inorganic electronic spectroscopy*, Elsevier Publishing Company (1968).
3. R. Gopalan and V. Ramalingam, *Concise coordination chemistry*, Vikas Publising House Pvt. Ltd. (2007).
4. J. E. House, Inorganic chemistry, Academic press, 2nd edition, 2013.

Unit-IV:

1. S. J. Lippard and J. M. Berg, *Principles of bioinorganic chemistry*, University Science Publications, Mill Valley, Caligronic, (1994).
2. R. R. Crichton, *Biological Inorganic Chemistry, A new introduction to molecular structure and function*, 2nd Edition, Elsevier, (2012).
3. I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, *Bioinorganic chemistry*, First South Indian Ed., Viva Books, New Delhi, (1998).
4. G. N. Mukherjee and A. Das, *Elements of bioinorganic chemistry*, Dhuri and Sons, Calcutta, (1988).
5. R. W. Hay, *Bioinorganic chemistry*, Ellis Harwood, England, (1984).
6. J. A. Cowan, *Inorganic biochemistry-An introduction*, VCH Publication, (1993).

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Paper-III	Course Code: **CHEM623** Course Title:- **INSTRUMENTAL METHODS & SPECTROSCOPY**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	–	**04**	**50**	**50**

Learning Objectives:

1. To understand the principle and use of X-Ray diffraction technique for the structural elucidation of crystals.
2. To study the role of electron and neutron diffraction in identification of crystalline, semi crystalline and amorphous inorganic materials.
3. To know the in-depth theory behind electron spin resonance spectroscopy and interpretation of transition metal spectra.
4. To get information about how the radioactive source and other phenomenon of Mossbauer technique can be utilized for structural elucidation of the inorganic and organometallic compounds.

Course Outcomes:

1. Learners will be able to study Bragg equation, miller indices, interplanar spacing, crystallite size and Bravais lattice using XRD technique.
2. Learners will be able to understand the instrumentation and applications of electron and neutron diffraction methods.
3. Learners will be able to understand the principle of ESR spectroscopy for inorganic metal complex
4. Learners will be able to study various terms such as Doppler effect, electronegativity, chemical shift etc in Mossbauer spectroscopy along with its application to iron and tin compounds.

Paper-III

Course Code: CHEM623

Course Title:- Instrumental Methods and Spectroscopy

Unit-I: X-RAY DIFFRACTION [15]

Introduction to X-ray diffraction, generation of X-rays (K-shell knockout), Bragg condition, Miller indices, relationship between Miller indices and inter planar spacing. Methods of diffraction: Laue method, Debye-Scherrer method of X-ray structural analysis of crystals, introduction to JCPDS format, index reflections, identification of unit-cells from systematic absences in diffraction pattern, uses of powder X-ray diffraction, description of the procedure for an X-ray structure analysis, density and crystallite size determination (numerical problems are expected).

Unit-II: [15L]

(a) Electron Diffraction:

Electron beam-specimen interaction, SAED pattern for single crystal, polycrystalline and amorphous material, difference between X-ray and electron, experimental technique, applications of electron diffraction, low energy electron diffraction, reflection high energy electron diffraction.

(b) Neutron diffraction:

Properties of neutron, principle of neutron scattering, comparison with X-rays, advantages of neutron scattering, scattering of neutron by solids and liquids, experimental technique with essential components, detection of neutrons, monochromatic technique, time of flight technique, magnetic scattering, applications of neutron scattering.

Unit-III: ELECTRON SPIN RESONANCE SPECTROSCOPY [15L]

Introduction, principle, instrumentation, selection rule, relaxation processes and line width in ESR transitions, hyperfine splitting, zero field splitting and Kramer's degeneracy, factors affecting g-value. Calculation of g-values with examples. Intensities of $g_{\parallel}$ and $g_{\perp}$ peaks.

Applications of ESR to the study of simple free radicals and metal complexes like methyl($^{\bullet}CH_3$), cyclopentadienyl ($^{\bullet}C_5H_5$), hydroxyl methyl ($^{\bullet}CH_2OH$), ammonia ($^{\bullet}NH_3$), 1,1-diphenyl-2-picryl hydrazyl (DDPH), pyrazine anion ($C_4N_2^-$), benzene anion ($C_6H_6^-$), bis(salicylaldiminato)copper(II), $IrCl_6^{2-}$, copper acetate dehydrate and [VO(5-chlorosalicylaldehyde-aniline)$_2$].

Unit-IV: MOSSBAUER SPECTROSCOPY [15L]

Basic principle, recoil energy and Doppler shift. Instrumentation: sources and absorber; motion devices, detection, quadrupole interaction, magnetic interaction, electronegativity and chemical shift.

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.

Reference books:

Unit-I-IV:

1. Lesley E. Smart and Elaine A. Moore, *Solid state chemistry – An introduction*, 3rd Ed., Taylor and Francis, (2005).
2. Fmiza Hammer, *Inorganic spectroscopy and related topics*, Sarup & Sons (2008).
3. R. S. Drago, *Physical methods for Chemists*, 2nd edition, Saunders college publishing (1992).
4. R. S. Drago, *Physical methods in Inorganic chemistry*, Affiliated East-West Press Pvt. Ltd; New Delhi.
5. R. A. Scott and C. M. Lukehart, *Applications of physical methods to inorganic and bioinorganic chemistry*, John Wiley & Sons Ltd. (2007).
6. D. N. Sathyanarayana, *Introduction to magnetic resonance spectroscopy ESR, NMR, NQR*, I. K. Intenational publishing house pvt. Ltd. (2009).
7. K. Burger, *Coordination chemistry: Experimental methods*, London Butterworths, (1973).
8. R. V. Parish, *NMR, NQR, EPR and Mossbauer spectroscopy in Inorganic Chemistry*, *Ellis Horwood.* (1990).

PROGRAM(s): M.Sc.-II	**SEMESTER: III**			
Course: Practical	**Course Code: CHEM 624** **Course Title:- Inorganic Chemistry Practical**			
Teaching Scheme				**Evaluation Scheme**
Practical (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 25)**	**Semester End Examination (Marks- 25)**
04	**NA**	**02**	**25**	**25**

Learning Objectives:

1. To gain knowledge of the in pH metry, conductometry, spectrophotometry-based experiments.
2. To gain ability to perform inorganic synthetic reactions and characterize synthesized compounds using different analytical methods.
3. The learners will learn the Quantitative Analysis of different types of commercial samples.
4. The learner will gain knowledge and hands on experience of different analytical methods to characterize the synthesized coordination compounds.
5. The learners will gain ability to measure and record experimental variables with appropriate precision.

Course Outcomes:

1. The learners will be able to interpret or characterize the synthesized inorganic compounds using various analytical techniques.
2. Apply the knowledge of quantitative analysis for the determination of metals from commercial samples.
3. The learner will be able to understand the analysis of various commercial inorganic compounds.
4. The learners will be able to separate two different metal ions using the techniques such as pH metry and solvent extraction methods.

.

Practical

Course Code: CHEM 624

Course Title:- Inorganic Chemistry Practical

I. Separation and estimation of metal ions

1. Separation of Mn and Fe by solvent extraction using isoamyl alcohol and estimation of Mn
2. Separation and estimation of Cu(II) and Zn(II) in a mixture using anion exchange resin.

II. Analysis of the commercial samples

1. Calcium tablet for its calcium content by complexometric titration.
2. Iron tablet for its iron content colorimetry by 1,10-phenonthroline method.
3. Fasting salt for chloride content conductometrically.
4. Washing soda for its Na_2CO_3 content by pH metry.

III. Coordination Chemistry

1. Determination of Stability constant of $[Zn(NH_3)_4]^{2+}$ by potentiometry
2. Determination of Racah parameters and verification of the spectrochemical series for $[Ni(H_2O)_6]^{2+}$, $[Ni(NH_3)_6]^{2+}$ and $[Ni(en)_3]^{2+}$ complexes.

IV. Synthesis and characterization of Inorganic compounds and materials.

1.Preparation of $[Mn(acac)_3]$ and its characterization by IR and conductivity measurement.

2.Preparation of $CuO/ZnO/MnO_2$ nanoparticles and its characterization by UV-Visible and XRD techniques.

3.Synthesis of tris(acetyl acetonato)aluminium (III) complex and its characterization by NMR.

4.Synthesis of calcium oxalate and its characterization by TGA/DTA.

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).

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Elective 1	Course Code: CHEM62511 Course Title:- Advances in Inorganic Chemistry			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks-50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To understand the physical and chemical properties of group 13 and 14 elements
2. To get knowledge about the physical and chemical properties of group 13 and 14 elements and industrial important compounds of it.
3. To know about the various methods of preparation and stereochemistry of coordination compounds along with industrially important MOF materials.
4. To get information about the extraction and metallurgy of important transition metal with emphasis on its application.

Course Outcomes:

1. Learners will be able to study the properties and application of various compounds of Group 13 and 14.
2. Learners will be able to study properties, synthesis, structure and applications of Group 15 and 16 compounds.
3. Learners will be able to understand the synthesis of of coordination compounds with its stereochemistry and application, structures of MOFs.
4. Learners will be able to study occurrence, extraction and metallurgy, properties and application of industrially important metals.

ELECTIVE-1

Course Code: CHEM62511

Course Title:- ADVANCES IN INORGANIC CHEMISTRY

Unit-I: CHEMISTRY OF GROUP 13 & 14 ELEMENTS **[15L]**

Occurrence, isolation and purification of Group-13 and 14 elements with special emphasis on aluminium, gallium, indium, thallium, silicon, Germanium, tin and lead. Properties and industrial applications of these elements, alloys and their compounds.

Unit-II: CHEMISTRY OF GROUP 15& 16 ELEMENTS **[15L]**

Occurrence, isolation and purification of Group-15 and 16 elements with special emphasis on phosphorus, arsenic, antimony, bismuth, sulphur, selenium and tellurium. Properties and industrial applications of these elements, alloys and their compounds. Concept of hypervalency in p-block elements, current status on participation of d-orbital in bonding of p-block compounds, inert pair effect, resurgence of dative bond in p-block compounds.

Unit-III: **[15L]**

(a) Preparation of coordination compounds by:

(i) Addition reaction, (ii) Substitution reaction, (iii) Redox reaction, (iv) Thermal dissociation of solid complexes, (v) Reaction in the absence of oxygen, (vi) Reaction of coordinated ligands, (vii) Trans effect.

(b) Steoreochemistry, Chirality and Fluxionality of coordination compoundswith:

Higher coordination numbers, Isomerism and polymorphism in coordination compounds

(c) Crystal Engineering: Metal organic frameworks (MOFs):

Strategies in Coordination Chemistry (Node-and-SpacerApproach), General analysis of Framework Structures (1D, 2D and 3D framework structures), MOFs with Polydentate ligands. Applications of MOFs.

Unit-IV: METALLURGY[15L]

Occurrence, extraction and metallurgy of Zirconium, Hafnium, Niobium, Tantalum, Palladium and Platinum. Physical and chemical properties and applications of these metals.

References

Unit-I:

1. A. J. Elias, *The Chemistry of the P-block elements, Synthesis, Reactions and Applications*,Universities Press India Pvt.Ltd.,(2019).

2. R. Gopalan, *Inorganic Chemistry for Undergraduates*, Universities Press India Pvt.Ltd. (2009).
3. P. L. Soni, *Textbook of Inorganic Chemistry*. Sultan Chand & Sons Publisher, 15th Edition (1984).
4. J. D. Lee, 5thEdn.,*Concise Inorganic Chemistry*, ELBS, (2010).
5. M. Weller, T. Overton, J. Rourke and F. Armstrong, *Inorganic chemistry*, 6thedition, Oxford University Press (2015).

Unit-II:

1. A. J. Elias, *The Chemistry of the P-block elements, Synthesis, Reactions and Applications*,Universities Press India Pvt.Ltd.,(2019).
2. M. Weller, T. Overton, J. Rourke and F. Armstrong, *Inorganic chemistry*, 6thedition, Oxford University Press (2015).
3. P. L. Soni, *Textbook of Inorganic Chemistry*. Sultan Chand & Sons Publisher, 15th Edition (1984).
4. J. D. Lee, 5thEdn.,*Concise Inorganic Chemistry*, ELBS, (2010).

Unit-III:

1. S. F. A. Kettle, *Coordination compounds*, Thomas Nelson and Sons Ltd. (1975).
2. D. Banerjea, *Coordination chemistry*, 3rd edition, Asian Books Pvt. Ltd. (2009).
3. R. Gopalan and V. Ramalingam, *Concise coordination chemistry*, Vikas Publising House Pvt. Ltd. (2007).
4. J. R. Gispert, *Coordination Chemistry*, Wiley-VCH (2008).

Unit-IV:

1. R.Gopalan, *Inorganic Chemistry for Undergraduates*, Universities Press India Pvt.Ltd. (2009).
2. P. L. Soni, *Textbook of Inorganic Chemistry*. Sultan Chand & Sons Publisher, 15th Edition (1984).
3. J. D. Lee, 5thEdn.,Concise Inorganic Chemistry, ELBS, (2010).

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Elective 2	Course Code: CHEM62511 Course Title:- APPLIED INORGANIC CHEMISTRY-I			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To study the causes of corrosion and its prevention using different techniques.
2. To learn the powder metallurgy and industrially important inorganic materials.
3. To understand about the energy storage devices such as batteries and fuel cells.
3. To study about the basic concepts of electrochemistry and various types of Voltammetry.

Course Outcomes:

1. Students will be able to explain mechanism of corrosion and various methods used for its prevention.
2. Students will get the knowledge about the application of powder metallurgy and various materials such as ceramics.
3. Students will be able to analyze the difference between batteries, fuel cells and supercapacitors.
4. Students will able to explain the principle and application of voltammetry in biosensors, catalytic sensors and gas sensors.

Elective-2

Course Code: CHEM62511

Course Title:- APPLIED INORGANIC CHEMISTRY-I

Unit-I:CORROSION SCIENCE AND ELECTRODEPOSITION [15L]

(i) Corrosion Science: Definition and Introduction to the concept of corrosion, Classification of corrosion: Dry and Wet Corrosion with mechanism, Types of Electrochemical Corrosion: Galvanic and Concentration cell corrosion, Metal and Environmental factors affecting the rate of corrosion. Methods of preventing corrosion: Electrochemical Methods: Cathodic and Anodic protection, Chemical Methods: Galvanizing and tinning, Techniques of metallic coatings, Organic coatings –Paints and its components, Relevance of Pourbaix diagram in corrosion mitigation.

(ii) Electrodeposition: Principle and mechanism of electroplating, Surface preparation, Factors affecting electroplating, Electroplating of Gold and Copper. Introduction to electroless plating, advantages, Electroless plating of Copper and Nickel, use of electroless plating for Printed Circuit Boards (PCB) for electronics industry

Unit-II: INORGANIC ENGINEERING MATERIALS [15L]

(i) Powder Metallurgy: - Introduction to powder metallurgy, Applications of powder metallurgy, Steps involved in powder metallurgy: fine metal powder formation, Mixing and blending, Sintering and Compaction, Introduction to the concept of shape memory alloy and its applications.

(ii) Ceramics: - Introduction to ceramics, General outline of methods to produce ceramic materials, Manufacturing of some important ceramics – Alumina (Al_2O_3), Zirconia (ZrO_2), Silicon Carbide (SiC)

Introduction to Cermet, Applications of cermet in the industry.

Unit-III: BATTERIES AND FUEL CELL TECHNOLOGY [15L]

Basic components of Batteries, Battery characteristics, Classification of batteries: -Primary battery: Zn- MnO_2, Secondary battery: Ni-Cd battery, Nickel-Metal hydride battery, Lithium-ion battery. Introduction to fuel cell, classification, components and advantages of fuel cell, Alkaline fuel cell, Methanol fuel cell, Phosphoric acid fuel cell, Molten carbonate fuel cell, Solid oxide fuel cell. Supercapacitors: Introduction, types of Supercapacitors, advantages and limitation.

Unit-IV: INORGANIC ELECTROCHEMISTRY **[15L]**

(i) Basic aspects of electrochemistry, electron transfer reactions at electrode surface, potential and electrochemical cells.

(ii) Voltammetry techniques**:** linear volatammetry, cyclic voltammetry, reversible, irreversible, and quasi-reversible processes, instrumentation, electrolytes and applications with reference to ferrocenes, transition metal complexes.

(iii) Stripping Voltammetry: Principle and technique in anodic and cathodic stripping voltammetry, applications to metal ion analysis, limitations. Adsorptive stripping voltammetry: Principle, technique, applications to metal ions analysis. Advantages over anodic stripping voltammetry. Catalytic effects in voltammetry.

(iv) Biosensors, catalytic sensors and gas sensors**.** Comparison of voltammetry with AAS and ICP-AES**.**

Reference Books

Unit-I-III:

1. P. C.Jain,*Engineering Chemistry*, 16th Edition, Dhanpat Rai Publication, (2014).

2. S. S. Dara, *A textbook of Engineering chemistry*, S. Chand and Company, (2013).

3. O. G. Palana, *Engineering Chemistry*, 2nd edition, Tata McGraw Hill Publication, (2017).

Unit-IV:

1. D. T. Sawyer, A. Sobkowak, J. L. Roberts Jr.. *Electrochemistry for Chemists*, 2nd Edition, John Wiley, Inc. New York, (1995).

2. P. Zanello, *Inorganic electrochemistry, Theory, Practice and Application*, Publisher RSC, (2003).

3. D.A. Skoog, D.M. West, Holler and Crouch, *Fundamental of Analytical Chemistry*, 8th edition, Saunders College Publishing, New York (2005).

4. Joseph Wang, *Electroanalytical chemistry*, John Wiley & Sons, Inc., (2006).

5. Kh. Brainina and E. Neyman, *Electroanalytical stripping methods*: Wiley-Interscience, (1994).

6. D. A. Skoog, F. J. Holler, and T. A. Nieman, *Principles of Instrumental Analysis*, 5th ed., Philadelphia: Saunders College Publishing, (1998).

7. A. J. Bard and L. R. Faulkner, *Electrochemical Methods*, Wiley, New York, (1980).

8. A. M. Bond, *Modern Polarographic Methods in Analytical Chemistry*, Marcel Dekker, New York, (1980).

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Research Project	**Course Code: CHEM 611** **Course Title:-Research Project**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
	–	**04**	**50**	**50**

Learning Objectives:

1. To understand and discuss the new research topics in the field of chemistry.
2. To understand the importance, relevance, and procedure to gather back ground literature information from various scientific database.
2. To display, organize and represent correlation between different types of data.
3. To summarize and provide a concise summary of research projects carried out.
4. Demonstrate a capacity to communicate research results clearly and comprehensively.

Course outcomes: -

1. Students will define a research question, design objectives and appropriate hypothesis for their project.
2. Students will find and evaluate relevant literature and back ground information related to their project.
3. Students will learn and use the techniques needed to do their experiments.
4. Students will learn and follow appropriate protocols for documenting their research as well to analyse the experimental data.
5. Students will be able to use logic and evidence to draw conclusions and future scope of the research work done.

Guidelines for the conducting the research project.

1. Each student will perform project separately.
2. **Students should devote enough time to their project work (08 hours each week).**
3. Select a topic that is relevant to your interests and social relevance considering the constraints of available resources and time.
4. Consult with faculty members or mentors to select a relevant research topic that has the potential to contribute to the discipline of chemistry.
5. Literature survey for the research project is suggested to be from Journals indexed in globally recognised databases including recently published research papers.
6. Participation in national and international conferences and other project competitions is encouraged.
7. Project report must be written systematically and presented in bound form.
8. Continuous evaluation of the research project will be done by the internal examiner or mentor.
9. Student must do presentation of the research work in external exam.

Evaluation of Research Project Semester - III

Internal Continuous Assessment: 50% (50 Marks)

Sr. No	Criteria for evaluation	Marks
1.	Attendance (DPR to be maintained)	10
2.	Literature Survey	25
3.	Scheme/ Outline of project / Methodology	15
	Total	**50**

Semester End External Examination: 50% (50 Marks)

Sr. No	**Criteria for evaluation**	**Marks**
1.	Presentation	15
2.	Dissertation	20
3.	Viva	15
Total		**50**

Semester – IV

PROGRAM(s): M.Sc.-II	**SEMESTER: IV**			
Course: Paper-I	**Course Code: CHEM 627** **Course Title:- Solid State Chemistry - II**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**

04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To understand the Ionic conductivity and electric properties in ionic solids, metal semiconductor and insulators.
2. To get knowledge about the magnetic properties in metal, metal oxide and complex metal oxides with its application.
3. To gets indepth knowledge about the optical and thermal properties of various inorganic materials.
4. To get information about the recent advances in nanomaterials with emphasis on special nonmaterial and their application in wider fields.

Course Outcomes:

1. Learners will be able to study the mechanism of conduction in solid electrolytes and its application in batteries, sensors and fuel cells.
2. Learners will be able to understand the peculiar electronic properties associated with metals, semiconductors, and insulators.
3. Learners will be able study the behavior of substances in magnetic field and their application in information storage devices.
4. Learners will be able to understand the optical properties of luminescence and phosphor materials along with thermal properties of metal, ceramics and polymers.
5. Learners will be able to study functionalization of nanomaterials and applications of special materials like carbon nanotubes, quantum dots and aerogels.

Paper-I

Course Code: CHEM 627

Course Title:- Solid State Chemistry – II

Unit-I: ELECTRICAL PROPERTIES OF SOLIDS: [15L]

(i) Ionic conductivity and solid electrolytes:

Mechanism of conduction in solid electrolytes, e.g. hopping conduction; fast ion conductors, e.g. silver ion conductors, oxygen ion conductors, sodium ion conductors; applications of solid electrolytes, e.g. electrochemical cells, batteries, sensors, fuel cells.

(ii) Electrical Properties:

Band structures of metals, insulators, semi-conductors and inorganic solids; Applications of semiconductors (diodes, transistors, etc.)

Other electrical properties: Thermocouples and their applications, Thomson, Peltier and Seebeck effects; Dielectric, piezoelectric, pyroelectric and ferroelectric materials; their inter-relationship and applications.

Unit-II: MAGNETIC PROPERTIES OF SOLIDS: [15L]

Behaviour of substances in magnetic field, mechanism of ferromagnetic and antiferromagnetic ordering, superexchange, Hysteresis, Hard and soft magnets, Structures and magnetic properties of metals and alloys, transition metal oxides, spinels, garnets, ilmenites, perovskite and magneto-plumbites, Applications of magnetic materials.

Spin glasses:Formation and characteristics.

Unit-III: [15L]

(a) **Optical Properties of Solids:** Luminescence and phosphor materials: Configurational coordinate model, Anti-Stokes phosphor, Lasers: Ruby laser, Neodymium laser. Absorption and emission of radiation in semiconductor: light emitting diodes, gallium arsenide laser, blue lasers; optical fibers.

(b) **Thermal properties of solids:** Introduction, heat capacity and its temperature dependence, thermal expansion of metals, ceramics and polymers, thermal conductivity, mechanism of heat conduction metals, ceramics and polymers; thermal stresses.

Unit-IV: ADVANCES IN NANOMATERIALS [15L]

(a) Introduction to nanotechnology:

General preparative methods for various nanomaterials, functionalization of nanoparticles for various applications (capping), generic challenges in nanomaterial synthesis.

(b) Special nanomaterials; Carbon nanotubes: Types, synthesis, properties, applications; Quantum dots: properties and applications. Aerogels: types, properties and applications.

(c) Applications of nanomaterials in consumer goods and biomedical fields.

(d) Environmental aspects of nanotechnology.

Reference books:

Unit-I:

1. A. R. West, *Solid state chemistry and its chemical applications,* John Wiley & Sons, (1984).
2. Lesley E. Smart and Elaine A. Moore, *Solid state chemistry – An introduction*, 3rd Ed., Taylor and Francis, (2005).
3. R. C. Ropp Warren, *Solid State Chemistry*, Elsevier Science B.V. (2003).

Unit-II:

1. A. R. West, *Solid state chemistry and its chemical applications,* John Wiley & Sons, (1984).
2. Lesley E. Smart and Elaine A. Moore, *Solid state chemistry – An introduction*, 3rd Ed., Taylor and Francis, (2005).

Unit-III:

1. A. R. West, *Solid state chemistry and its chemical applications,* John Wiley & Sons, (1984).

2. W. D. Callister, Jr., (adapted by R. Balasubramaniam), *Callister's Materials science and engineering*, Wiley-India (2010).

Unit-IV:

1. Sulabha K. Kulkarni, *Nanotechnology: Principles and practices*, Capital publishing company (2007)
2. Lesley E. Smart and Elaine A. Moore, *Solid state chemistry – An introduction*, 3rd Ed., Taylor and Francis, (2005).
3. M. Weller, T. Overton, J. Rourke and F. Armstrong, *Inorganic chemistry*, 6thedition, Oxford University Press (2015).

PROGRAM(s): M.Sc.-II	**SEMESTER: IV**			
Course: Paper-II	**Course Code: CHEM 628** **Course Title:- Organometallic Chemistry and Catalysis**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**

04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To get basic knowledge about the trends in properties of organometallic compounds of main group elements.
2. To know about the f-block organometallics and structure and bonding in metal atom clusters.
3. To gets in-depth knowledge about the use of organometallic compounds in various organic reactions.

Course Outcomes:

1. Learners will be able to study the properties, stability, preparation methods of sand p-block organometallic compounds.
2. Learners will be able to study organometallic chemistry of f-block elementsand bonding in metal atom clusters
3. Learners will be able to study use of organometallic catalyst reactions involving hydrogen and carbon monoxide.
4. Learners will be able to study the use of organometallic catalyst in reactions involving hydrocarbon and C-C bond formation.

Paper-II

Course Code: CHEM 628

Course Title:- Organometallic Chemistry and Catalysis

Unit-I: ORGANOMETALLIC CHEMISTRY OF MAIN GROUP ELEMENTS **[15L]**

Recapitulation of Organometallics compoumnds. General properties, stability of oranometalic compounds, Preparation methods for s- and p-block elements organometallics. Trends in group 1-2 and 13-16 organometallics.

Unit-II: **[15L]**

(a) Organometallic chemistry of f-block elements: Neutral binary σ-organyls, agostic interactions, alkynyl compounds, η^5, η^6, η^7 andη^8 compounds.

(b) Metal-metal bonding and metal atom clusters: Electron count and structures of clusters, synthesis, reactions, isolobal analogy and structures, Wade's rule (applications to boranes, carboranes and organometallic compounds).

Unit-III: **[15L]**

(a) Introduction to catalysis andorganometallics as catalysts in organic reactions involving hydrogen: Hydrogenation,asymmetric hydrogenation,hydrosilyation, hydroboration and hydroamination reactions,

(b) Organometallics as catalysts in organic reactions involving carbon monoxide: Hydroformylation, carbonylation, Water-Gas shift reaction, Fischer-tropsch, alcohol carbonylation, Wacker process, aminocarbonylation reactions.

Unit-IV: **[15L]**

(a) Organometallics as catalysts in organic reactions involving unsaturated hydrocarbons: Olefin oligomerization (SHOP process, ethene trimerization, propene dimerization and cyclotrimerization of butadiene), alkene isomerization and alkene/alkyne metathesis.

(b) Organometallics in C-C bond formations reactions: Heck, Suzuki, Sonogasira, Stille reactions and Reppe Synthesis.

References Books

Unit-I-IV:

1. Jahn Hartwig, *Organotransition chemistry-From bonding to catalysis*, University science books, California (2010).
2. Christoph Elschenbroich, *Organometallics*, 3rd edition, Wiley-VCH (2005).
3. R. C. Mehrotra and A. Singh, *Organometallic chemistry- A unified approach*, 2nd edition, New Age International (P) Ltd. (2000).
4. R. H. Crabtree, *The organometallic chemistry of the transition metals*, 5th edition, John Wiley & Sons (2009).
5. D. F. Shriver and P. W. Atkins, *Inorganic chemistry*, 3rd edition, Oxford University Press (1999).
6. Gary O. Spessard and Gary L. Miessler, Organometallic Chemistry,3rdedn., Oxford University Press (2015).

PROGRAM(s): M.Sc.-II	**SEMESTER: IV**
Course: Paper-III	**Course Code: CHEM629** **Course Title:- Instrumental Methods, Spectroscopy and Group Theory**
Teaching Scheme	**Evaluation Scheme**

Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. To understand the use of IR and NMR techniques in characterization of various inorganic compounds.
2. To study the various microscopy technique for determination of surface chemistry of solid materials.
3. To know the in-depth theory of different thermos-analytical techniques and optical methods of polymeric and inorganic compounds.
4. To get information about application of group theory in interpretation of IR and Raman spectra, construction of MOD and in ligand field theory.

Course Outcomes:

1. Learners will be able to study IR absorption band in metal-donor atoms and NMR technique in structural elucidation of inorganic molecules.
2. Learners will be able study the surface microscopy techniques such as AES, ESCA, SEM, TEM and AFM.
3. Learners will be able to understand various thermos-analytical techniques such as TGA, DTA and DSC used in material science and industry along with CD and ORD techniques for optical active inorganic complexes.
4. Learners will be able to learn construction character tables and their use in various applications such as determination of number of vibrations bands in IR and Raman spectroscopy, in construction of MOD and in crystal field theory for interpretation of spectra.

Paper-III

Course Code: CHEM 629

Course Title:-Instrumental Methods, Spectroscopy and Group Theory

Unit-I **[15L]**

(a) Infrared spectroscopy: Introduction to basic principles, instrumentation, factors affecting the character of vibrations, IR absorption bands of metal - donor atom, effect of complex

formations on the IR spectrum of ligands. Application of IR spectroscopy to inorganic molecules.

(b) Nuclear Magnetic Resonance: Introduction to basic principles and instrumentation, NMR parameters, Relaxation process. Use of ^{1}H, ^{19}F, ^{31}P, ^{11}B NMR spectra in structural elucidation of inorganic compounds.

Unit-II: MICROSCOPY FOR SURFACE CHEMISTRY **[15L]**

Introduction to surface characterization, problems associated with surface analysis, distinction of surface species, sputter etching, depth profile and chemical imaging. Principle, instrumentation and applications of following techniques: Auger emission spectroscopy (AES), electron spectroscopy for chemical analysis (ESCA), scanning electron microscopy (SEM), transmission electron microscopy (TEM) and atomic force microscopy (AFM).

Unit-III: THERMAL& OPTICAL METHODS OF ANALYSIS **[15L]**

(a) Introduction to principles and instrumentation of thermoanalytical techniques TGA, DTA, DSC, Applications of thermal techniques in materials science and industry, Determination of thermodynamic parameters for the reaction employing thermoanalytical measurements.

(b) Circular dichroism (CD) and optical rotatory dispersion (ORD): Introduction, principle, Cotton effect, Faraday and Kerr effects, instrumentation, and applications in determining absolute configuration of metal complexes.

Unit-IV: APPLICATIONS OF GROUP THEORY **[15L]**

(a) Introduction to basic concepts of symmetry, Matrix representation of symmetry operations, reducible and irreducible representations. Construction of character tables for point groups C_{2v}, C_{3v} and C_{2h} using and great orthogonality theorem, Mulliken's notations for irreducible representations, structure of character tables, determination of symmetry species for translations and rotations, reduction of reducible representations using reduction formula.

(b) Applications of group theory in: (i) infrared and Raman spectroscopy, (ii) construction of Molecular orbital diagram (tetrahedral AB_4 and octahedral AB_6 molecule involving both sigma and pi-bonding) (iii) Ligand Field Theory**:** Splitting of levels and terms in a chemical environment; Construction of energy level diagrams; Methods of descending Symmetry; Correlation diagrams for d^2 ions in octahedral and tetrahedral ligand field.

References Books

Unit-I:

1. R. S. Drago, *Physical methods for Chemists*, 2nd edition, Saunders College publishing (1992).
2. R. S. Drago, *Physical methods in Inorganic chemistry*, Affiliated East-West Press Pvt. Ltd; New Delhi
3. Fmiza Hammer, *Inorganic spectroscopy and related topics*, Sarup & Sons (2008).
4. D. N. Sathyanarayana, *Introduction to magnetic resonance spectroscopy ESR, NMR, NQR*, I. K. Intenational publishing house pvt. Ltd. (2009).
5. K. Burger, *Coordination chemistry: Experimental methods*, London Butterworths, (1973).
6. C. E. Housecroft and A. G. Sharpe, *Inorganic Chemistry*, Pearson Education Ltd. 2nd Edition (2005).

Unit-II:

1. D. A. Skoog and F. J. Holler and T. A. Nieman, *Principles of instrumental analysis*, 5th ed., Harcourt Asia PTE Ltd. (1998).
2. R. A. Scott and C. M. Lukehart, *Applications of physical methods to inorganic and bioinorganic chemistry*, John Wiley & Sons Ltd. (2007).
3. Sulabha K. Kulkarni, *Nanotechnology: Principles and practices,* Capital publishing company (2007).

Unit-III:

1. W. W. Wendlandt, *Thermal analysis*, Interscience (1985).
2. P. D. Garn, *Thermoanalytical methods of investigation*, Academic press, N. Y. (1963).
3. A. Blazek, *Thermal analysis*, Van Norstrand Reinhold Co., London (1973).
4. T. Daniel, *Thermal analysis*, Kogan page Ltd., London (1973).
5. C. J. Keattch and D. Dollimore, *An introduction to thermal analysis*, Heyden, London (1975).
6. M. D. Judd and M. I. Pope, *Differential thermal analysis*, Heydon, London (1977).
7. G. W. H. Hohne, W. F. Hemminger and H. Flammerscheim, *Differential scanning calorimetry-An introduction for practioners*, Springer-verlag, Berlin (1996).
8. K. Burger, *Coordination chemistry: Experimental methods*, London Butterworths, (1973).
9. G. W. H. Hohne, W. F. Hemminger and H. Flammerscheim, *Differential scanning calorimetry-An introduction for practioners*, Springer-verlag, Berlin Heidelberg (2003).
10. R. A. Scott and C. M. Lukehart, *Applications of physical methods to inorganic and bioinorganic chemistry*, John Wiley & Sons Ltd. (2007).
11. D. A. Skoog and F. J. Holler and S. R. Crouch, Instrumental analysis, 5th ed., Harcourt Asia PTE Ltd. (1998).
12. J. Mohan, Organic Spectroscopy: Principles and Applications, CRC press, (2001).
13. A. K. Das and M. Das, Fundamental Concepts of Inorganic Chemistry,Volumes-VI, CBS Pub.(2000).

Unit-IV:

1. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt. Ltd., (2002).
2. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorganic chemistry- Principles of structure and reactivity*, 4th edition, Pearson (2006).
3. D. F. Shriver and P. W. Atkins, *Inorganic chemistry*, 3rd edition, Oxford University Press (1999).
4. R. L. Carter, *Molecular symmetry and group theory*, John Wiley & Sons, New York, (1998).
5. S. F. A. Kettle, *Symmetry and structure-Readable Group Theory for Chemists*, 3rd Ed., John Wiley & Sons, Inc. (200&0.
6. K. V. Reddy, *Symmetry and Spectroscopy of molecules*, New Age International (P) Ltd. 2nd Edition, (2009).
7. A. S. Kunju and G. Krishnan, *Group theory and its application in chemistry, PHL Learning Pvt. Ltd., (2010).*
8. F. A. Cotton, *Chemical applications of group theory,* Wiley Eastern Ltd., (1989).

PROGRAM(s): M.Sc.-II	**SEMESTER: IV**

Course: Elective 1	Course Code: CHEM 63011 Course Title:-Intellectual Property Rights and Chemoinformatics			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours perweek)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To understand the Ethics and concepts of intellectual property rights in research.
2. To the fundamentals of patent laws and drafting procedure.
3. To understand the copyright laws and related subject matters in research.
4. To understand the basic concepts of chemoinformatics.
5. To design and develop solutions to analyze pharmaceutical problems using computers.

Course outcomes:

1. Correlate the knowledge of IPR with its utilization in designing strategy for chemical product development for various purposes.
2. Acquire comprehensive knowledge on Patents including filing of patents.
3. Gain ability to bridge the gap between chemistry and data science, creating innovative solutions and driving advancements in pharma and chemical industries.
4. The learnings can help the budding researchers in accelerating drug discovery by efficiently screening large compound libraries and predicting molecular properties of novel compounds.

Course Title:-Intellectual Property Rights and Chemoinformatics

Unit-I **[15L]**

Introduction to Intellectual Property:

Histroical Perspective, Different types of IP, Importance of protecting IP.

Patents:

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.

Industrial Designs:

Definition, How to obtain, features, International design registration.

Layout design of integrated circuits:

Circuit boards, Integrated Chips Importance for electronic industry.

Copyrights:

Introduction, How to obtain, Differences from Patents.

Trade Marks:

Introduction, How to obtain, Different types of marks-Collective marks, certification marks, service marks, Trade names, etc.

Unit-II **[15L]**

Geographical Indications:

Definition, rules for registration, prevention of illegeal exploitation, importance to India.

Trade Secrets:

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

IP Infringement issue and enforcement:

Role of Judiciary, Role of law enforcement agencies-Police, Customs, etc.

Economic Value of Intellectual Property:

Intangible assests and their valuation, Intellectual Property in the Indian Context- Various Laws in India Licensing an technology transfer.

Different International agreements:

(a) World Trade Organization (WTO):

(i) General Agreement on Tariffs & Trade (GATT) , Trade Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade related Services (GATS) Madrid Protocol

(iii) Berne Convention

(iv) Budapest Treaty

(b) Paris Convention

WIPO and **TRIPS, IPR** and Plant Breders Rights, IPR and Biodiversity

Unit-III **[15L]**

Introduction to Cheminformatics:

History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular Modeling and Structure elucidation.

Representation of molecules and chemical reactions:

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Searching chemical structures:

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit-IV **[15L]**

Applications: Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure-Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure-Spectra correlations, Prediction of NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, Analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-Based and Structure Based Drug Design, Application of Cheminformatics in Drug Design.

Reference books:

1. Andrew R. Leach & Valerie, J. Gillet (2007) *An introduction to Cheminformatcs*. Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) Cheminformatics: a text-book. Wiley-VCH.
3. Gupta, S.P. *QSAR and Molecular Modeling*, Springer-Anamaya Pub.: New Delhi.

PROGRAM(s): M.Sc.-II	**SEMESTER: IV**

Course: Elective -2	Course Code: CHEM 63012 Course Title:- Applied Inorganic Chemistry-II			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To understand the manufacturing of industrially important fibers, fillers, polymers and chemicals.
2. To get knowledge of supramolecular materials and inorganic pharmaceuticals agents.
3. To understand the various applications of inorganic fertilizers, glass paints, pigments and zeolites.
4. To get information about inorganic acids, ceramics, refractory, cements,and inorganic explosives.

Course Outcomes:

1. Learners will be able to study the manufacturing and application of fibers, fillers and inorganic polymers.
2. Learners will be able to study basics of supramolecular compounds and their role in developing devices for sensing cations, anions and neutral molecules.
3. Learners will be able to understand the manufacturing and applications of fertilizers, paints & pigments, zeolites.
4. Learners will gain information about widely used inorganic acids, intercalation compounds, ceramics, refractories and inorganic explosives.

Elective -2

Course Code: CHEM 63012

Course Title:-Applied Inorganic Chemistry-II

Unit-I: **[15L]**

(a) Inorganic Materials:

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: Sodium peroxide, sodium hydrosulphide, sodium thio sulphate, bleaching powder, hydrogen peroxide, Sodium hydroxide, chlorine and lime.

Unit-II:[15L]

(a) Supramolecular chemistry:

Definitions, intermolecular bonds, concepts and perspectives, cationic recognition, anionic recognition, neutral molecular recognition: self-assembly concept and its application in molecular and supramolecualar chemistry, supra molecular devices and machines.

(b) Inorganic Pharmaceuticals:

Lithium drugs, gold antiarithritic drugs, bismuth drugs in treatment of gastric ulcers, radio diagnostic agents, contrast agents for X-ray and MRI imaging.

Unit-III: MANUFACTURING & APPLICATIONS OF THE FOLLOWING [15L]

(i)Fertilizers and nutrients (ii) Glass (iii) Paints and pigments (iv) Zeolites: synthesis, characterization, determination of surface acidity, shape selectivity, characterizations and applications.

Unit-IVMISCELLANEOUS TOPICS **[15L]**

(i) Isopoly and heteropoly acids (ii) Intercalation compounds,(iii) Ceramics and refractory materials (iv) Cement (v) Inorganic explosives (lead azide and mercury fulminate).

Reference Books:

Unit-I:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorganic chemistry- Principles of structure and reactivity*, 4th edition, Pearson (2006).
2. P. L. Soni, *Textbook of Inorganic Chemistry*. Sultan Chand & Sons Publisher, 15th Edition (1984).

Unit-II:

1. J. R. Gispert, *Coordination Chemistry*, Wiley-VCH (2008).
2. J. M. Lehn, *Supramolecular Chemistry: Concepts and Perspectives*, VCH, 38 Weinheim, (1995).
3. D. F. Shriver and P. W. Atkins, *Inorganic chemistry*, 3rd edition, Oxford University Press (1999).
4. J. H. Block, E. B. Roche, T. O. Soine and C. O. Wilson, *Inorganic medicinal and pharmaceutical chemistry*, Lea and Febiger, (1974).

Unit-III:

1. P. L. Soni, *Textbook of Inorganic Chemistry*. Sultan Chand & Sons Publisher, 15th Edition (1984).
2. Lesley E. Smart and Elaine A. Moore, *Solid state chemistry – An introduction*, 3rd Ed., Taylor and Francis, (2005).

Unit-IV:

1. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorganic chemistry- Principles of structure and reactivity*, 4th edition, Pearson (2006).
2. P. L. Soni, *Textbook of Inorganic Chemistry*. Sultan Chand & Sons Publisher, 15th Edition (1984).

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Research Project	**Course Code: CHEM 611** **Course Title:-Research Project**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 75)**	**Semester End Examination (Marks- 75)**
	–	**06**	**75**	**75**

Learning Objectives:

1. To understand and discuss the new research topics in the field of chemistry.
2. To understand the importance, relevance, and procedure to gather back ground literature information from various scientific database.
3. To display, organize and represent correlation between different types of data.
4. To summarize and provide a concise summary of research projects carried out.
5. Demonstrate a capacity to communicate research results clearly and comprehensively.

Course outcomes: -

1. Students will define a research question, design objectives and appropriate hypothesis for their project.
2. Students will find and evaluate relevant literature and back ground information related to their project.
3. Students will learn and use the techniques needed to do their experiments.
4. Students will learn and follow appropriate protocols for documenting their research as well to analyse the experimental data.
5. Students will be able to use logic and evidence to draw conclusions and future scope of the research work done.

SEMESTER IV

Course: Research Project

Guidelines:

1. Students are to work on research project individually and should be the continuity of the research project selected in the semester.
2. Research Project is of 6 credits which equals to project working hours of 180.
3. The title of the research project should be descriptive, appropriate and concise as possible.
4. A detailed description of Chemicals, equipment, experimental procedures should be mentioned in the project report.
5. The project report should be well-structured, should present an accurate and complete account of the research performed with data, discussion and conclusions.
6. The publications of earlier work should be cited.
7. Record of attendance and continuous performance of the student is monitored by the mentor.
8. At the end of the semester, the student has to present the project report in a bound form for external evaluation.
9. Participation in national and international conferences and other project competitions is encouraged.

Evaluation of Research Project Semester - IV

A) CONTINUOUS ASSESSMENT - 50%

Sr. No.	Evaluation Type	Marks
1	Attendance (DPR* to be maintained)	**20**
2	Experimental/ Interpretation	**35**
3	Conclusion/ output	**20**
	Total	**75**

DPR: Daily Progress Report

B) SEMESTER ENDEXAMINATION - 50%

Sr.No	Evaluation Type	Marks
1	Presentation	**20**
2	Dissertation	**30**
3	Viva	**25**
	Total	**75**

Theory Examination Pattern:

Internal Assessment- 50%- 50 Marks per paper

Sr.No.	Evaluation Type	Marks
1	Written Objective/Short Answer Examination	25
2	Assignment/ Case study/ field visit report/ presentation/ project	25
	Total	50

External Examination- 50%- 50 Marks per paper

Paper Pattern:

Question	Options	Marks
Q.1	2 out of 3	10
Q.2	2 out of 3	10
Q.3	2 out of 3	10
Q.4	2 out of 3	10
Q.5	2 out of 4	10
	TOTAL	**50**

Semester End Practical Examination:

Particulars	Continuous assessment (CA)	Semester end external examination
Laboratory work	15	15
Viva	05	10
Journal	**05**	-
Total	**25**	**25**

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Research Project (4 Credits)

Particulars	Continuous assessment (CA)	Particulars	Semester end external examination
Completion of Hours	30	**Content**	**20**
Quality/Performance	10	Presentation	10
Punctuality/Regularity	**10**	Written Report	05
		Question & Answer	**15**
Total	**50**		**50**

Research Project (6 Credits)

Particulars	Continuous assessment (CA)	Particulars	Semester end external examination
Completion of Hours	30	**Content**	**30**
Quality/Performance	30	Presentation	20
Punctuality/Regularity	**15**	Written Report	10
		Question & Answer	**15**
Total	**75**		**75**

Letter Grades and Grade Points

Semester GPA/ Program CGPA/Semester	% Marks	Letter Grade Result
9.00-10.00	90.0-100.0	O (Outstanding)
8.00<9.00	80.0<90.0	A+ (Excellent)
7.00<8.00	70.0<80.0	A (Very Good)
6.00<7.00	60.0<70.0	B+ (Good)
5.50<6.00	55.0<60.0	B (Above Average)
5.00<5.50	50.0<55.0	C (Average)
4.00<5.00	40.0<50.0	P (Pass)
Below 4.00		F (Fail)
Ab (Absent)		Absent

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Team for Creation of Syllabus

Name	Department/College Name	Sign
Dr. Shivram S. Garje	Department of Chemistry, University of Mumbai	
Dr. Suresh D. Pawar	Department of Chemistry, University of Mumbai	
Dr. Shilpee Sachar	Department of Chemistry, University of Mumbai	
Dr. Sudesh T. Manjare	Department of Chemistry, University of Mumbai	
Dr. Julekha Shaikh	Department of Chemistry, Maharashtra College	

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Appendix B

Justification for M.Sc. (Inorganic Chemistry)

1.	The necessity for starting the course:	M.Sc. (Inorganic Chemistry) course is necessary for those who seek to deepen their knowledge, specialize in a particular area, and pursue advanced careers in research, industry, academia, or other chemistry-related fields. It offers numerous opportunities for personal and professional growth, enabling you to make a positive impact on the world through scientific exploration and discovery.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	The course has already commenced from the academic year from 1967 and in the academic year 2022-23 it is restructured under NEP 2020
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	This course is not self-financed. Currently, twelve permanent faculty members are working in the department out of 26 sanctioned faculty positions.
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	The duration of the program is two years (4 semesters). It is not possible to compress the course. Under NEP 2020 students have option of exit at the end of first year with PG Diploma in Inorganic Chemistry.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	The intake capacity of the program is 20. Number of admission for the academic year 2022-23 is 20.
7.	Opportunities of Employability / Employment available after undertaking these courses:	M.Sc. (Inorganic Chemistry) students have a wide range of employment opportunities across various sectors. The skills and knowledge acquired during their master's program make them well-equipped for diverse roles. Some of the common areas where M.Sc. (Inorganic Chemistry) students can find employment include;Research and Development (R&D), Pharmaceutical Industry, Chemical Manufacturing, Environmental and Analytical Chemistry, Quality Assurance and Control, Materials

		Science and Nanotechnology, Teaching and Academia, Healthcare and Clinical Research etc.The key to employability for M.Sc. (Inorganic Chemistry) students are to build a strong resume through internships, research projects, and networking. Additionally, staying updated with the latest advancements in the field and continuously improving their skills can enhance their competitiveness in the job market.

Sign of HOD

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