माँ शाकुम्भरी विश्वविद्यालय, सहारनपुर
Maa Shakumbhari University, Saharanpur

Post-Graduation in Chemistry
For

2024 - 2025

School of Science-Chemistry

Department of Chemistry of P.G. Studies & Research in Chemistry
University Campus
Maa Shakumbhari University
Saharanpur -247120

Mukesh Chand
(Convener)

Members, Board of Studies (Chemistry)

S.No.	Name	Designation	College/University	Signature
1.	Prof. Mukesh Chand	Convener	D.A.V. College, Muzaffar Nagar	
2.		Member	J. V. Jain College, Saharanpur	
3.		Member	C.C.R. College, Muzaffar Nagar	
4.		Member	J. V. Jain College, Saharanpur	
5.		External Expert	C.C.S. University, Meerut	-
6.		External Expert	Chinmay Degree College, Haridwar	

SCHOOL OF SCIENCE (Chemistry)
MAA SHAKUMBHARI UNIVERSITY, SAHARANPUR

VISION OF THE SCHOOL

To produce such academicians with morality, global competence, vision and skilled as are necessary to meet the challenges of emerging global knowledge, economy by the power of innovation, creativity and efficient learning ability.

MISSION OF THE SCHOOL

To emerge among the top institution in India within next ten years through applicability, humanity, implementing and operating dynamic-academic, administrative and functional process, for optimal use of available resources.

ABOUT THE SCHOOL OF SCIENCE - CHEMISTRY

The School of Chemistry is going to establish with the objective of promoting post-graduate studies and research in Chemical sciences Chemistry is a multidisciplinary basically involves all sciences like Physics, Mathematics, Biology, Pharmacology etc., therefore, Chemistry is the demanding curriculum of the modern era. Chemistry is widely useful in each and every field in daily life and this is the only subject able to modify life style, that is why at Post Graduate level, Chemistry is one of the subjects having so many special curricula for a disciple like specialist in Inorganic, Organic, Physical Chemistry, Analytical etc. which is going to be introduced in the University since inception.

VISION

- Vision of the School of Science University: Campus and affiliated Colleges are able to create a community of scientific learning by

promoting outstanding teaching, Indian knowledge system (IKS), deep understanding and creating global centre of excellence in research for the growth of the Nation and Humanity.

- To achieve high standards of excellence in generating and propagating scientific knowledge.
- To provide sustainable environment to the students and researchers who can learn, teach, become innovator and use their knowledge for humanity.

MISSION

- To provide an effective teaching-learning process.
- To impart world-class education in an environment of fundamental and applied research in Chemistry.
- To emerge as a global centre of digital learning, academic excellence and innovative research.
- To include innovative skills, teamwork and ethical practices among students so as to meet societal expectations.
- To provide quality education for higher studies and competitive like CSIR-UGC JRF/NET, GATE, SLET, Civil Services, Scientist, and research programme.

M.Sc. Chemistry Programme prerequisites

To study this programme a student must have/ had the subject Chemistry at UG level.

PROGRAMME OBJECTIVES

The broad objectives of the course have been listed below:

- Demonstrate broad knowledge of descriptive Chemistry.
- Demonstrate the basic analytical and technical skills to work effectively in the various fields of chemistry.
- Demonstrate critical thinking and analysis skills to solve complex chemical problems, e.g., analysis of data, synthetic logic, spectroscopy, structure and modelling, team-based problem solving, etc.
- Demonstrate the ability to calculate the physical properties of chemical reagents, predict outcomes of chemical reactions, and perform critical analysis of data.
- Demonstrate an ability to conduct experiments in the above sub-disciplines with mastery of appropriate techniques and proficiency using core chemical instrumentation and modelling methods.
- Demonstrate the ability to perform accurate quantitative measurements with an understanding of the theory and use of contemporary chemical instrumentation, interpret experimental results, perform calculations on these results and draw reasonable, accurate conclusions.
- A mastery of a broad set of factual chemical knowledge concerning the properties of substances, molecules and atoms.
- Develop skills in quantitative modelling of static and dynamic chemical systems.
- Develop a detailed understanding of the relationship between changes in chemical composition or state and changes in energy content.
- Develop laboratory competence in relating chemical structure to spectroscopic phenomena.

- Students need to learn and understand the concepts of safe laboratory practices.
- Students should learn and understand safe disposal techniques, understand and comply with safety regulations, understand and use material safety data sheets (MSDS) and recognize and minimize potential chemical and physical hazards in the laboratory.
- Demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.

PROGRAMME OUTCOMES

PO-1. Demonstrate, solve and an understanding of major concepts in all disciplines of Chemistry independently and in group as well as draw logical conclusions through Project and Seminar Presentation.

PO-2. Employ critical thinking and the scientific knowledge to design, carry out, record and analyse the results of Chemistry experiments

PO-3. Equip students to face the employment challenges and instil confidence to turn into entrepreneur and also step into research career.

PO-4. Generation of new scientific insights or to the innovation of new applications of chemical research

PO-5. Present scientific and technical information resulting from laboratory experimentation in both written and oral formats.

PO-6. Apply modern methods of analysis to chemical systems in a laboratory setting.

PO-7. The students will become well versed in the mechanisms of all types of high level and complicated chemical reactions.

PO-8. The students will improve their competencies on par with their counterparts in premier institutions across the nation.

Programme Specific Outcomes

PSO-1. Appreciates the importance of various elements present in the periodic table, coordination chemistry and structure of molecules, properties of compounds, structural determination of complexes using theories and instruments.

PSO-2. Gathers attention about the physical aspects of atomic structure, dual behaviour, reaction pathways with respect to time, various

energy transformations, molecular assembly in nano level, significance of electrochemistry, molecular segregation using their symmetry.

PSO-3. Learns about the potential uses of analytical, industrial chemistry and medicinal chemistry.

PSO-4. Understand and apply principles of Organic Chemistry for understanding the scientific phenomenon in Reaction mechanisms, Stereochemistry, Organic Synthesis, complex chemical structures, instrumental method of chemical analysis, molecular rearrangements and separation techniques.

PSO-5. Study of organometallic reactions.

PSO-6. Study of biological mechanisms using amino acids.

PSO-7. Learn the classical status of thermodynamics.

Syllabus M. Sc. (Chemistry)

(Effective from 2023-24)

(B.Sc. in Research - Chemistry) as per NEP2020

Year	Semester	Course Code	Core/Elective/Value Added	Paper Title	Theory/ Practical/ Project	Credits	Internal Marks	External Marks (MinMarks)	Total Marks	Minimum Marks (INT+EXT)	Teaching Hours	
											Theory	Tutorial
Year-4 as per NEP/Year -]	Semester-VII as per NEP2020/Semester-I	0720201	Core Compulsory	Inorganic Chemistry I	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0720202	Core Compulsory	Organic Chemistry I	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0720203	Core Compulsory	Physical Chemistry I	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0720204	Core Compulsory	Computers for Chemists	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0720280	Core Compulsory	Lab I Chemistry	Practical	4		100(40)	100	40		
			Select one qualifying paper, * To be Qualified during the Course									
		0720205	Qualifying	Mathematics for Chemists* (for students studied Biology previously)	Theory		25	75(25)	100	40	3x15=45	1x15=15
			OR	OR								
		0720206	Qualifying	Biology for Chemists* (for students studied maths previously)	Theory		25	75(25)	100	40	3x15=45	1x15=15
	Semester VIII as per NEP2020/Semester -II	0820201	Core Compulsory	Inorganic Chemistry II	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0820202	Core Compulsory	Organic Chemistry II	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0820203	Core Compulsory	Physical Chemistry II	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0820204	Core Compulsory	Group Theory, Spectroscopy & Solid State	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		0820280	Core Compulsory	Lab II Chemistry	Practical	4		100(40)	100	40		

M. Sc. in Chemistry as per NEP2020

Year-5 as per NEP/Year -2	Semester IX as per NEP2020/Semester -III	0920201	Core Compulsory	Photo Chemistry	Theory	4	25	75(25)	100	40	3x15=60	1x15=15
		0920202	Core Compulsory	Spectroscopy	Theory	4	25	75(25)	100	40	3x15=60	1x15=15
			Elective									
			Select any one of the following									
		0920203	Elective	Analytical Chemistry	Theory	4	25	75(25)	100	40	3x15=60	1x15=15
				OR								
		0920204	Elective	Bio-inorganic Chemistry	Theory	4	25	75(25)	100	40	3x15=60	1x15=15
				OR								
		0920205	Elective	Bio-organic Chemistry	Theory	4	25	75(25)	100	40	3x15=60	1x15=15
				OR								
		0920206	Elective	Bio-physical Chemistry	Theory	4	25	75(25)	100	40	3x15=60	1x15=15
		0920280	Core Compulsory	Lab III Chemistry	Practical	4		100(40)	100	40		
		0920265	Core Compulsory	Project-I	Project		100(40)		100	40		
	Semester X as per NEP2020/Semester -IV	1020201	Core Compulsory	Environmental Chemistry	Theory	4	25	75(25)	100	40		
			Select any ONE group of Specialization out of Following Three									
			(Group I) Inorganic Chemistry (Select any TWO of the following Five papers)									
		1020202	Elective Inorganic chemistry special I	Inorganic Materials	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		1020203	Elective Inorganic chemistry special II	Organo-transition Chemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15

1020204	Elective Inorganic chemistry special III	Advanced Techniques in Inorganic chemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020205	Elective Inorganic chemistry special IV	Solid State chemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020206	Elective Inorganic chemistry special V	Inorganic Catalysts	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020280	Core compulsory	**Lab IV Special Inorganic Chemistry Special**	Practical	4		100(40)	100	40		
	(Group II) Organic Chemistry (Select any TWO of the following Five papers)									
1020207	Elective Organic chemistry special I	Polymer Chemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020208	Elective Organic chemistry special II	Natural Products	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020209	Elective Organic chemistry special III	Medicinal Chemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020210	Elective Organic chemistry special IV	Organic Synthesis	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020211	Elective Organic chemistry special V	Heterocyclic Chemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020281	Core compulsory	**Lab IV Organic Chemistry Special**	Practical	4		100(40)	100	40		
	(Group III) Physical Chemistry (Select any TWO of the following Five papers)									
1020212	Elective Physical chemistry special I	Physical chemistry of Organic Reactions	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020213	Elective Physical chemistry special II	Electrochemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020214	Elective Physical chemistry special III	Advanced Physical chemistry	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
1020215	Elective Physical chemistry special IV	Electrochemical Techniques and Sensors	Theory	4	25	75(25)	100	40	3x15=45	1x15=15

		1020216	Elective Physical chemistry special V	Physical chemistry of solids	Theory	4	25	75(25)	100	40	3x15=45	1x15=15
		1020282	Core compulsory	**Lab IV Physical Chemistry Special**	Practical	4		100(40)	100	40		
		1020265	Core compulsory	Project II	Project	4		100(40)	100	40		
			Core Compulsory	**Project-I + Project-II**	**VIVA-VOCE**	**8**	**100**	**100**	**200**	**80**		

PGDR (Post Graduate Diploma in Research) in Chemistry as per NEP 2020 OR Pre-Ph.D. Course Work in Chemistry
(Effective from 2022-23)

Year-6 as per NEP2020/Year - 1	Semester XI as per NEP2020/Semester - I	Paper Code		Title Paper		Credits						
		1120201	Core Compulsory	Research Methodology	Theory	4	25	75	100	55	3x15=45	1x15=15
		1120202	Core Compulsory	Analytical techniques	Theory	2	25	75	100	55	2x15=30	0x15=0
		1120203	Core Compulsory	Advances in Chemistry	Theory	2	25	75	100	55	2x15=30	0x15=0
		1120204	Core Compulsory	Molecular Magnets and Liquid Crystals	Theory	2	25	75	100	55	2x15=30	0x15=0
		1120205	Core Compulsory	Emerging Methodologies in Organic Synthesis	Theory	2	25	75	100	55	2x15=30	0x15=0
		1120265	Core Compulsory	Research Project		4						

Examination Pattern

Internal Examination:

1. One written Test of 20 Marks.(5 Marks Quiz + 15 Marks (Very Short + Short + Long Question))
2. 5 Marks for Class performance/Attendance.

External Examination: Written Exam of 75 marks 3Hrs Duration.

External Exam Pattern:

Unit-I : Attempt all five question . Each question carry 3 marks.

Unit- II : Attempt Any Two out of three. Each Question carry 7.5 marks each.

Unit-III : Attempt Any Three out of Five. Each Question carry 15 marks each.

MinimumMarks:

1. In each individual paper Forty Marks i.e. 40%.
   1. For PG Division: First Division - CGPA 6.0 and Less than 10, Second division - CGPA 5.0 and less than 6.0. There is no provision of Third division.
   2. For PGDR Division: First Division - CGPA 6.5 and Less than 10, Second division - CGPA 5.5 and less than 6.5. There is no provision of Third division.

Equivalent Percentage = CGPA x 9.5

Note: Percentage and Grading system applicable as per NEP2020 GO 1032/Sattar-2022-08(35)/2020, Higher Education Division -3, Lucknow Dated 20.04.2022

Detailed Syllabus

for

M.Sc. (Chemistry)

Or

B.Sc. (Research) Chemistry

Detailed Syllabus

For

M.Sc. (Chemistry)

Or

B.Sc. (Research) Chemistry

Semester-I

Course-1		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: 0720201	**Course Title: Inorganic Chemistry I**	**Theory**

Course Objectives: Acquiring ability for understanding complex molecule formation, their structure, chemical reaction and reaction mechanism.

Course Outcomes (CO's):

CO1. Ability to learn the stereochemistry and bonding in main group compounds

CO2. Determining constants for metal ligand equilibrium in solution

CO3. Understanding reaction mechanism of transition metal complexes.

CO4. Describing relationship between metal-ligand bonding and geometry of molecules.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours

I	Stereochemistry and Bonding in Main Group Compounds: VSEPR, Walsh diagrams (tri atomic molecules), dπ-Pπ bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.	**12**
II	Metal-Ligand Equilibria in Solution: Stepwise and overall formation constants and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and Ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.	**12**
III	Reaction Mechanism of Transition Metal Complexes: Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories. Kinetics of Substitution Reactions- acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism. Anation reactions, reactions without Metal-Ligand bond cleavage. Substitution reactions in square planer complexes, the trans effect, mechanism of the substitution reaction. Redox reactions (electron transfer reactions) -Mechanism of one electron transfer reactions [such as Henry Taube's classical reaction of $(NH_3)_5Co^{3+}$-Cr^{2+}, Inner sphere type reactions]. Outer-sphere type reactions (cross reactions) and Marcus-Hush theory (No mathematical treatment).	**24**
IV	Metal-Ligand Bonding: Adjusted CFT, Limitations of crystal field theory. Octahedral, tetrahedral and square planar complexes.	**12**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
3. Chemistry of the Elements. N.N. Greenwood and A. Earnshow, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5. Magnetiochemistry, R.1. Carlin, Springer Verlag.

6. Comprehensive Coordiantion Chemistry eds., G. Wilkinson, R.D. Gillars and J.A. Mc Cleverty,Pergamon.
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions: .....

COURSE-2		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: **0720202**	**Course Title: Organic Chemistry I**	**Theory**

Course Objectives: Acquiring ability for defining organic molecule formation, bonding nature, structure, reactivity and reaction mechanism.

Course Outcomes (CO's):

CO1. Developing skills in the identification of nature of bonding in organic molecules

CO2. Determining the connection between molecular geometry and their reactivity.

CO3. Ability to apply different approaches in formation of organic molecules.

CO4. Describing relationship between molecular structure and isomers and also their transformation.

CO5. Understanding the stereochemistry and reaction mechanism.

CO6. Understanding aliphatic nucleophilic substitution and aliphatic electrophilic substitution to form specific product.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Nature of Bonding in Organic Molecules: Delocalized chemical bonding, Conjugation, hyperconjugation, bonding in fullerenes, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of n-molecular orbitals, annulenes, antiaromaticity, w-aromaticity, homo-aromaticity, PMO approach. Bonds weaker than covalent- addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes. Stereochemistry and Bonding in Main Group Compounds: VSEPR, Walsh diagrams (tri atomic molecules), dπ-Pπ bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.	**10**
II	Stereochemistry: Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding. Elements of symmetry, chirality, molecules with more than one chiral centre, threo and erythro isomers, methods of resolution, optical purity. Enantiotopic and diastereotopic atoms, groups and faces. Stereospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.	**15**
III	Reaction Mechanism: Structure and Reactivity-Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining	**15**

	mechanisms, isotope effects. Hard and soft acids and bases. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. Effect of structure on reactivity-Resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.	
IV	Aliphatic Nucleophilic Substitution: The SN2, SN1, mixed SN1 & SN2 and SET mechanisms. The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance. Classical and nonclassical carbocations, Phenonium ions, nonbornyl system, Common carbocation rearrangements. Application of NMR spectroscopy in the detection of carbocations. The SNi mechanism, Nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium. Phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity. Metal-Ligand Bonding: Adjusted CFT, Limitations of crystal field theory. Octahedral, tetrahedral and square planar complexes.	**15**
V	Aliphatic Electrophilic Substitution: Bimolecular mechanisms- SE2 and SE1. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.	**5**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sunderg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Comell University Press.
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professionsl.
8. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.
9. Pericyclic Reactions, S.M. Mukherji, Macmillan, India

10. Stereochemistry of Organic Compounds, D.Nasipuri, New Age International.
11. Stereochemisty of Organic Compounds, P.S. Kalsi, New Age International.Advanced Inorganic Chemistry, F.A. Cotton and Wilkinson, John Wiley.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-3		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: 0720203	**Course Title: Quantum Chemistry & Thermodynamics**	**Theory**

Course Objectives: To grow the students with knowledge of advanced quantum chemistry and thermodynamics.

Course Outcomes (CO's):

CO1. Ability to solve the quantum mechanics e.g. angular momentum etc. of molecules.

CO2. Determining the electronic structure, bond order and charge density of molecular orbitals.

CO3. Calculating the thermodynamic parameters of substances

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100**

		Minimum Marks: 40
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Introduction to Exact Quantum Mechanical Results: The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom. Approximate Methods: The variation theorem, linear variation principle. Perturbation theory (first order and nondegenerate). Applications of variation method and perturbation theory to the Helium atom. Angular Momentum: Ordinary angular momentum, generalized angular momentum, eigen functions for angular momentum, eigen values of angular momentum, operator using ladder operators, addition of angular momenta, spin, anti symmetry and Pauli's exclusion principle.	**15**
II	Electronic Structure of Atoms: Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the pn configuration, term separation energies for the dn configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of self -consistent field, the virial theorem. Molecular Orbital Theory: Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene, cyclopropenyl radical, cyclobutadiene etc. Introduction to extended Huckel theory.	**15**
III	Classical Thermodynamics: Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significances. Determinations of these quantities. Concept of fugacity and determination of fugacity.	**8**
IV	Statistical Thermodynamics: Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and	**14**

	microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers). Partition functions - translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Applications of partition functions. Heat capacity behaviour of solids - chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics - distribution law and application to helium.	
V	Non equilibrium Thermodynamics: Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, nonequilibrium stationary states, phenomenological equations, microscopic reversibility.	**8**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Introduction to Quantum Chemistyry, A.K. Chandra, Tata Mc Graw Hill.
3. Quantum Chemistry, Ira N. Levine, Prentice Hall.
4. Coulson's Valence, R.Mc Ween y, ELBS.
5. Chemical Kinetics. K.J. Laidler, McGraw-Hill.
6. Kinetics and Mechanism of Chemical Transformation J.Rajaraman and J. Kuriacose, Mc Millan.
7. Micelles, Theoretical and Applied Aspects, V. MOraoi, Plenum.
8. Modern Electrochemistry Vol. 1 and Vol II J.O.M. Bockris and A.K.N. Reddy, Planum.
9. Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan and J. Sridhar, Wiley Eastern.
10. Introduction to Quantum Chemistry-R.K. Prasad, New Age PublicationAdvanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions: .....

	COURSE-4	
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: **0720204**	**Course Title: Computer for Chemists**	**Theory**
Course Objectives: Acquiring ability to develop the skills in computer application, language and programming in FORTRAN/C/BASIC/ C with the knowledge about programs available for chemists. **Course Outcomes (CO's):** **CO1.** Ability to formulate programs for calculating problems in chemistry. **CO2.** Ability to use MS office for documentation, calculations and graphics presentation. **CO3.** Ability to apply software to sort out general puzzles in chemistry. **CO4.** Ability to present the scripts in power point. **CO5.** Internet searching to solve academic problems and to know about recent studies and advancement in chemistry.		
	Core Compulsory	**Max Marks (Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Introduction to Computers and Computing: Basic structure and functioning of computers with a PC as an illustrative example. Memory, I/O devices. Secondary storage. Computer languages. Operating systems with DOS as an example. Introduction to UNIX and Windows. Data Processing, principles of programming. Algorithms and flow-charts.	**15**
II	Computer Programming in FORTRAN/C/BASIC: The language feature are listed here with reference ton FORTRAN. The instructor may choose another language such as BASIC or C and the feature may be replaced appropriately. Elements of the computer language. Constants and variables. Operations and symbols. Expression. Arithmetic assignment statement input and output. Format statement. Termination statements. Branching statements such as IF or GO TO statement. LOGICAL variables, Double Precision variables. Subscripted variables and DIMENSIONS. DO statements. FUNCTION and SUBROUTINE. COMMON and DATA statements. Decision control structure, case4 control structure, functions, introduction ton arrays, programmes based on above.	**15**
III	Programming in Chemistry: Development of small computer course involving simple formula in chemistry such as Vander Waal's equation, pH titration, kinetics, radioactive decay. Evaluation of lattice energy and ionic radii from experimental data. Linear simultaneous equations to solve secular equation with in the Huckel theory. Elementary structural features such as bond lengths, bond angels, dihedral angels etc. of molecule extracted from a database such as Cambridge database.	**15**
IV	Use of Computer Programmes: Execution of linear regression, X-V plot, Numerical integration and differentiation as well as differential equation solution programmes. Monte –Carlo and Molecular dynamics. Introduction to MS Office (MS Word, MS Excel, MS PowerPoint). Lab sessions based on MS Office package, Introduction to Internet Explorer.	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Computers and Common Sense, R, Hunt and J, Shelly, Prentice Hall.
2. Computational Chemistry, AC, Norris.
3. Microcomputer Quantum Mechanics, J.P., Killngbeck. Adam Hilger.
4. Computer Programming in FORTRAN IV, V. Rajaraman, Prentice Hall.
5. An Introduction to Digital Computer Design, V. Rajaraman and T. Radhakrishnan,

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-5

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: **0720280**	**Course Title: Lab I Chemistry Practical**	**Practical**

Course Objectives: Understanding analysis and separation of inorganic and organic mixtures and chemical preparation of organic and inorganic molecules. Also, to provide advance insight about preparation of solutions standardization, pH meter, solubility, viscosity etc.

Course Outcomes (CO's):

CO1. Qualitative analysis of inorganic mixtures and insoluble.

CO2. Chemical separation techniques of cations and anions.

CO3. Qualitative analysis of two component organic mixture.

CO4. The basic knowledge like preparation of solutions standardization of secondary solution, dilution and handling of pH meter related to the practical syllabus.

CO5. The basic knowledge of some experimental determinations and chemical synthesis to focus their aim for future prospects of Ph.D programme.		
Credits: 4	**Practical**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 120 Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Physical Chemistry Practical (minimum 5 practical) • To find out the strength of the given HCl solution by titrating it against N/10 NaOH using pH meter. • To find out the strength of the given CH3COOH solution by titrating it against N/10 NaOH using pH meter. • To find out the strength of HCl and CH3COOH in a mixture of both by titrating it against N/10 NaOH using pH meter. • To determine the solubility of a given salt at room temperature and also draw its solubility curve. • To find out the heat of solution of oxalic acid by solubility method. • To standardize the given KMnO4 solution by titrating it against standard Ferrous Ammonium Sulphate solution. • To determine the critical solution temperature of phenol water system. • To determine the viscosity of given sample of oil at different temperature using Red Wood Viscometer.	**30**
II	INORGANIC PRACTICAL • Macro Qualitative analysis of the mixture of three components (6 radicals). • Inorganic preparations (Minimum 3 preparations) i. To prepare Hexa-Ammine (II) Chloride. ii. To prepare potassium Dioxalato Cuprate (II) Dihydrate.	**30**

	iii. To prepare Potassium Trioxalato Chromate (III). iv. To prepare Tetrammine Cupric Sulphate. v. To prepare Sodium Ferric Oxalate. vi. To prepare crystals of Potassium Tris Oxalate Aluminate (III).	
III	Organic Chemistry Practical • To identify the given organic compound and prepare its derivatives. • To analyse the given organic mixture (water separation). • Single step preparations (Minimum 3 preparations) i. Hydrolysis ii. Bromination iii. Nitration iv. Oxime formation Reduction v. Hoffmann Bromide reaction vi. Benzoin condensation reaction etc.	**30**
IV	Computer • Computer Programming in FORTRAN/C/BASIC/ C Language (Any one Language) • Application of MS Office (MS Word, MS Excel, MS PowerPoint). • Introduction to Internet Explorer.	**30**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly. Prentice Hall 2. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS. 3. Experiments and Techniques in Organic Chemistry, D.P. Pasto, C. Johnson and M. Miller, Prentice Hall. 4. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Health. 5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.		

6. Handbook of Organic Analysis-qualitative and Quantitative. H. Clark, Adward Arnold.
7. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
8. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
9. Findley's Practical Physical chemistry, B.P. Levitt, Longman.
10. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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	COURSE-6	
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: 0720205	**Course Title: Mathematics for Chemists**	**Theory**

Course Objectives: To develop the skills in vectors and matrix algebra analysis.

Course Outcomes (CO's):

CO1. Ability to apply matrix algebra to solve problems in chemistry.

CO2. Determining the energy distribution, bond energy, phase transformation energy, chemical kinetics using differential and calculus mathematics.

CO3. Calculating molecular dimensions correctly and correlate results with experimental outcomes.

CO4. Describing kinetic theory of gases by probability concept and theorem..

CO5. Understanding the dependency of results on earlier results, and thereby developing a correct approach towards life realizing the deep connection among past, present and future.

Credits: 4	**Qualifying Course**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	**Course Topic**	**No. of Lectures Hours**
I	Vectors: Vector, dot, cross and triple products etc. The gradient, divergence and curl. Vector calculus. Matrix Algebra: Addition and multiplication; inverse, adjoint and transpose of matrices, special matrices (Symmetric, skew-sym0etric, Hermitian, unit, diagonal, unitary, etc.) and their properties. Matrix equation: Homogeneous, non-homogenous linear and conditions for the solution, linear dependence and independence. Introduction to vector spaces, matrix eigen values and eigen vectors, diagonalization, determinants (examples from Huckel theory). Elementary Differential Equations: Variables-separable and exact, first-order differential equations, homogenous, exact and linear equations. Applications to chemical kinetics, secular equilibria, quantum chemistry, etc. Solutions of differential equations by the power series method, second order differential equations and their solutions.	**15**
II	Differential Calculus: Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima (examples related to maximally populated rotational	**15**

	energy levels, Bohr's radius and most probable velocity from Maxwell's distribution etc), exact and inexact differentials with their applications to thermodynamic properties. Integral calculus: Basic rules for integration, integration by parts, partial fraction and substitution. Reduction formulae, applications of integral calculus. Functions of several variables, partial differentiation, co-ordinate transformations (e.g. Cartesian to spherical polar), curve sketching.	
III	Elementary Differential Equations: Variables-separable and exact first order differential equations, homogeneous, exact and linear equations, Applications to chemical kinetics, Secular equilibria, Quantum chemistry etc., Solutions to differential equations by the power series method, Fourier series, Solutions to harmonic oscillator and Legendre equation etc., spherical harmonics, Second order differential equations and their solutions.	**15**
IV	Permutation And Probability: Permutations and combinations, probability and probability theorems, probability curves, average, root mean square and most probable errors, examples from the kinetic theory of gases etc., curve fitting (including least squares fit etc.) with a general polynomial fit.	**15**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. The Chemistry Mathematics, Steiner E., 1st edition, Oxford University Press. 2. Mathematics for Chemistry, Doggett Sucliffe, 1st edition, Longman, 2003. 3. Mathematical Preparation for Physical Chemistry, Daniels F., McGraw Hill. 4. Chemical Mathematics, Hirst D.M., Longman. 5. Applied Mathematics for Physical Chemistry, Barr ante J. R., 3rd edition, Prentice Hall, 2004. 6. Basic Mathematics for Chemists, Tebbutt, 1st edition, John Wiley, 1994.		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:		

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COURSE- 7		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** First/Seventh
Course Code: **0720206**	**Course Title: Biology for Chemists**	**Theory**
Course Objectives: To help them to learn the cell structure and functions and organic molecules carbohydrates, lipids, amino acids, peptides and proteins and nucleic acids in living beings. **Course Outcomes (CO's):** **CO1.** Ability to understand molecules responsible for life in organisms. **CO2.** Understanding metabolic chemical reactions in living cells. **CO3.** Ability to know genetic codes and its connection with living species. **CO4.** Describing energy production for working and growing of organisms. **CO5.** Understanding the dependency of organisms on molecules their chemical structure and chemical reactions.		
Credits: 4	**Qualifying Course**	**Max Marks (Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		

Unit	Course Topic	No. of Lectures Hours
I	Cell Structure and Functions: Structure of prokaryotic and eukaryotic cell, intracellular organelles and their functions, comparison of plant and animal cells. Overview of metabolic processes –catabolism and anabolism. ATP-the biological energy currency. Origin of life – unique properties of carbon, chemical evolution and rise of living systems. Introduction to biomolecules, building blocks of bio-macromolecules.	10
II	Carbohydrates: Conformation of monosaccharides, structure, and functions of important derivatives of monosaccharides like glycosides, deoxy sugars, myoinositol, amino sugars. N-acetylmuramic acid, sialilic acid, disaccharides, and polysaccharides. Structure and biological functions of glycosaminoglycans or muco-polysaccharides. Carbohydrates of glycoproteins and glycolipids. Role of sugars in biological recognition. Blood group substances. Ascorbic acid. Carbohydrate metabolism- Krebs cycle, glycolysis, glycogenesis and glycogenolysis, gluconeogenesis, pentose phosphate pathway.	10
III	Lipids: Fatty acids, essential fatty acids, structure, and function of triacylglycerols, glycerophospholipids, cholesterol, bile acids, prostaglandins, lipoproteins-composition and function, role in atherosclerosis. Properties of lipid aggregates micelles, bilayers, liposomes, and their possible biological functions. Biological membranes. Fluid mosaic model of membrane structure. Lipid metabolism - beta oxidation of fatty acid.	10
IV	Amino-acids, Peptides and Proteins: Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins forces responsible for holding of secondary structures. Alpha helix, Beta sheets, secondary structure, triple helix structure of collagen. Tertiary structure of protein-folding and domain structure. Quaternary structure. Amino acid metabolism- degradation and biosynthesis of amino acids, sequence determination chemical enzymatic mass spectral, racemization detection. Chemistry of oxytocin and tryptophan releasing hormone.	10
V	Nucleic Acids: Purines and pyrimidines bases of nucleic acids, base pairing via H-bonding. Structure of ribonucleic acids RNA and deoxyribonucleic acids DNA, double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. The chemical basis for hereditary, an overview of replication of DNA, transcription, translation, and genetic code. Chemical synthesis of mono and tri nucleoside.	10

VI	Enzymes: Introduction and classification of enzymes, Properties of enzymes: Enzyme efficiency ii) Enzyme specificity, Enzyme Kinetics: i) Effect of substrate ii) Other factors affection enzyme kinetics such as temperature, pH etc., Enzymes as Catalyst: Specificity of Enzyme Catalysed Reactions, Rate accelerators. Mechanism of enzyme action and Synthetic approach of enzyme, Mechanism of alcoholic fermentation, Role of main enzymes involved in the synthesis and breakdown of glycogen, Glycogen store diseases caused by enzyme deficiency, Co enzymes.	10

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Principles of Biochemistry, Lehninger, A.L. Worth Publishers.
2. Biochemistry, Stryer L., W.H. Freeman
3. Biochemistry, Rawn J. David, Neil Patterson.
4. Biochemistry, Voet, Voet , John Wiley.
5. Outlines of Biochemistry, Conn E.E., Stumpf P. K., John Wiley.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Semester II

COURSE-1

Programme/Class: M.Sc.	Year: P.G. Ist Year or UG in Research Fourth Year	Semester: Second/Eight
Course Code: 0820201	**Course Title: Inorganic Chemistry II**	**Theory**

Course Objectives: To develop the knowledge about electronic spectra and magnetic properties of transition metal complexes, metal pi complexes, metal clusters, nuclear and Radiochemistry chemistry.

Course Outcomes (CO's):

CO1. Ability to understand electronic spectra and magnetic properties of transition metal complexes.

CO2. Understanding the structure of coordination complex compounds.

CO3. Ability to find out bonding patterns of metal π-Complexes using vibrational spectroscopy.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Electronic Spectra and Magnetic Properties of Transition Metal Complexes: Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d1-d9 states), calculations of Dq, B and β parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover	16
II	Metal π-Complexes: Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding. Structure	16

	and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as Ligand	
III	Metal Clusters: Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.	**8**
IV	Nuclear and Radiochemistry: Nuclear structure and nuclear stability, Nuclear models, Radioactivity and nuclear reactions (including nuclear fission and fusion reactions), Chemical effects of nuclear transformations Fission & Fusion, Fission products & fission yields, Hot atom chemistry, nuclear fission and fusion reactors, The interaction of nuclear reactions with matter, Radiation hazards and therapeutics, Detectors and their principles, The direction of radioactivity, The counting errors and their corrections, tracer techniques and their applications, isotope dilution and radioactivation methods of analysis, fission product analysis (e.g. the technique of isolating two or three different fission products of U and Th and determining the yield)	**20**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Advanced Inorganic Chemistry, FA Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J.E. Huhey, Harpes & Row.
3. Chemistry of the Elements, N.N. Greenwood and A. Earnshaw, Pergamon.
4. Inorganic Electronic Spectroscopy, A.B.P. Lever, Elsevier.
5. Magnetochemistry, R.L. Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry eds., G. Wilkinson, RD. Gillars and J.A. Mc Cleverty, Pergamon.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-2

Programme/Class: M.Sc.	Year: P.G. Ist Year or UG in Research Fourth Year	Semester: Second/Eight
Course Code: 0820202	**Course Title: Organic Chemistry II**	**Theory**

Course Objectives: To develop the knowledge about aromatic electrophilic substitution, aromatic nucleophilic substitution, free radical reactions, addition to carbon carbon multiple bonds, addition to carbon hetero multiple bonds, elimination reactions and pericyclic reactions.

Course Outcomes (CO's):

CO1. Ability to understand organic reaction mechanism.

CO2. Understanding the various types of aliphatic nucleophilic substitution reactions and will give them a better understanding of the processes involved.

CO3 Describing mechanisms for various organic reactions and how to use their understanding of organic mechanisms to predict the outcome of reactions.

CO4 Understanding molecular orbital symmetry and possibility of thermal and photochemical pericyclic reactions.

CO5. Ability to know organic addition reaction on multiple bonds and their product with stereo isomeric chemistry.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.	6

II	Aromatic Nucleophilic Substitution: The SNAr, SN 1, benzyne and SRN 1 mechanisms. Reactivity - effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.	5
III	Free Radical Reactions: Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenations (NBS), oxidation of aldehydes to carboxylic acids, autooxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.	8
IV	Addition to Carbon-Carbon Multiple Bonds: Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.	6
V	Addition to Carbon-Hetero Multiple Bonds: Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction. Mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions.Hydrolysis of esters and amides, ammonolysis of esters.	12
VI	Elimination Reactions: The E2, E1 and E1 CB mechanisms and their spectrum. Orientation of the double bond. Reactivity - effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.	5
VII	Pericyclic Reactions: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3- butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward--Hoffmann correlation diagrams. FMO and PMO approach. Electrocyclic reactions - conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloaddditions - antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloadditions and cheleotropic reactions.	18

	Sigmatropic rearrangements - suprafacial and antarafacial shifts of H, Sigmatropic shifts involving carbon moieties, 3,3- and 5,5- Sigmatropic rearrangements. Claisen, Cope, Sommelet Hauser Rearrangement, Ene reaction.	

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C. K. Ingold. Cornell University Press.
5. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall.
6. Modern Organic Reactions, H. O. House, Benjamin.
7. Principles of Organic Synthesis, R. O. C. Norman and J. M. Coxon, Blackie Academic & Professional.
8. Pericyclic Reactions, S. M. Mukherji, Macmillan, Irdia.
9. Reaction Mechanism in Organic Chemistry, S. M. Mukherji and S. P. Singh, Macmillan.
10. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
11. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 3

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** Second/Eight

Course Code: 0820203	Course Title: Physical Chemistry II	Theory

Course Objectives: To grow the students with deep knowledge regarding chemical dynamics, surface chemistry and electro chemistry.

Course Outcomes (CO's):

CO1. Ability to understand Chemical dynamics in detail.

CO2. Understanding surface chemistry in broad spectrum.

CO3. Ability to grow deep knowledge about electro chemistry.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Chemical Dynamics: Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions. Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov - Zhabotinsky reaction), homogeneous catalysis, kinetics of enzyme, reactions, general features of fast reactions, study of fast reactions by flow method: relaxation method, flash photolysis and the nuclear magnetic resonance method.	20

	Dynamics of molecular motions, probing the transition state, dynamics of unimolecular reactions (Lindemann Hinshelwood and Rice-Ramsperger - Kassel-Marcus [RRKM] theories of unimolecular reactions).	
II	Surface Chemistry: Adsorption -Surface tension, capillary action, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), Elementary treatment of BET equation, catalytic activity at surfaces. Micelles-Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization, solubilization, micro emulsion, reverse micelles. Macromolecules- Polymer definition, types of polymers, kinetics of radical polymerization, mechanism of polymerization. Molecular mass, number and mass average molecular mass, molecular mass determination (Elementary treatment of Osmometry, Viscometry, Sedimentation and Light scattering methods), chain configuration of macromolecules, calculation of average dimensions of various chain structures.	**20**
III	Electrochemistry: Electrochemistry of solutions. Debye-Huckel - Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Jerum mode. Thermodynamics of electrified interface equations. Derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces. Guoy -Chapman, Stern. Over potentials, exchange current density, derivation of Butler -Volmer equation, Tafel plot. Quantum aspects of charge transfer at electrodes-solution interfaces, quantization of charge transfer, tunneling. Semiconductor interfaces - theory of double layer at 'Semiconductor, electrolyte solution interfaces, structure of double layer interfaces. Electrocatalysis - influence of various parameters. Hydrogen electrode, Bioelectrochemistry, Polarography theory, Ilkovic equation, half wave potential and its significance. Introduction to corrosion, homogenous theory, forms of corrosion, corrosion monitoring and prevention methods.	**20**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings:		

1. Physical Chemistry, P.W Atkins, ELBS.
2. Introduction to Quantum Chemistry, AK. Chandra, Tata McGraw Hill.
3. Quantum Chemistry, Ira N. Levine. PrentCe Hall.
4. Coulson's Valence, R. McWeeny, ELBS.
5. Chemical Kinetics, K. J. Laidler, Mcgraw-Hill.
6. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman and J. Kuriacose, McMillan.
7. Micelles, Theoretical and Applied Aspects, V. Moroi, Plenun
8. Modern Electrochemistry Vol. I and Vol. II, J.O.M. Bockris and AK.N. Reddy, Plenum.
9. Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan and J. Sridhar, Wiley Eastern.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-4

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** Second/Eight
Course Code: **0820204**	**Course Title: Group Theory, Spectroscopy & Diffraction Methods & Solid State**	**Theory**

Course Objectives: To help them to learn the group theory for molecules.

Course Outcomes (CO's):

CO1. Ability to understand symmetry and symmetry elements.

CO2. Understanding electromagnetic energy and their interaction with matter.

CO3. Ability to know vibrational and Raman spectroscopy.

CO4. Describing electronic spectroscopy.

CO5. Understanding the magnetic resonance spectroscopy and Xray diffraction.		
Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Symmetry and Group Theory in Chemistry: Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups by matrices (representation for the Cn, Cnv, Cnh. Dnh etc. groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use; spectroscopy.	**10**
II	Unifying Principles: Electromagnetic radiation, interaction of electromagnetic radiation with matter absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering. Uncertainty relation and natural line width. and natural line broadening, transition probability, results of the time dependent perturbation theory, transition moment, selection rules, intensity of spectral lines, Born-Oppenheimer approximation, rotational, vibrational and electronic energy levels.	**10**
III	Vibrational Spectroscopy: Infrared Spectroscopy - Review of linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy, P,Q,R branches. Breakdown of Oppenheimer approximation; vibrations of poly atomic molecules. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, metal-ligand vibrations, normal co-ordinate analysis.	**12**

	Raman Spectroscopy- Classical and quantum theories of Raman effect. Pure rotational, vibrational and Vibrational-rotational Raman spectra, selection rules, mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS).	
IV	Electronic Spectroscopy: Atomic Spectroscopy- Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms. Molecular Spectroscopy- Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of the excited states, Franck-Condon principle, electronic spectra of polyatomic molecules. Emission spectra; radiative and non-radiative decay, internal conversion, spectra of transition metal complexes, charge-transfer spectra. Photoelectron Spectroscopy-Basic principles; photo-electric effect, ionization process, Koopman's theorem. Photoelectron spectra of simple molecules, ESCA, chemical information from ESCA. Auger electron spectroscopy - basic idea.	**8**
V	Magnetic Resonance Spectroscopy: Nuclear Magnetic Resonance Spectroscopy Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurements, factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant 'J'. Classification (ABX, AMX, ABC, A2B2 etc.), spin decoupling; basic ideas about instrument, NMR studies of nuclei other than proton - 13C. Electron Spin Resonance Spectroscopy-Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and McConnell relationship, measurement techniques, application.	**10**
VI	X-ray Diffraction: Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity' and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules, Ramchandran diagram.	**10**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho, Wiley Interscience.
2. NMR, NOR, EPR and M6ssbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
3. Physical Methods in Chemistry, R.S. Drago, Saunders College.
4. Chemical Applications of Group Theory, F. A. Cotton.
5. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
6. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
7. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, ISHOxford.
8. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
9. Introduction to Magnetic Resonance, A Carrington and A.D. Maclachalari, Harper & Row.
10. Modern Spectroscopy, J.M. Hollas, John Wiley

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 5

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** Second/Eight
Course Code: **0820280**	**Course Title: Lab II Chemistry**	**Practical**

Course Objectives: To help them to learn about different analytical techniques used in inorganic, organic and physical chemistry.

Course Outcomes (CO's):

CO1. Ability to understand different techniques and their applicability.

CO2. Understanding quantitative estimation by titrimetric methods.

CO3. Ability to perform separation of organic mixture.

CO4. Ability to prepare useful organic compounds.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 120 Lecture Hours in a Semester

Unit	**Course Topic**	**No. of Lectures Hours**
I	Physical Chemistry • To find out the surface tension of the given liquid by drop weight method at room temperature. • To determine the parachor value of given liquid. • To find out the surface tension of CH_3COOH, C_2H_5OH, n-Hexane at room temperature and hence calculate the atomic parachors of C, H, and O. • To compare the cleaning powers of two samples of detergents supplied to you. • To determine the critical micelle concentration of soap. • To find out the strength of HCl solution by titrating it against N/10 NaOH using conductometer. • To find out the strength of given NH_4OH by titrating it against HCl solution using conductometer. • To find the velocity constant of the hydrolysis of methyl acetate catalysed by i. HCl ii. H_2SO_4	**30**

	• Determine the relative strengths of two acids i.e. HCl & H_2SO_4 by studying the hydrolysis of methyl acetate.	
II	Inorganic Chemistry • Acidimetry- Alkalimetry titration. • Oxidation –Reduction titration. • Silver Nitrate titration. • Complexometric - EDTA titration. • pH-metry titration. • To estimate Copper and Nickel in the given solution. • To estimate Iron and Nickel in a given solution.	**60**
III	Organic Chemistry • Analysis of binary organic mixtures i. Separation with $NaHCO_3$ ii. Separation with NaOH iii. Separation with HCl • Two step preparations i. To prepare Anthranilic Acid from Phthaic Anhydride. ii. To prepare o- Chlorobenzoic Acid from Phthalamide. iii. To prepare Benzil from Benzaldehyde. iv. To prepare Benzanilide from Benzophenone.	**30**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly. Prentice Hall 2. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS.		

3. Experiments and Techniques in Organic Chemistry, D.P. Pasto, C. Johnson and M. Miller, Prentice Hall.
4. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Health.
5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
6. Handbook of Organic Analysis-qualitative and Quantitative. H. Clark, Adward Arnold.
7. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
8. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
9. Findley's Practical Physical chemistry, B.P. Levitt, Longman.
10. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Semester III

COURSE-1		
Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Third/Nine
Course Code: 0920201	**Course Title: Photochemistry**	**Theory**
Course Objectives: To help them to learn the detailed ideas about photo chemistry. **Course Outcomes (CO's):** **CO1.** Ability to understand the basic of photo chemical processes. **CO2.** Understanding the photochemical reactions. **CO3.** Ability to know the properties of excited states of molecules. **CO4.** Describing the mechanism of the photochemical reactions. **CO5.** Understanding the photo chemistry of organic reactions and other miscellaneous photochemical reactions.		
Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		

Unit	Course Topic	No. of Lectures Hours
I	Basic of Photochemistry: Absorption, Excitation, photochemical laws, electronically excited states- life times- measurements of the times. Flash photolysis, stopped flow techniques, Energy dissipation by radiative and non-radiative processes, absorption spectra, Franck-Condon principle, photochemical stages- primary and secondary processes	10
II	Photochemical Reactions: Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy, actinometry.	10
III	Properties of excited states: Structure, dipole moment, Acid-Base strengths, reactivity, Photochemical Kinetics- Calculation of rates of radioactive processes, Bimolecular deactivation quenching	10
IV	Determination of Reaction Mechanism: Classification, rate constants and life times of reactive energy state determination of rate constants of reactions, Effect of light intensity on the rate of photochemical reactions, Types of photochemical reactions-photo dissociation, gas-phase photolysis.	10
V	Photochemistry of Organic compounds: Alkene- Intramolecular reactions of the olefinic bond-geometrical isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5-dienes. Photochemistry of Aromatic Compounds, Isomerisation, additions and substitutions. Carbonyl Compounds-Intramolecular reactions of carbonyl compounds-saturated, cyclic and acyclic, α, β, γ unsaturated and α, β, unsaturated compounds, cyclohexadienones, Intermolecular cylcoaddition reactions-dimerisation and oxetane formation. Aromatic Compounds- Isomerisation, Addition and substitutions	10
VI	Miscellaneous Photochemical Reactions: Photo-Fries reactions of annelids, Photo-Fries rearrangement, Barton reaction, Singlet molecular oxygen and its reactions, Photochemical formation of smog, Photodegration of polymers, Photochemistry of vision.	10
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings:		

1. Fundamentals of photochemistry, K.K. Rothagi-Mukheriji, Wiley-Eastern.
2. Essentials of Molecular Photochemistry, A Gilbert and J. Baggott, Blackwell Scientific Publication.
3. Molecular Photochemistry, N.J. Turro, W.A. Benjamin.
4. Introductory Photochemistry, A. Cox and t. Camp, McGraw Hill.
5. Photochemistry, R.P. Kundall and A. Gilbert. Thomson Nelson.
6. Organic Photochemistry, J. Coxon and B.halton, Cambridge University Press.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-2

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Third/Ninth
Course Code: 0920202	**Course Title: Spectroscopy**	**Theory**

Course Objectives: To help them to learn about different techniques of spectroscopy.

Course Outcomes (CO's):

CO1. Ability to understand ultra violet and visible spectroscopy.
CO2. Understanding infrared spectroscopy.
CO3. Ability to know optical rotatory dispersion and circular dichroism.
CO4. Describing nuclear magnetic resonance and C13 NMR spectra.
CO5. Understanding ESR and Mass spectrometry.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Ultraviolet and Visible Spectroscopy: Various electronic transitions (185-800 nm), Beer-Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Steric effect in biphenyls.	**10**
II	Infrared Spectroscopy Instrumentation and sample handling: Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines, Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds), Effect of hydrogen bonding and solvent effect on vibrational frequencies, Symmetry and shapes of AB2, AB3, AB4, AB5 and AB6, mode of bonding of ambidentate ligand, ethylenediamine and diketonato complexes, application of resonance	**10**
III	Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD): Definition, deduction of absolute configuration, octant rule for ketones.	**5**
IV	Nuclear Magnetic Resonance Spectroscopy: General introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, complex spin-spin interaction between two, three, four and five nuclei (first order spectra), virtual coupling. Stereochemistry, hindered rotation, Karplus curve variation of coupling constant with dihedral angle. Simplification of complex spectra, nuclear magnetic double resonance, contact shift reagents, solvent	**10**

	effects. Fourier transforms technique, nuclear Overhauser effect (NOE). Resonance of other nuclei-F, P. some applications including biochemical systems.	
V	Carbon-13 NMR Spectroscopy: General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Introduction to 2 D NMR.	5
VI	Electron Spin Resonance Spectroscopy: Hyperfine coupling, spin polarization for atoms and transition metal ions, spin-orbit coupling and significance of g-tensors, application to transition metal complexes (having one unpaired electron) including biological systems and to inorganic free radicals such as PH4, F2- and [BH3].	10
VII	Mass spectrometry: Experimental arrangements and presentation of spectra, molecular ions, appearance and ionization potential, fragmentation, ion reactions and their interpretation, effect of isotopes on the appearance of a mass spectrum, molecular weight determination, thermodynamic data. Application of mass spectrometry to inorganic compounds.	10

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
2. Structural Methods in Inorganic Chemistry. E.AV. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
3. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
4. Progress in inorganic Chemistry vol., 8. ed, F.A. Cotton, vol., 15, ed. S.J. Lippard, Wiley.
5. Transition Metal Chemistry ed, R.L. Carlin vol. 3, Dekker
6. Inorganic Electronic Spectroscopy,. A.P.B. Lever, Elsevier.
7. NMR, NOR, EPR and Mabssbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis
8. Horwood. Practical NMR Spectroscopy, M.L. Martin, J.J. DelpeuGh and G.J. NBrtin, Heyden.
9. Spectrometric Identification of Organic Compounds, R. M. Silverstein, G. C. Bassler and T. C. Morrill, John Wiley
10. Introduction to NMR Spectroscopy, R. J. Abraham, J. Fisher and P. Loftus, Wiley.
11. Application of Spectroscopy of Organic Compounds, J. R. Dyer, Prentice Hall. Spectroscopic Methods in Organic Chemistry, D. H. Williams, I. Fleming, Tata McGraw-Hill.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 3

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Third/Ninth
Course Code: **0920203**	**Course Title: Analytical Chemistry**	**Theory**

Course Objectives: To help them to learn about analytical methods like radio chemical methods, thermal methods, chromatographic and electro analytical techniques along with errors in observe results and their evaluation.

Course Outcomes (CO's):

CO1. Ability to understand various analytical processes in chemistry.
CO2. Understanding radio chemical methods.
CO3. Ability to know precision of outcomes and to evaluate errors of results.
CO4. Describing thermal, chromatographic methods.
CO5. Understanding electro analytical techniques.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction: Classification of analytical methods- classical and instrumental, types of Instrumental analysis, selecting an analytical method.	4
II	Errors and Evaluation: Definition of terms of mean and median, precision- standard deviation, relative standard deviation, accuracy, absolute error, relative error. Types of error in experimental data-determination (systematic), intermediate (random) and gross. Sources of errors and the effect upon the analytical results. Methods for reporting analytical data. Statistical evaluation of data indeterminate errors. The use of statistics.	6
III	Radiochemical methods: Elementary working, Principles of Giger Muller, Ionization, proportional and γ-ray counters. Neutron radiation sources, radio tracer techniques, Neutron Activation Analysis (NAA): Principle, techniques, and applications in preparation of some commonly used radioactive isotopes. Use of radioactive isotopes in analytical and physiochemical problems, Isotopic Dilution Analysis (IDA), sub stoichiometric IDA, advantages and limitations of IDA and comparison of IDA with NAA. Principle of Radiometric Titrations, Types, Experimental techniques, and its applications.	10
IV	Thermal methods of Analysis: Introduction of different thermal methods, Thermogravimetry- TGA & DTG, static thermogravimetry, quasi thermogravimetry and dynamic thermogravimetry, Instrumental and balances, X-Y recorder, thermogram, factors affecting thermograms. Application of thermogravimetry. Differential Scanning Calorimetry (DSC): Introduction, instrumentation, DSC curves, factors affecting DSC curves and applications. Thermometric Titrations: Introduction, instrumentation, apparatus, theory and applications.	15
V	Chromatographic Techniques: Adsorption and Partition chromatography, Paper chromatography, Thin Layer chromatography, Ion exchange and Gas chromatography, HPLC, Size Exclusion Chromatography, their principles, techniques, and important applications.	10
VI	Electro Analytical Techniques: Voltametry- General Introduction, Principle, Instrumentation, Types of Voltammetry: Polarography (Principle & Instrumentation), Cyclic Voltammetry, Pulse Methods.	15

	Stripping Technique: Anodic and Cathodic Stripping Voltametry and their applications in the trace determination of metal ions and biologically important compounds. Ion Selective Electrodes- Electrical properties of membrane, Glass electrode with special reference to H^+, Na^+, K^+ ions, operation of solid membrane electrode, operation of liquid membrane electrode, coated type ion electrode. Applications of ion selective electrode in determination of some toxic metals and some anions (F^-, Cl^-, Br^-, I^-, and NO_3^-).	

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Quantitative Analysis: Day and Underwood
2. A text book of Quantitative Analysis A.I. Vogal
3. Advanced Analytical Chemistry: Meites and Thomas
4. Analytical Chemistry: Dr. R.K. Soni
5. Instrumental methods of Chemical Analysis: G.W. Ewing
6. Physical Methods in Inorganic Chemistry: R.S. Drago
7. Analytical Chemistry: G.D. Christian
8. Basic Concepts of Analytical Chemistry: S.M. Khopkar
9. Polarography: Kolltath and Lingane
10. Instrumental Methods of Chemical Analysis: Braun
11. Instrumental Methods of Analysis: Willard, Merritt & Dean
12. Analytical Chemistry: Strouts, Crifillan & Wilson
13. Introduction to radiation Chemistry: J.W.T. Spinks & R.J. Woods
14. Fundamentals of Analyttical Chemistry: S.A. Skoog & D.W. West
15. Analytical Chemistry: R.V. Dilts
16. EDTA Titration: Flaschka

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:		
COURSE-4		
Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Third/Ninth
Course Code: 0920204	**Course Title: Bioinorganic Chemistry**	**Theory**
Course Objectives: To help them to learn the functions of inorganic molecules in living beings. **Course Outcomes (CO's):** **CO1.** Ability to understand the importance of metal ions for living organisms. **CO2.** Understanding bioenergetics and ATP cycle in living cells. **CO3.** Ability to know transport and storage of dioxygen in living species. **CO4.** Describing energy production by electron transport system for working and growing of organisms. **CO5.** Understanding nitrogen fixation process by bacteria in nature.		
Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Metal Ions in Biological Systems: Essential and trace metals, Na+/K+ Pump, Role of metal ions in biological processes.	**10**

II	Bioenergetics and ATP Cycle: Standard Gibbs energy change in biological reactions, exergonic and endergonic. Hydrolysis of ATP, Synthesis of ATP and ADP, DNA polymerisation, glucose storage, metal complexes in transmission of energy; chlorophylls, photosystem I and photosystem II in cleavage of water.	**10**
III	Transport and Storage of Dioxygen: Heme proteins and oxygen uptake, structure and function of haemoglobin, myoglobin, hemocyanins and hemerythrin, model synthetic complexes of iron, cobalt and copper, synthetic oxygen carriers.	**10**
IV	Electron Transfer in Biology: Structure and function of metalloproteins in electron transport processes - cytochromes and ion-sulphur proteins, synthetic models	**10**
V	Nitrogenase: Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.	**10**
VI	Transition metal ion catalysts for organic transformations and their application in hydrogenation (using symmetric and chiral organometallic catalysts), isomerization, olefin oxidation, carbonylation and polymerization reactions. Toxic metal ions and their detoxification, chelation therapy/chelating agents in medicine. Recent advances in cancer chemotherapy using chelates. Futuristic aspects of organo transition metal complexes as catalysts and in bio-inorganic chemistry	**10**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Inorganic Biochemistry vols I and II. ed. G.L. EichhHn, Elsevier.
4. Progress in Inorganic Chemistry, Vois 18 and 38 ed. J.J. Lippard, Wiley.
5. M. N. Hughes, Inorganic Chemistry of Biological Processes, 2nd Ed. (1981), John Wiley & Sons, New York.
6. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An introduction and Guide, Wiley, New York (1995).

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-5

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester: Third/Ninth**
Course Code: 0920205	**Course Title: Bio-organic Chemistry**	**Theory**

Course Objectives: Acquiring ability for understanding bio-organic chemistry.

Course Outcomes (CO's):

CO1. Ability to understand the importance of organic molecules for living organisms.

CO2. Describing the connection between enzymes and chemical reactions take place in a living body.

CO3. Ability to know about enzymes, their mechanism and biological action.

CO4. Describing relationship between molecular structure and isomers and also their transformation.

CO5. Understanding the chemistry and action of co enzymes.

CO6. Understanding biotechnological applications of enzymes.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction: Basic considerations, Proximity effects and molecular adaptation	4
II	Enzymes: Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis Menten and Lineweaver-Burk plots, reversible and irreversible inhibition.	8
III	Mechanism of Enzyme Action: Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.	8
IV	Kinds of Reactions Catalysed by Enzymes: Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in isomerization reactions, I)-cleavage and condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.	12
V	Co-Enzyme Chemistry: Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD+, NADP+, FMN, FAD, lipoic acid, vitamin B12. Mechanisms of reactions catalyzed by the above cofactors.	9
VI	Enzyme Models: Host-guest chemistry, chiral recognition' and catalysis, molecular recognition, molecular asymmetry and prochirality. Biomimetic chemistry, crown ethers, cryptates. Cyclodextrins, cyclodextrin-based enzyme models, calixarenes, ionophores, micelles, synthetic enzymes or synzymes.	9
VII	Biotechnological Applications of Enzymes: Large-scale production and purification of enzymes, techniques and methods of immobilization of enzymes, effect of immobilization on enzyme activity,	10

	application of immobilized enzymes, use of enzymes in food and drink industry-brewing and cheese making, syrups from corn starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology, Application of enzymes in organic synthesis.	

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and. Penny, SpringerVerlag.
2. Understanding Enzymes, Trevor Palmer, Prentice Hall.
3. Enzyme Chemistry: Impact and Applications, Ed. Collin J Suckling, Chapman and Hall.
4. Enzyme Mechanisms Ed, M. I. Page and A. Williams, Royal Society of Chemistry.
5. Fundamentals of Enzymology, N.C. Price and L. Stevens, Oxford University Press.
6. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
7. Enzymatic Reaction Mechanisms, C. Walsh, W - H. Freeman.
8. Enzyme Structure and Mechanism, A Fersht, W.H. Freeman.
9. Biochemistry: The Chemical Reactions of Living Cells, D. E. Metzler, Academic Press

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-6

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Third/Ninth

Course Code: 0920206	Course Title: Bio-Physical Chemistry	Theory

Course Objectives: Acquiring ability for defining some advanced topics of bio physical chemistry.

Course Outcomes (CO's):

CO1. Describing biological cell and its constituents.

CO2. Determining the bio energetics.

CO3. Ability to understand bio polymers.

CO4. Understanding the thermodynamics of Biopolymer Solutions.

Credits: 4	Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 120 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Biological Cell and its' Constituents: Biological cell, Bio molecules- their structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition. Cell membrane and Transport of ions-Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamic treatment of membrane transport, Nerve conduction	7
II	Bioenergetics: Standard free energy change in biochemical reactions, exergonic, endergonic, Hydrolysis of ATP, synthesis of ATP from ADP	10

III	Biopolymers: General Introduction, Kinds of Biopolymers Evaluation of size, shape and extent of hydration of biopolymers by various experimental techniques. Molecular Weights determination by Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, viscosity, electrophoresis and rotational motions. Statistical Mechanics in Biopolymers Chain configuration of macromolecules, statistical distribution end to end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem. Biopolymer Interactions: Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibria and various types of binding processes in biological systems. Hydrogen ion titration curves, DNA protein interaction Thermodynamics of Biopolymer Solutions Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.	**25**
IV	Nutritional biochemistry: Basic concepts- Function of nutrients. Measurement of the fuel values of foods. Direct and indirect calorimetry. Basal metabolic rate; factors affecting BMR, measurement and calculation of BMR. Measurement of energy requirements. Specific dynamic action of proteins. Recommended dietary allowances. Elements of nutrition- Dietary requirement of carbohydrates, lipids and proteins. Biological value of proteins. Concepts of protein quality. Protein sparing action of carbohydrates and fats. Essential amino acids, essential fatty acids and their physiological functions.	**18**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Principles of Biochemistry, A. L. Lehninger, Worth Publishers.		

2. Biochemistry, L.Stryer, WH.Freeman.
3. Biochemistry, J. David Rawn, Neil Patterson.
4. Biochemistry, Voet and Voet, John Wiley.
5. Outlines of Biochemistry, E. E. Conn and P. K. Stumpf, John Wiley.
6. Biorganlc Chemistry: A Chemicak Approach to Enzyme Action, H. Duga, and C. Penny.
7. Macromolecules: Structure and Function, F. Wold, Prentice Hall.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-7

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Third/ninth
Course Code: **0920280**	**Course Title: Lab III Chemistry**	**Practical**

Course Objectives: To help them to learn about different techniques of biochemistry and analytical chemistry.

Course Outcomes (CO's):

CO1. Ability to understand different experiments of analytical chemistry.

CO2. Understanding experiments of bio chemistry.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Analytical Chemistry 1. To verify Lambert's –Beer's Law with the help of U.V visible spectrophotometer. i. To determine λmax of a given sample. ii. To determine the concentration of unknown sample with the help of U.V visible spectrophotometer. 2. To determine the concentration of Na+, Ca+, K+ with the help of flame photometer. 3. To scan the U.V visible spectra of unknown sample with the U.V-visible double beam spectrophotometer. 4. To determine the calorific value of unknown sample. 5. To determine the degradation peak, Tg, Tm of unknown sample with the help of DSC. 6. To determine kinematics viscosity of plasticizer with the help of Redwood viscometer. 7. To determine the dynamic viscosity of polymeric plasticizer at different temperature with the help of Brukfield viscometer. 8. To separate the chlorophyll pigments with the help of TLC. 9. Apply paper chromatography to separate i. The chlorophyll pigments ii. Lead anions and cations 10. To separate the amino acids with the help of TLC. 11. To determine formation constant of FeSCN2+ compounds by conductometry. 12. To determine rate constants & formation constants of intermediate complex in the reaction of Cerium (IV) ammonium nitrate and hypophosphoric acid in acid medium.	**60**

II	Biochemistry 1. To make a phosphate buffer of pH. 2. Qualitative test for carbohydrates Molisch's, Iodine, Scliwanhoff, Benedict, Anthrone, Barfoed, Fehling, Bial 3. Qualitative tests for lipids Acrotien test, test for presence of FA, test for unsaturation of FA. 4. Determination of acid values of fats and oils 5. Determination of saponification value of fats and oils 6. Determination of iodine no. of a fat sample 7. Qualitative test for amino acid and protein 8. To detect ketone bodies in urine sample 9. Seperation of plant pigment by TLC 10. Estimation of amylase activity in saliva 11. To know blood sample in given sample of blood 12. To have RBC and WBC count 13. To estimate glucose in urine sample 14. To estimate sugar in blood	**60**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly. Prentice Hall
2. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS.
3. Experiments and Techniques in Organic Chemistry, D.P. Pasto, C. Johnson and M. Miller, Prentice Hall.
4. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Health.

5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
6. Handbook of Organic Analysis-qualitative and Quantitative. H. Clark, Adward Arnold.
7. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
8. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
9. Findley's Practical Physical chemistry, B.P. Levitt, Longman.
10. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-8

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Third/Ninth
Course Code: 0920265	**Course Title: Project III**	

Course Objectives: Acquiring ability to grow innovation, deep thoughts and implement them to develop novelty in prevailing practices that can origin new inventions.

Course Outcomes (CO's):

CO1. Ability to select area of research and can prepare meaningful research project.
CO2. Planning the strategy, method, and time bound process for research project.
CO3. understanding existing research outcomes and problems to sort out article writing skills.
CO4. Ability to understand data collection, its treatment, presentation and applicability.
CO5. Understanding how to write an impressive paper.
CO6. Ability to know how to explore data by project writing.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100**

		Minimum Marks: 40
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 120 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	How to select topic for research	**20**
II	How to prepare Research Proposal	**20**
III	Selection of methodology, Literature survey & Review writing Skill	**20**
IV	Data collection, data treatment & data analysis	**20**
V	Data treatment & data analysis	**20**
VI	Review paper writing to publish	**20**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. How to write and Publish by Robert A. Day and Barbara Gastel, (Cambridge University Press).
2. Survival skills for Scientists by Federico Rosei and Tudor Johnson, (Imperial College Press).
3. How to Research by Loraine Blaxter, Christina Hughes and Malcum Tight, (Viva Books).
4. Probability and Statistics for Engineers and Scientists by Sheldon Ross, (Elsevier Academic Press).
5. The Craft of Scientific Writing by Michael Alley, (Springer).
6. A Students's Guide to Methodology by Peter Clough and Cathy Nutbrown, (Sage Publications).
7. Research Methodology - A Step-By-Step Guide for Beginners, Kumar, R., Pearson Education, Delhi (2006).
8. Design & Analysis of Experiments, Montgomery, D. C., 5th Ed., Wiley India (2007).

9. Research Methodology-Methods and Techniques, Kothari, C. K., 2nd Ed., New Age International, New Delhi
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions: .....

Semester IV

COURSE-1

Programme/Class: M.Sc.	Year: P.G. IInd Year or UG in Research Fifth Year	Semester: Fourth/tenth
Course Code: 1020201	**Course Title: Environmental Chemistry**	**Theory**

Course Objectives: To develop the knowledge about different aspects of environmental chemistry.

Course Outcomes (CO's):

CO1. Ability to understand our environment.

CO2. Understanding the hydrosphere.

CO3. Ability to find out relation between atmosphere and living beings.

CO4. Ability to understand how to deal with pollution.

CO5. Understanding environmental toxicology.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Environment Introduction. Composition of atmosphere, vertical temperature, heat budget of the earth atmospheric system, vertical stability atmosphere. Biogeochemical cycles of C, N, P, S and O. Biodistribution of elements.	12
II	Hydrosphere Chemical composition of water bodies-lakes, streams, rivers and wet lands etc. Hydrological cycle. Aquatic pollution - inorganic, organic, pesticide, agricultural, industrial and sewage, detergents, oil spills and oil pollutants. Water quality parameters - dissolved oxygen, biochemical oxygen demand, solids, metals, content of chloride, sulphate, phosphate, nitrate and micro-organisms. Water quality standards. Analytical methods for measuring BOD, DO, COD, F, Oils, metals (As, Cd, Cr, Hg, Pb, Se etc.), residual chloride and chlorine demand. Purification and treatment of water.	12
III	Atmosphere Chemical composition of atmosphere - particles, ions and radicals and their formation Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals, chlorofluorohydrocarbons. Green house effect, acid rain, air pollution controls and their chemistry. Analytical methods for measuring air pollutants. Continuous monitoring instruments	12
IV	Industrial Pollution Cement, sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy. Polymers, drugs etc. Radionuclide analysis. Disposal of wastes and their management.	12
V	Environmental Toxicology Chemical solutions to environmental problems, biodegradability, principles of decomposition, better industrial processes. Bhopal gas tragedy, Chernobyl, Three Mile Island, Sewal D and Minamata disasters.	12
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Environmental Chemistry, S. E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
3. Environmental Chemistry, A. K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
5. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis Airborne Particle,. Ed. S. Landsberger, aod M. Cealchmao, GO'doo aod Beach Scleoce
8. Environmental Chemistry, C. Baird, W. H. Freeman.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Group I – Specialization in Inorganic Chemistry (Select any TWO out of following FIVE Elective paper)

Course 2

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/tenth
	Inorganic Chemistry Special I	

Course Code: 1020202	Course Title: Inorganic Materials	Theory

Course Objectives: To develop the knowledge about some advance topics of inorganic materials.

Course Outcomes (CO's):

CO1. Ability to understand chemistry of inorganic materials.

CO2. Understanding the various types of multiphase of materials.

CO3 Describing glass, ceramics, composites and nano materials.

CO4 Understanding about thin and Langmuir-Blodegett films.

CO5. Ability to know liquid crystals, materials for solid state devices and high Tc materials.

Credits: 4	Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Chemistry of Inorganic Materials: Introduction to the solid phase, metallic bond, Band theory (zone model, Brillouin Zones, Limitations of the Zone model), Defects in solids, p-type and n type, Inorganic semiconductors & their use in transistors and IC etc., Electrical, optical, magnetic and thermal properties of inorganic materials, Super conductors with special emphasis on the synthesis and structure of high temperature super conductors, solid state Lasers (Ruby, YAG and tuneable lasers). Inorganic Phosphorous materials: Synthesis, advantage of optical fibres over conducting fibres, Diffusion in solids, catalysis and Zone refining of metals, Preparation of nano materials and their characteristic differences over bulk materials.	14

II	Multiphase of materials: Ferrous alloys, Fe-C phase transformations in ferrous alloys, stainless steels, non-ferrous alloys, Properties of ferrous and non ferrous alloys and their applications.	**4**
III	Glasses, Ceramics, Composites and Nano materials: Glassy state, Glass formers and glass modifiers, applications, ceramic structures, mechanical properties, clay products, Refractories, characterizations, properties and applications, Microscopic composites, dispersion-strengthened and partical-reinforced, fibre- reinforced composites, macroscopic composites, Nanocrystalline phase, preparation procedures, special properties, applications.	**10**
IV	Thin films and Langmuir-Blodegett films: Preparation techniques, evaporation/sputtering, chemical processes, MOCVD, sol-gel etc., Langmuir-Blodegett (LB) film, growth techniques, photolithography, properties and applications of thin and LB films.	**8**
V	Liquid Crystals: Mesomorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophase, smectic-nematic transition and clearing temperature-homeotropic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic A and smectic phase, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phase and their description of ordering in liquid crystals.	**12**
VI	High Tc Materials: Defect Perovskites, high Tc superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials, normal state properties, anisotropy, temperature dependence of electrical resistance, optical phonon modes, superconducting state, heat capacity, coherence length, elastic constants, position lifetimes, microwave absorption-pairing and multigap structure in high Tc materials. applications of high Tc materials.	**8**
VII	Materials for solid state devices: Rectifiers, transistors, capacitors-IV-V compounds, Low dimensional quantum structures, optical properties.	**4**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Structural Inorganic Chemistry, Wells A.F., 5th Edition, Oxford University Press, Oxford (1984). 2. Inorganic Solids. An Introduction to Concepts in Solid-State Structural Chemistry, Adams D.M., John Wiley & Sons, London (1974).		

3. Solid State Chemistry & its Applications, West A.R., John Wiley & Sons (1987).
4. Basic Solid State Chemistry, West A.R., 2nd Edition, John Wiley & Sons (2000).
5. Solid State Chemistry - An Introduction, Smart L.E. & Moore E.A., 3rd Edition, CRC Press (2005).
6. Descriptive Inorganic, Coordination & Solid-State Chemistry, Rodgers G.E., 3rd Edition, Brooks/Cole, Cengage learning (2002).
7. Understanding Solids: The science of materials., Tilley R.J.D., 2nd Edition, John Wiley & Sons (2004).
8. New Directions in Solid State Chemistry, C.N R. Rao and J. Gopalkrishnan, Cambridge Univ. Press (1997).
9. Superconductivity Today, T. V. Ramakrishnan and C.N. Rao, Wiley Eastern Ltd., New Delhi (1992).
10. Designing the Molecular World: Chemistry at the Frontier, P. Ball, Princeton Univ. Press, (1994)

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 3

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/tenth
	Inorganic Chemistry Special II	
Course Code: **1020203**	**Course Title: Organotransition Metal Chemistry**	**Theory**

Course Objectives: This paper provides detailed knowledge about Organotransition Metal Chemistry.

Course Outcomes (CO's):

CO1. Ability to understand organotransition Metal Chemistry and their Futuristic aspects.
CO2. Understanding chemical reactions of organotransition Metal complexes.
CO3. Ability to know about alkyl, carbene, carbyne and alkene coplexex.
CO4. Describing alkyne, allyl and buta-1,3-diene complexes.
CO5. Understanding the cyclic polyene complexes.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	**Course Topic**	**No. of Lectures Hours**
I	Organotransition Metal Chemistry: General introduction, Structure and bonding, Survey of organometallic complexes according to ligands, p bonded organometallic compounds including carbonyls,nitrocyls, tertiary phosphines, hydrides, alkene, alkyne, cyclobutadiene, cyclopenadiene, arene compounds and their M.O. diagrams,Metal-carbon multiple bonds, Fluxional organometallic compounds including p-allyl complexes and their characterization, Metallocycles, unsaturated nitrogen ligends including dinitrogen complexes, Futuristic aspects of organotransition metal chemistry.	**16**
II	Reactions of Organometallic compounds: Oxidative addition, mechanisms for Oxidative addition, oxidative addition to M-M multiple bond, migratory insertion, evidence in favour of migratory insersion, insertion of alkenes, β-H elimination, important features of β-H elimination reactions, α-H Abstraction.	**12**
III	Alkyl, carbene, carbyne and alkene complexes: Metal alkyl complexes, synthesis of metal alkyl complexes, alkyl lithium, aluminium trialkyls, metal carbenes, fischer carbenes, schrock carbenes, carbenes intermediate between fischer and schrock types, comparison between fischer and schrock carbenes, metal carbines, metal alkene complexes, synthesis of metal alkene complexes.	**12**

IV	Alkyne, allyl and buta-1,3-diene complexes: Alkyne complexes, pauson-khand reaction, allyl complexes, synthesis of allyl complexes, davies-green-mingos (DGM) rule.	**8**
V	Cyclic polyene complexes: Half sandwich compounds, bent sandwich compounds, bonding in metallocenes (cyclopentadienyl complexes, ferrocene-synthesis, physical properties, reactions-friedal-craft acylation, friedal-craft alkylation, sulphonation, mannich reaction, nitration and halogenations, synthesis of ferrocene carboxylic acid, synthesis of ferrocene boronic acid, application of ferrocene.	**12**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Inorganic Chemistry, Shriver, D. F., Atkins, P. W. & Langford, C. H., 2nd Ed., Oxford Univ. Press (1998).
2. Inorganic Chemistry, Purcell, K. F. & Kotz, J. C., W. B. Saunders and Co.: N. Y. (1985).
3. Inorganic Chemistry, Wulfsberg, G., Univ. Science books: Viva Books: New Delhi (2000)
4. Magnetism and Transition Metal Complexes, Mabbs, F. E. & Machin D. J., Chapman and Hall: U.K. (1973).
5. Organometallic Chemistry- Ayodhya Singh & Ratnesh Singh
6. Organometallic Chemistry- R. C. Mahrotra & A. Singh
7. Organometallic Chemistry of transition metals- Robert H.Crabtre
8. Organometallic Compounds- Inderjeet Kumar

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-4

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** fourth/tenth

	Inorganic Chemistry Special III	
Course Code: **1020204**	**Course Title: Advanced techniques in Inorganic Chemistry**	**Theory**

Course Objectives: To help them to learn the advanced techniques of Inorganic Chemistry.

Course Outcomes (CO's):

CO1. Ability to understand electronic, vibrational and Raman spectroscopy of inorganic compounds.

CO2. Understanding the Mossbauer spectroscopy and nuclear magnetic resonance spectroscopy for inorganic compounds.

CO3. Ability to know electro paramagnetic resonance and nuclear quadrupole resonance spectroscopy.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	**Course Topic**	**No. of Lectures Hours**
I	Electronic spectroscopy: Vibrational and electronic energy levels in a diatomic molecule, potential energy level diagram. Symmetry requirements for n to π* transitions, oscillator strengths, transition moment integrals (electric dipole and magnetic dipole moment operator), selection rules, spin orbit and vibronic coupling contributions, mixing of d and p orbitals in certain symmetries. Polarized absorption spectra. Survey of the electronic spectra of tetragonal complexes. Calculation of Dq and β for Ni(II) Oh complexes, nephelauxetic effect, effect of σ and π bonding on the energy of t 2g orbitals and Dq, spectrochemical series, effect of distortion on the d orbital energy level (Td, D2d, D4h), cis and trans isomers and bonding parameters from spectra of tetragonal complexes, bonding	**12**

	parameters, calculation of Dq, Ds and Dt for tetragonal complexes, intervalence electronic transition, structural evidence from electronic spectra.	
II	Vibrational spectroscopy: Vibrational motion and energies, number of vibrational modes, anharmonicity, absorption in infrared, FT spectrometers, cell systems, effects of phase on spectra, vibrational spectra and symmetry, selection rules, symmetry of an entire set of normal vibrations, F and G matrix. Raman spectra and selection rules, polarized and depolarized Raman lines, resonance Raman spectroscopy, use of symmetry to determine the number of active infrared and Raman lines, rotational fine structure in gas phase IR. Non-resonance overtones and difference bands. Application of Raman and Infrared selection rules to the determination of inorganic structures, bond strength frequency shift relations, changes in spectra of donor molecules on coordination, change in symmetry on coordination.	**12**
III	Mossbauer Spectroscopy: Basic principles, spectral parameters, and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds - nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms.	**12**
IV	Nuclear magnetic resonance spectroscopy: Nuclear spin quantum number, I, and its calculation using the nuclear shell model, spin parity rules. Types of nuclei based on value of I, nuclear spin angular momentum quantum number, and its relation to classical magnetic moment. Behaviour of a bar magnet in a magnetic field. The NMR transition and NMR experiment, measuring chemical shifts, signal intensities and splitting. Application of chemical shifts, signal intensities and spin-spin coupling to structure determination of inorganic compounds carrying NMR active nuclei like 1H, 11B, 15N, 19F, 29Bi, 31P, 183W, 195Pt, etc. Effect of fast chemical reactions, coupling to quadrupolar nuclei, NMR of paramagnetic substances in solution, nuclear and electron relaxation time, the expectation value of <Sz>, contact shift, pseudo contact shift, factoring contact and pseudo contact shift for transition metal ions. Contact shift and spin density, π delocalization, simplified M.O. diagram for Co(II) and Ni(II). Application to planar tetrahedral equilibrium, Contrast agents.	**12**
V	Electronic paramagnetic resonance spectroscopy: Electronic Zeeman effect, Zeeman Hamiltonian and EPR transition energy. EPR spectrometers, presentation of spectra. The effects of electron Zeeman, nuclear Zeeman and electron nuclear hyperfine terms in the Hamiltonian on the energy of the hydrogen atom. Shift operators and	**12**

	the second order effect. Hyperfine splittings in isotropic systems, spin polarization mechanism and McConnell's relations Anisotropy in g-value, EPR of triplet states, zero field splitting, Kramer's rule, survey of EPR spectra of first row transition metal ion complexes.	
VI	Nuclear Quadrupolar Resonance (NQR) Spectroscopy: Quadrupolar moment, energy lends of a quadrupolar nuclease and effect of asymmetry parameters and energy lends. Effect of an external magnetic field, selected examples for elucidation of structural aspects of inorganic compounds using NQR spectroscopy.	**12**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Physical Inorganic Chemistry: A Coordination Chemistry Approach, Kettle. S. F. A., Springer, Berlin, Heidelberg (1996).
3. Magnetism and Transition Metal Complexes, F. E. Mabbs, & D. J. Machin, Dover Publications; 2008 edition (2008).
4. Polyoxometalates Properties, Structure and Synthesis, A. P. Roberts, Nova Science Publishers, Incorporated (2016).
5. NMR, NOR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
3. Physical Methods in Chemistry, R.S. Drago, Saunders College.
5. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
6. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
7. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, ISHOxford.
9. Introduction to Magnetic Resonance, A Carrington and A.D. Maclachalari, Harper & Row.
10. Modern Spectroscopy, J.M. Hollas, John Wiley

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Course-5

Programme/Class: M.Sc.	Year: P.G. IInd Year or UG in Research Fifth Year	Semester: Fourth/tenth
	Inorganic Chemistry Special IV	
Course Code: 1020205	**Course Title: Solid State Chemistry**	**Theory**

Course Objectives: Acquiring ability for understanding the detailed knowledge about solid state chemistry.

Course Outcomes (CO's):

CO1. Ability to learn the electrical and magnetic properties of solids.

CO2. Understanding the optical and thermal properties of solids.

CO3. Describing advances in nanomaterials and their applications.

Credits: 4	Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Electrical properties of solids: 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. Diffusion in Solids: Fick's laws of diffusion, mechanism, Kirkendall effect, diffusion and ionic conductivity.	12

	Electrical Properties: Band structures of metals, insulators, semi-conductors and inorganic solids; Applications of semiconductors; Other electrical properties: Thomson, Peltier and Seebeck effects, thermocouples and their applications, Hall effect, dielectric, ferroelectric, piezoelectric and pyroelectric materials and their inter-relationship and applications.	
II	Magnetic properties of solids: Behaviour of substances in magnetic field, mechanism of ferromagnetic and antiferromagnetic ordering, super exchange, Hysteresis, Hard and soft magnets, Structures and magnetic properties of metals and alloys, transition metal oxides, spinels, garnets, ilmenites, perovskite and magneto-plumbites, Applications in transformer cores, information storage, magnetic bubble memory devices and as permanent magnets.	**12**
III	Optical Properties of Solids: Luminescence and phosphor materials: Configurational coordinate model, AntiStokes phosphor, Lasers: Ruby laser, Neodymium laser. Absorption and emission of radiation in semiconductor:light emitting diodes, gallium arsenide laser, blue lasers; optical fibers. 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.	**24**
IV	Advances in nanomaterials: Introduction to nanotechnology: General preparative methods for various nanomaterials, functionalization of nanoparticles for various applications (capping), generic challenges in nanomaterial synthesis. Some important properties of nanomaterials: Optical properties of metal and semiconductor nanoparticles, magnetic properties. Some special nanomaterials: Carbon nanotubes: Types, synthesis using various methods, growth mechanism, electronic structure; quantum dots: properties and applications. Aerogels: types of aerogels, properties and applications of aerogels. Applications of nanomaterials in electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defence. Environmental aspects of nanotechnology.	**12**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Solid state chemistry and its chemical applications, A. R. West, John Wiley & Sons, (1984).
2. Solid state chemistry – An introduction, Lesley E. Smart and Elaine A. Moore, 3rd Ed., Taylor and Francis, (2005).
3. Solid State Chemistry, R. C. Ropp Warren, Elsevier Science B.V. (2003).
4. Materials science and engineering, W. D. Callister, Jr., (adapted by R. Balasubramaniam), Callister's Wiley-India (2010).
5. Nanotechnology: Principles and practices, Sulabha K. Kulkarni, Capital publishing company (2007)
6. Inorganic chemistry, M. Weller, T. Overton, J. Rourke and F. Armstrong, 6thedition, Oxford University Press (2015)
7. The Chemistry of Nano Materials, CNR Rao, Muller and Cheetham, Vol.I & II, Wiley-VCH (2005)
8. Nano Chemistry, Geoffrey A. Ozin, and Andre Arsentte, RSC Publishing, 2005
9. Nano Crystalline Materials, S.C. Tjong, Elsevier, 2006
10. Principles of the Solid State, H.V. Keer, Wiley Eastern.
11. Solid State Chemistry, N.B. Hannay.
12. Solid State Chemistry, D.K. Chakrabarty, New Wiley Eastern

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Course-6

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/tenth

	Inorganic Chemistry Special IV	
Course Code: **1020206**	**Course Title: Inorganic Catalysts**	**Theory**

Course Objectives: Acquiring ability for understanding the detailed idea about inorganic catalysts.

Course Outcomes (CO's):

CO1. Ability to learn about catalysis.

CO2. Determining homogeneous and heterogeneous catalysis.

CO3. Understanding electro catalysis and nano catalysis.

CO4. Describing relationship between catalysis and green chemistry.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Catalysis: Introduction, catalytic cycles, application of organometallic compounds as homogeneous catalysts, hydroformylation or oxo process, wacker process, Monsanto acetic acid process, cativa process, Tennessee Eastman acetic anhydride process, alkene metathesis-simple metathesis, cross metathesis, ring opening metathesis, ring opening metathesis polymerization (ROMP), ring closing metathesis (RCM), enyne metathesis (EM), alkyne metathesis, alkene polymerization: Ziegler-natta catalyst, water gas reaction: fischer-tropsch process, synthetic gasoline.	12

II	Homogeneous Catalysis: Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, polymerization of olefins, catalytic reactions involving carbon monoxide such as hydro carbonylation of olefins (oxo reaction),oxo palladation reaction ,activation of C-H bond.	**12**
III	Electrocatalysis: Chemical catalysts and Electrochemical catalysts with special reference to pure states, porphyrin oxides of rare earths. Electrocatalysis in simple redox reactions, in reaction involving adsorbed species. Influence of various parameters.	**12**
IV	Nanocatalysis: Role of transition metals & metal oxides in homogeneous and heterogeneous catalysis and their mechanism of catalysis, manufacture of these catalysts in nano-form and their characterization. Coupling reactions: Introduction, homocoupling reactions, cross coupling reactions, tsui-trost reaction, mizoroki-heck reaction, miyaura-suzuki coupling, stille coupling, negishi coupling, sonogasira coupling, kumada coupling, hiyamacoupling, Buchwald-hartwig amination coupling.	**12**
V	Catalysis and Green Chemistry: Comparison of catalyst types, Heterogeneous catalysts (zeolites and the bulk chemical industry, catalysts in fine chemicals and pharmaceutical industries, catalytic converters), homogeneous catalysts (transition metal catalysts with phosphene ligands, greener Lewis acids, asymmetric catalysis), phase transfer catalysis, Biocatalysis, Photocatalysis.	**12**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Homogeneous Transition Metal Catalysis. Masters C., Chapman & Hall (1981).
2. Heterogeneous Catalysis, G. C. Bond, 2nd ed., Clarendon Press, Oxford, 1987
3. Inorganic Chemistry, James E. Huheey, Ellen A. Keiter, Richard L. Keiter and Okhil K. Medhi, Indian Ed. 2006
4. Inorganic Chemistry, Catherine E. Housecroft and Alan G. Sharpe, 2nd Ed.
5. Inorganic Chemistry, Shriver and P.W. Atkins, 3rd Ed.
6. Inorganic Chemistry, Keith F. Purcell and John C. Kotz, Indian Ed.
7. Catalysis: Principles and Application, editor(s) : B. Viswanathan, S. Sivasanker, A.V. Ramaswamy ISBN: 978-81-7319-375-0: (2007).
8. Comprehensive Asymmetric Catalysis I-III; Jacobsen, E.N., Pfaltz, A.; Yamamoto, H. (ed), Springer Verlag: Berlin, 1999
9. Green Chemistry: An Introductory Text, Mike Lancaster, Royal Society of Chemistry, 2002.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 7

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fourth Year	**Semester:** Fourth/Tenth
	Inorganic Chemistry Special Practical	
Course Code: **1020280**	**Course Title: Lab IV Inorganic Chemistry**	**Practical**

Course Objectives: To help them to learn the qualitative and quantitative analytical techniques and spectroscopic methods of determination.

Course Outcomes (CO's):

CO1. Ability to understand qualitative and quantitative determinations.

CO2. Understanding inorganic chemical reactions for preparing inorganic compounds.

CO3. Ability to know determining structures of inorganic compounds by spectroscopic studies.

CO4. Understanding flame photometric determinations and chromatographic separation methods.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100**

		Minimum Marks: 40
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 120 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
2I	Qualitative/Quantitative determinations: • Qualitative analysis of mixture of salts including rare earth metals (soluble and insoluble) containing eight radicals including interfering. • Quantitative analysis of mixtures of metal ions by complexometric titrations (mixture of two metals) with the use of masking and demasking agents. • Determination of concentration of some metal ions such as iron,nickel etc. by colorimetric method.	**30**
II	Inorganic preparations Preparation of any three selected of following inorganic compounds and their study by electronic spectra, IR, ESR, NMR etc. • Sodium amide, Inorg. Synth h., 1946,2, 128. • Synthesis and thermal analysis of group II metal oxalate hydrate, J. Chem. Ed. 1988, 65, 1024. • Tri alkyl boranes- Preparation, IR and NMR spectra • $PhBCl_2$ Dichlorophenyl borane-Synthesis in vacuum line. • Preparation of Tin (IV) i.e. Ammonium hexa chloro stannate $[(NH_4)_2SnCl_6]$ and Pb (IV) i.e. Ammonium hexa chloro plumbate stannate $[(NH_4)_2PbCl_6]$ Complexes • Sodium tetra thionate ($Na_2S_4O_6$) • Bromination of Cr(acac), J. Chem. Edu., 1986, 63, 90. • Separation of optical isomer of cis-$[Co(en)_2Cl_2]Cl$, J. Chem. Soc., 1960, 4369. • Determination of Cr(III) complexes $[Cr(H_2O)_6]NO_3.H_2O$, $[Cr(H_2O)_4Cl_2]Cl_2.2H_2O$, $[Cr(en)_3]Cl_2.H_2O$, Cr(ac ac)$_3$ Inorg. Synth., 1972, 13, 184.	**30**

III	Spectrophotometric determinations • Manganese/Chromium/Vanadium in steel sample • Nickel/Molybdenum/Tungsten/Vanadium/ Uranium by extractive Spectrophotometric method. • Fluoride/nitrate/phosphate. • Iron-phenanthroline complex: by Job's method of continuous variations. • Zirconium-Alizarin Red-S complex: Mole raito method. • Copper-Ethylene diamine complex: Slope-ratio method	**20**
IV	Flame photometric determinations • Sodium and Potassium when present together • Lithium/Calcium/Barium/ Strontium • Cadmium and Magnesium in tap water	**20**
V	Chromatographic Seperations • Zinc and Magnesium • Cadmium and Zinc • Thin layer Chromatography-Separation of Nickel, Manganese, Cobalt and Zinc with determination of their R_f values	**20**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly. Prentice Hall 2. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS.		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		

Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:		
Group II – Specialization in Organic Chemistry (Select any TWO out of following FIVE Elective paper)		
COURSE-8		
Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fifth Year	**Semester:** fourth/tenth
	Organic Chemistry Special I	
Course Code: **1020207**	**Course Title: Polymers**	**Theory**
Course Objectives: To develop the knowledge about the advance aspects regarding polymer chemistry. **Course Outcomes (CO's):** **CO1.** Ability to understand the basics of polymers. **CO2.** Understanding the structure and properties of polymers. **CO3.** Ability to gain knowledge about characterizing polymers. **CO4.** Understanding about polymer processing. **CO5.** Ability to understand the properties of commercial polymers.		
Credits: 4	**Elective**	**Max Marks** **(Int. + Ext.):** **25+75 Total = 100** **Minimum Marks:** **40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Basics: Importance of polymers. Basic concepts: Monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization: condensation, addition, radical chain-ionic and co-ordination and copolymerization. Polymerization conditions and polymer reaction. Polymerization in homogeneous and heterogeneous systems.	8
II	Polymer characterization: Polydispersion-average molecular weight concept. Number, Weight and Viscosity average molecular weight. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weight. End group, viscosity light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers and chemical analysis of polymers, spectroscopic methods, physical testing – tensile strength, fatigue, impact. Tear resistance. Hardness and abrasion resistance.	14
III	Structure and Properties: Morphology and order in crystalline polymers-configurations of polymer chains. Crystal structures of polymers. Morphology of crystalline polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties-crystalline melting point Tm-melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, Tg relationship between Tm & Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.	14
IV	Polymer Processing: Plastics, elastomers and fibers. Compounding. Processing techniques: Calendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fiber spinning.	12
V	Properties of Commercial Polymers: Polyethylene, Polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicon polymers. Functional Polymers- Fire retarding polymers and electrically conducting polymers. Biomedical polymers- contact lens, dental polymers, artificial heart, kidney, skin and blood cells.	12
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Text Book of Polymer Science, F.W. Billmeyer Jr, Willey.
2. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, WileyEastern
3. Functional Monomers and Polymers, K. Takemoto, Y. Inaki and RM. Ottanbrite.
4. Contemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.
5. Physics and Chemistry of Polymers, J. M. G Cowie, Blackie Academic and Professional.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-9

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/tenth
	Organic Chemistry Special II	
Course Code: **1020208**	**Course Title: Natural Products**	**Theory**

Course Objectives: To develop the knowledge about natural products.

Course Outcomes (CO's):

CO1, Ability to understand terpenoids and caratonoids.

CO2. Understanding the alkaloids and steroids.

CO3 Describing plant pigments and prostaglandins.		
Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Terpenoids and Carotenoids: Classifications, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, Geraniol α-Terpeneol, Menthol, Farnesol, Zingiberence, Santonin, Phytol, Abietic acid and β-Carotene.	**12**
II	Alkaloids: Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine, (+)- Coniine, Nicotine, Atropine, Quinine and Morphine.	**12**
III	Steroids: Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry, Isolation, Structure determination and synthesis of Cholesterol, Bile acids, Androsterone, Testosterone, Estrone, Progesterone, Aldosterone, Biosynthesis of Steroids.	**12**
IV	Plant Pigments: Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of Apigenin, Luteolin Quercetin, Myrcetin, Quercetin 3-glucoside, Vitexin, Diadzein, Aureusin, Cyanidin-7arabinoside, Cyanidin, Hirsutidin, Biosynthesis of flavonoids: Acetate pathway and Shikimic acid pathway. Prophyrins; Structure and synthesis of Haemoglobin and Chlorophyll.	**12**

V	Prostaglandins: Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE2 and PGF2a. Pyrethroids and Rotenones Synthesis and reactions of Pyrethroids and Rotenones. (For structure elucidation, emphasis is to be placed on the use of spectral parameters wherever possible).	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Natural Products, Chemistry and Biological Significance, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope adn J.B. Harbome, Longman, Esses.
2. Organic Chemistry,Vol. 2 1L. Finar, ELBS
3. Stereoselective Synthesis, A Practical Approach, M. Norgradi, VCH.
4. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
5. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, M.P. Gupta and A. Marston, Harwood Academic Publishers.
6. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers.
7. New Trends in Natural Product chemistry, Ataaur Rahman and M.L. Choudhary, Harwood Academic Publishers.
8. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers., A. P. S. University, Rewa (M.P.)

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 10

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth

	Organic Chemistry Special III	
Course Code: **1020209**	**Course Title: Medicinal Chemistry**	**Theory**

Course Objectives: To develop the knowledge about medicinal chemistry.

Course Outcomes (CO's):

CO1. Ability to understand drug designing methods and to know about molecules as medicines.

CO2. Understanding computational approaches used for studying physicochemical parameters of medicines.

CO3. Ability to know neuroactive and antineoplastic agents.

CO4. Describing cardiovascular and local anti- infective drugs.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Introduction to Medicinal Chemistry: Introduction to important functional groups in medicinal chemistry, a century of drug research. Drug design: Strategies for drug research including various targets, lead generation/ sources for drugs, receptor and drug receptor interactions; enzymes and design of inhibitors; concept of Prodrugs, hard and soft drugs. Combinatorial Chemistry: Introduction; solid support and linkers; combinatorial synthesis of compounds on solid phase, split and mix method, premix method, spatially addressable parallel chemical synthesis, multiple synthesis;	**15**

	Identification of active compounds from combinatorial libraries; Analytical methods for characterization of combinatorial libraries; Application of combinatorial libraries using solid phase chemistry.	
II	Computational approaches: Structure activity relationship, concept of QSAR, physicochemical parameters lipophilicity, partition coefficient, electronic-ionization constants, H-bonding, steric parameters, Hammett equation. Isosterism, bioisosterism. Biodisposition and implications: Pharmacokinetics; concepts including absorption, distribution, metabolism and excretion of the drug, pharmacokinetic parameters; drug metabolism including phase I and phase II biotransformatins; mention of the uses of pharmacokinetics in drug development process. Molecular toxicology, avoidance of toxic intermediates,	**15**
III	Neuroactive agents: The chemotherapy of the mind: Introduction, neurotransmitters, CNS depressant, General anaesthetics, mode of action of hypnotics, sedatives, antianxiety agents, bezodiazepines, buspirone, neurochemistry of mental diseases. Antipsychotic drugsthe neuroleptics, antidepressants, butyrophenone, serendipity and drug development, stereochemical aspects of neuroactive drugs. Synthesis of Diazepam, Oxazepam, Chlorazepam, barbiturates. Cardiovascular agents: Introduction, cardiovascular diseases, drug inhibitors of the peripheral sympathetic function, central intervention of the cardiovascular output, direct acting arteriolar dilators, synthesis of amyl nitrate, sorbitrate, diltiazam, quinidine, verapamil, methyldopa, atenolol, oxeprenolol.	**15**
IV	Antineoplastic agents: Introduction, cancer chemotherapy, role of alkylating agents and antimetabolites in the treatement of cancer. Mention of carcinolytic antibiotics and mitotic inhibitors; synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, mustards, 6-mercaptopurine. Recent development in cancer chemotherapy, the hormones and natural products. Local anti-infective drugs: Introduction and general mode of action, synthesis of sulphonamide, furazolidone, naxilidic acid, eiprofloxacin, dapsone, aminosalicylic acid, isoniazid, ethionamide, ethambutol, fluconazole, econozole, gresiofulvin, chloroquin, primaquin.	**15**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
1. Comprehensive Medicinal Chemistry, Vols. 1-6, Corvin Hansch (editor) 1990.		

2. Burger's Medicinal Chemistry, 4th edition, 3 parts; M.E. Wolff, Ed. (RS 403.B8-1979-pt. 1,2 &3).
3. Principles of Medicinal Chemistry, W.O. Foye (editor), 4th edition, 1995.
4. Molecular Mechanism of Drug Action, C. J. Coulson, 1998.
5. Medicinal Chemistry : A Biochemical Approach, Thomas Nogrady, 2nd edition, 1998.
6. Wilson and Gisvold's Textbook of Organic, Medicinal and Pharmaceutical Chemistry, J.N. delago and W.A. Remers (editors) 9th edition 1991.
7. Organic Chemistry of Drug Synthesis, Vol. I, Daniel Lednicer and Lester A., Mitscher (RS 403.L38-Vols. 1,2 and 3).
8. The Pharmacological Basis of Therapeutics, Louis S. Goodman and Alfred Gilman.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-11

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth
	Organic Chemistry Special IV	
Course Code: **1020210**	**Course Title: Organic Synthesis**	**Theory**

Course Objectives: To help them to learn different aspects regarding organic synthesis.

Course Outcomes (CO's):

CO1. Ability to understand organometallic reagents.

CO2. Understanding oxidation chemical reaction in detail.

CO3. Ability to know reduction chemical reaction in detail.

CO4. Describing rearrangement chemical reactions in organic molecules.
CO5. Understanding the metallocenes.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Organometallic Reagents: Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details: Group I & II metal organic compounds Li, Mg, Hg, Cd, Zn and Ce Compounds Transition metals Cu, Pd, Ni, Fe, Co, Rh, Cr and Ti Compounds. Other elements S, Si, B and I compounds.	**15**
II	Oxidation: Introduction. Different oxidative processes. Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated and unactivated). Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids. Amines, Hydrazines and sulphides. Oxidation with ruthenium tetraoxide, iodobenzene diacetate and thallium (III) nitrate.	**11**
III	Reduction: Introduction. Different reductive processes. Hydrocarbons- alkanes, alkenes, alkynes and aromatic rings. Carbonyl Compounds- aldehydes, ketones, acids and their derivatives. Epoxides, nitro, nitroso, azo and oxime groups..	**11**
IV	Rearrangements: General mechanistic considerations- nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: Pinacol-Pinnacolone, Wagner-Meerwin, Demjanov, benzyl-Benzilic acid, Favorskii, Arndt-Eistern synthesis, Neber, Beckmann, Hoffman, Curtius, Schmidt, Baeyer Villiger, Shaprio reaction, Barton, Chichibaben, Hoffman-Lofler Freytag reaction, Wittig reaction.	**15**
V	Metallocenes, Nonbenzenoid Aromatic and Polycyclic Aromatic Compounds: General considerations, synthesis and reactions of Ferrocene, Chrysene, Azulene.	**8**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Modern Synthetic reactions, H. O. House, W.A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3. Advanced Organic Chemistry, Reaction Mechanisms and Structure, J. March, John Wiley.
4. Principles of Organic Synthesis, R.O.C. Norman and J. M. Coxoxn, Blackie Academic and Professional.
5. Advanced Organic Chemistry Part B, F.A. Carey and R. j. Sundberg, Plenum Press.
6. Rodd's Chemistry of carbon compounds, Ed. S. Coffey, Elsevier.
7. Modern Organic Synthesis, Dale L. Boger, TSRI press.
8. Organic Reactions and Their Mechanisms, P. S. Kalsi, 1st Edition (1996), New Age International Pub., New Delhi.
9. Organic Synthesis, M. B. Smith, (1998) Mc Graw Hill Inc, New York

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-12

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth
	Organic Chemistry Special V	

Course Code: 1020211	Course Title: Heterocyclic Chemistry	Theory
Course Objectives: Acquiring ability for defining heterocyclic chemistry in detail. **Course Outcomes (CO's):** **CO1.** Developing skills in the nomenclature of heterocycles, aromatic and non aromatic heterocycles and their synthesis. **CO2.** Ability to know monocyclic fused and bridged heterocycles. **CO3.** Ability to apply different heterocycles in medicinal purpose. **CO4.** Describing small ring, meso ionic heterocycles and their medicinal application. **CO5.** Understanding six membered heterocycles with two or more heteroatoms. **CO6.**Understandingheterocycles containing P, As, Sb and B as hetero atoms.		
Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Nomenclature of Heterocycles: Replacement and systematic nomenclature (Hantzs MCH-Widman system) for monocyclic fused and bridged heterocycles. Aromatic Heterocycles: General chemical behaviour of aromatic heterocycles, classification (structural type), criteria of aromaticity (bond lengths, ring current and chemical shifts in 1H NMR spectra. Empirical resonance energy, delocalization energy and Dewar resonance energy, diamagnetic susceptibility exaltations). Heteroaromatic reactivity and tautomerism in aromatic heterocycles.	**12**
II	Non-aromatic Heterocyoles: Strain-bond angle and torsional strains and their consequences in small ring heterocycles. Conformations of six-membered heterocycles with reference to molecular geometry, barrier	**12**

	to ring inversion, pyramidal inversion and 1,3-diaxial interaction. Stereo-electronic effects anomeric and related effects, Attractive interactions-hydrogen bonding and intermolecular nucleophilic electrophilic interactions. Heterocyclic Synthesis Principles of heterocyclic synthesis involving cyclization reactions and cycloaddition reactions.	
III	Small Ring Heterocycles: Three-membered and four-membered heterocycles-synthesis and reactions of azirodines, oxiranes, thiranes, azetidines, oxetanes and thietanes. Benzo-Fused Five-Membered Heterocycles Synthesis and reactions including medicinal applications of benzo pyrroles, benzofurans and benzo thiophenes.	**12**
IV	Meso-ionic Heterocycles: General classification, chemistry of some important meso-ionic heterocycles of type-A and B and their applications. Six-Membered Heterocycles with one Heteroatom- Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and phridones. Synthesis and reactions of quionlizinium and benzo pyrylium salts, coumarins and chromones.	**12**
V	Six Membered Heterocycles with Two or More Heteroatoms: Synthesis and reactions of diazones, triazines, tetrazines and thiazines. Seven-and Large-Membered Heterocycles Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines. Heterocyclic Systems Containing P, As, Sb and B Heterocyclic rings containing phosphorus : Introduction, nomenclature, synthesis and characteristics of 5- and 6-membered ring systems phosphorinaes, phosphorines, phospholanes and phospholes. Heterocyclic rings containing As and Sb: Introduction, synthesis and characteristics of 5- and 6-membered ring system. Heterocyclic rings containing B : Introduction, synthesis reactivity and spectral characteristics of 3- 5- and 6- membered ring system.	**12**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Heterocyclic Chemistry Vol. 1-3, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag. 2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Theme. 3. Heterocyclic chemistry J.A. Joule, K. Mills and G.F. Smith, Chapman and Hall.		

4. Heterocyclic Chemistry, T.L. Gilchrist, Longman Scientific Technical.
5. Contemporary Heterocyclic Chemistry, G,.R. Newkome and W.W. Paudler, Wiley Inter Science.
6. An Introduction to the Heterocyclic Compounds, R.M. Acheson, John wiley.
7. Comprehensive Heterocyclic Chemistry, A.R. Katrizky and C.W. Rees, eds. Pergamon Press.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 13

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth
	Organic Chemistry Special Practical	
Course Code: **1020281**	**Course Title: Lab IV Organic Chemistry**	**Practical**

Course Objectives: To help them to learn experimental techniques of organic chemistry.

Course Outcomes (CO's):

CO1. Ability to understand analysis of organic mixture using chemical and solvent separation methods.

CO2. Understanding synthesis of organic molecules following three steps of preparation.

CO3. Ability to perform quantitative analysis regarding aniline and Sulphur containing compounds.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 120 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Analysis of ternary organic mixtures. • Separation with NaHCO3 and water • Separation with NaOH and water. • Separation with HCl and water • Separation with organic solvents.	**60**
II	Three step organic preparations. • TO prepare O-chlorobenzoic acid from phthalic anhydride. • To prepare benzilic acid from benzaldehyde. • To prepare dibenzil from benzaldehyde. • To prepare benzoic acid from benzophenone. Inorganic Chemistry	**40**
III	Quantitative Analysis • To determine the strength of the given aniline solution (estimation of aniline). • To determine the percentage of sulphur in the given organic compound by messenger's method.	**20**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly. Prentice Hall
2. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R.C. Denney, G.H. Jeffery and J. Mendham, ELBS.
3. Experiments and Techniques in Organic Chemistry, D.P. Pasto, C. Johnson and M. Miller, Prentice Hall.
4. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Health.
5. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
6. Handbook of Organic Analysis-qualitative and Quantitative. H. Clark, Adward Arnold.
7. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
8. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
9. Findley's Practical Physical chemistry, B.P. Levitt, Longman.
10. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Group III – Specialization in Physical Chemistry (Select any TWO out of following FIVE Elective papers)

COURSE-14

Programme/Class:	Year:	Semester:
M.Sc.	P.G. IInd Year or UG in Research Fifth Year	Fourth/Tenth

Physical Chemistry Special I

Course Code: 1020212	Course Title: Physical Chemistry of Organic Reactions	Theory

Course Objectives: To develop the knowledge about physical chemistry of organic reactions and principles of reactivity of molecules.

Course Outcomes (CO's):

CO1. Ability to understand MO, VB and HMO theory of molecular structure that affect the reactivity.

CO2. Understanding the structure and other properties of compounds affect the reactivity.

CO3. Ability to find out the effect of isotopes, solvent, catalysts on reactivity.

CO4. Understanding the Steric and Conformational Properties affecting the reactivity of organic molecules.

Credits: 4	Elective	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Concept in molecular orbital (MO) and Valance bond (VB) Theories: Introduction to Huckel Molecular Orbital method as a means to explain modern theoretical methods. Advanced techniques and FMO theory, molecular mechanics, Semi empirical methods and ab initio and density functional methods, Scope and limitations of several computational programs Quantitative MO Theroy: Huckel molecular Orbital (HMO) methods as applied to ethane, allyl and Butadiene . Qualitative MO Theory: Ionization Potential, Electron affinities, MO energy levels, Orbital symmetry, Orbital interaction diagrams, MO of simple organic systems like ethane, allyl, butadiene, methane ans methyl group, conjugation and hyperconjugation, Aromaticity.	22

	Valance bond (VB) configuration mixing diagrams, Relationship between VB configuration mixing and resonance theory, Reaction profiles, Potential energy diagrams, Curve crossing model, Nature of activation barriers in chemical reactions.	
II	Principles of Reactivity: Mechanistic significance of entropy, enthalpy and Gibb's Free energy, Arrhenius equation, Transition state theory, Use of activation parameters, Hammond's Postulates, Bell-Evens-potanyl potential energy surface model, Marcus theory of electron transfer, Reactivity and selectivity principles. Structural Effects of Reactivity: Linear free energy relationships (LFER), The Hammet equation, Substituent constant theories of substituent effects, Interpretation of σ- values, Reaction constant ρ, Deviation from Mammet equation, Dual parameter correlations, Inductive substituent constant, The Theft model, σl and σR Scales.	**10**
III	Kinetic Isotope Effect: Theory of isotope effects, Primary and secondary kinetic isotope effects, Heavy atom isotope effects, Tunnelling effect, Solvent effects. Solvation and solvent effects: Qualitative understanding of solvent-solute effects on reactivity, Thermodynamic measure of solvation, Effect of solvation on reaction rates and equilibrium, Various empirical indexes of solvation based on physical properties, solvent sensitive reaction rates, Spectroscopic properties and scales for specific solvation, Use of solvation scales in mechanistic studies, Solvent effects from the curve crossing model.	**8**
IV	Acids, Bases, Electrophiles, Nucleophiles and Catalysis Acid-Base dissociation, Electronic and structural effects, Acidity and Basicity, Acidity functions and their applications, Hard and soft acids and bases, Nucleophilicity scales, Nucleo fugacity, The σ-effect, Ambivalent nucleophiles, Acid-base catalysis-Specific and general catalysis, Bronsted catalysis, Nucleophilic and electrophilic catalysis, Catalysis by non covalent binding-micellat catalyst.	**10**
V	Steric and Conformational Properties: Various types of steric strain and their influence on reactivity, Steric acceleration, Molecular measurements of steric effects upon rates, Steric LFER, Conformational barrier to bond rotation-Spectroscopic detection of individual conformers, Acyclic and mono cyclic systems, Rotation around partial double bonds, Winstein-Holness and Curtin-Hammet principle.	**10**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Physical Organic Chemistry, Isaccs N.S., Longman Scientific & Technical,1987.
2. Modern Physical Organic Chemistry, Eric V. Anslyn, Dennis A. Dougesty, University Science books, California
3. Mechanics and Theory in Organic Chemistry, T.H. Lowry and K.C. Richardson. Harper and Row
4. The Physical Basis of Organic Chemistry, H. Maskill, Oxford University Press
5. Molecular Mechanics, U. Bukert and N.L.Alinger, ACS Monograph, 1982
6. Physical Organic Chemistry, Hammett L.P., McGraw-Hill Book Company, 1970

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-15

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth
	Physical Chemistry Special II	
Course Code: **1020213**	**Course Title: Electrochemistry**	**Theory**

Course Objectives: To develop the knowledge about electrochemistry and electro chemical energy.

Course Outcomes (CO's):

CO1. Ability to understand conversion and storage of electrochemical energy, electrochemical generators.

CO2. Understanding the various types of batteries, their performance, Charging and discharging.
CO3 Describing mechanisms for corrosion and methods to protect metals.
CO4 Understanding bioelectrochemistry, electrical conductance in biological organism and their mechanism.
CO5. Ability to know Potential Sweep and Bulk Electrolysis Methods and also their applications.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	**Course Topic**	**No. of Lectures Hours**
I	Conversion and Storage of Electrochemical Energy: Present status of energy Consumption- Pollution problem. History of fuel cells, Direct energy conversion by electrochemical means. Maximum intrinsic efficiency of an electrochemical converter. Physical interpretation of the Carnot efficiency factor in electrochemical energy converters. Power outputs. Electrochemical Generators (Fuel Cells): Hydrogen oxygen cells, Hydrogen Air cell, Hydrocarbon air cell, Alkane fuel cell, Phosphoric and fuel cell, direct NaOH fuel cells, applications of fuel cells. Electrochemical Energy Storage: Properties of Electrochemical energy storage: Measure of battery performance, Charging and discharging of a battery, Storage Density, Energy Density. Classical Batteries: (i) Lead Acid (ii)Nickel-Cadmium, (iii) Zinc manganese dioxide. Modern Batteries: (i) Zinc-Air (ii) Nickel-Metal Hydride, (iii) Lithium Battery, Future Electricity storers: Storage in (i) Hydrogen, (ii) Alkali Metals, (iii) Non aqueous solutions.	**16**
II	Corrosion and Stability of Metals: Civilization and Surface mechanism of the corrosion of the metals; Thermodynamics and the stability of metals, Potential -pH (or Pourbaix) Diaphragmsl; uses and abuses, Corrosion current and corrosion potential -Evans diagrams. Measurement of corrosionrate: (i) Weight Loss method, (ii) Electrochemical Method.	**12**

	Inhibiting Corrosion: Cathodic and Anodic Protection. (i) Inhibition by addition of substrates to the electrolyte environment, (ii) by charging the corroding method from external source, anodic Protection, Organic inhibitors, The fuller Story Green inhibitors. Passivation: Structure of Passivation films, Mechanism of Passivation, Spontaneous Passivation Nature's method for stabilizing surfaces.	
III	Bioelectrochemistry: Bioelectrodics, Membrane potential, simplistic theory, modern theory Electrical conductance in biological organism: Electronic, protonic electrochemical mechanism of nervous system, Enzymes as electrodes Kinetics of electrode process: Essentials of electrode reaction, current density, overpotential, Tafel equation, Butler Volmer equation, standard rate constant (K) and transfer coefficient (a), exchange current. Irreversible Electrode processes: Criteria of irreversibility, information from irreversible wave.	**8**
IV	Methods of determining kinetic parameters of quasi-reversible and irreversible waves: Koutecky's methods, Meits Israel Method, Gellings method. Electrocatalysis: Chemical catalysts and Electrochemical catalysts with special reference to puro states, porphyrin oxides of rare earths. Electrocatalysis in simple redox reactions, in reaction involving adsorbed species. Influence of various parameters.	**16**
V	Potential Sweep Method: Linear sweep Voltammetry, Cyclic Voltammetry, theory and applications. Diagnostic criteria of cyclic voltammetry. Controlled current microelectrode techniques: comparison with controlled potentials methods, chronopotentiometry, theory and applications. Bulk Electrolysis Methods: Controlled potential coulometry, Controlled Coulometry, Electroorganic synthesis and its important applications. Stripping analysis: anodic and Cathodic modes, Pre electrolysis and Stripping steps, applications of Stripping Analysis.	**8**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Modern Electrochemistry Vol. I, IIa, Vol. IIB J'OM Bockris and A.K.N. Reddy, Plenum Publication, New York.		

2. Polarographic Techniques, L. Meites, Interscience.
3. Fuel Cells Their electrochemistry. M. B. Smith, McGraw Hill Book Company, New York.
4. Modern Polarographic Methods, A.M. Bond, Marcell Dekker.
5. Polarography and allied techniques, K. Zutshi, New age International publicatin. New Delhi.
6. Electroaalytical Chemistry, Basil H. Vessor & Galen W. ; Wiley Interscience.
7. Electroanalytical Chemistry, Basil H. Vessor & alen w. ; Wiley Interscience.
8. Topics in pure and Applied Chemistry, Ed. S. K. Rangrajan, SAEST Publication, Karaikudi (India).
9. Electrochemical Methods: Fundamentals and Applications; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.
10. Principal of Physical Chemistry by Puri Sharma and Pathania
11. Fuel cell catalysis edited by Marc T.M. Koper, Wiley publication (2009).

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 16

Programme/Class: M.Sc.	Year: P.G. IInd Year or UG in Research Fifth Year	Semester: Fourth/Tenth
	Physical Chemistry Special III	
Course Code: 1020214	**Course Title: Advanced Physical Chemistry**	**Theory**

Course Objectives: To develop the knowledge about advanced topics of physical chemistry.

Course Outcomes (CO's):

CO1. Ability to understand applied colloids, surface chemistry and nano catalysis.
CO2. Understanding principles and concepts of Green Chemistry.
CO3. Ability to know waste production and process for its treatment.
CO4. Describing hyphenated instrumental techniques of chemical analysis.
CO5. Understanding advanced instrumental techniques of chemical analysis.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	**Course Topic**	**No. of Lectures Hours**
I	Applied colloids-Surface chemistry and nano catalysis: Introduction to the nature of colloidal solution, Surface Tension, Wetting, Solubilisation, Dispersion, Detergency, contact angle measurement, lotus effect, Surfactants and Self-assembly, Emulsions and Micro emulsion, Role of surfactants in synthesis of nanoparticles Nano catalysts: Role of transition metals & metal oxides in homogeneous and heterogeneous catalysis and their mechanism of catalysis, manufacture of these catalysts in nano-form and their characterization.	**20**
II	Principles and Concepts of Green Chemistry: Sustainable development and green chemistry, Atom economy, examples of atom economic and atom un-economic reactions, reducing toxicity. Waste: Production, Problems and Prevention: Sources of waste from chemical industry, waste minimization techniques, on-site waste treatment (Physical treatment, Chemical treatment and bio-treatment plants), and design for degradation: Degradation and surfactants, DDT, Polymers, rules for degradation. Organic solvents: Environmentally benign solutions: solvent free systems, supercritical fluids Supercritical carbon dioxide, decaffeination process, ScCO2 as reaction solvent, Supercritical water, ionic liquids as catalysts and solvents.	**20**

III	Hyphenated Instrumental techniques of chemical analysis: Introduction, need for hyphenation, possible hyphenation, interfacing devices and applications of the following: GC-MS, GC-IR, MS-MS, LC-MS, ICP-MS and Spectro-electrochemistry. Radio-chemical methods: Auto, X-ray and gamma radiography.	**10**
IV	Advanced instrumental techniques: Electron microprobe method, Reflectance spectroscopy, Chemiluminescence method, Photoacoustic spectroscopy, Polarimetry: ORD, CD.	**10**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Green Chemistry: An Introductory Text, Mike Lancaster, Royal Society of Chemistry, 2002.
2. Green Chemistry – Theory and Practice Paul T. Anastas and John C. Warner, Oxoford University Press, 1998.
3. Introduction to Green Chemistry, Albert S. Matlack, Marcel Dekker, Inc., 2001.
4. Tandem Techniques, R.P.W. Scott, Wiley India Pvt.Ltd. Reprint 2009.
5. Analytical chemistry for open learning, Mass spectrometry, J. Barker, Wiiley IndiaED.
6. Essential of Nuclear Chemistry, H. J. Arnikar, New Age International, 1995.
7. Heterogeneous Catalysis, G. C. Bond, 2nd ed., Clarendon Press, Oxford, 1987Physical Chemistry, P.W Atkins, ELBS.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-17

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth

	Physical Chemistry Special IV	
Course Code: **1020215**	**Course Title: Electrochemical techniques and Sensors**	**Theory**

Course Objectives: To help them to learn the electrochemical techniques and sensors, also their applications.

Course Outcomes (CO's):

CO1. Ability to understand techniques based on Impedance measurements.

CO2. Understanding electrochemical technique based on rotating disk electrode.

CO3. Ability to know cyclic voltammetry and other advanced electrochemical techniques.

CO4. Describing principles of chemical sensing energy production for working and growing of organisms.

CO5. Understanding the bio chemical sensors, physico-chemical sensors and transducers.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Techniques based on Impedance measurements: Application of Impedance technique for studying electrode kinetics and corrosion, Measuring techniques, Representation of Faradic Impedance, Equivalent circuits, Kinetic parameters from impedance measurements, separation of RS & CS from total impedance, Use of the Fourier transformation in the analysis of data.	12

II	Electrochemical Technique based on Rotating Disk Electrode: Application of Rotating Disc Electrode (RDE) for measurement of electrochemical rate constant, Theoretical treatment of convective systems, Current -potential curves at RDE for reversible, irreversible and quasi reversible reactions.	**12**
III	Cyclic Voltammetry: Methods based on voltammetry; current-potential relation applicable for Linear Sweep Voltammetry (LSV) and Cyclic Voltammetry (CV), Reversible, irreversible & quasi-reversible systems, interpretation of cyclic voltammograms and parameters obtainable from voltammograms.	**12**
IV	Other Electrochemical Techniques: Basic principles related to Chronoamperometry, Chronocoulometry and Chronopotentiometry. Mechanisms of some technologically important electrochemical reactions: Hydrogen evolution reaction, oxygen reduction reaction, CO2 reduction reaction and Cl2 evolution reaction. Dye-sensitized solar Cells (DSSC): Working principle of Dye-sensitized PEC Cells (DSSC), Use of sensitizers.	**12**
V	Introduction to principles of chemical sensing: Signal transduction, Physico-chemical and biological transducers, Sensor types and technologies. Screen-printed electrodes Physico-chemical sensors and transducers: Thermal sensors, Electrochemical sensors (amperometry, potentiometry, conductimetry), Semiconductor transducers (ISFET), Optical transducers (absorption, fluorescence, bio/chemiluminescence, SPR), Piezoelectric and acoustic wave transducers, An Overview of Performance and Applications. Biochemical sensors: Enzymes, Oligonucleotides and Nucleic Acids, Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes), Membrane receptors and transporters, Immunoreceptors. Applications: Environmental monitoring, Technological process control, Food quality control, Clinical chemistry, Test-strips for glucose monitoring, Screen printed electrodes, Implantable sensors for long-term monitoring, Forensic science.	**12**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Modern Electrochemistry, Vol. 1 & 2A and 2 B, J.O'M. Bockris and A.K.N. Reddy, Plenum Press, New York (1998).		

2. Electrochemical Methods: Fundamentals and Applications; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.
3. Principal of Physical Chemistry by Puri Sharma and Pathania
4. Fuel cell catalysis edited by Marc T.M. Koper, Wiley publication (2009)
5. Principles of Chemical and Biological Sensors, D. Diamond Editor, John Wiley& Sons, 2000.
6. Chemical Sensors and Biosensors, Brian Eggins, John Willey & Sons, 2002.
7. Sensors, Nanoscience, Biomedical Engineering, and Instruments. Richard Dorf Editor, CRC Taylor & Francis, 2006
8. Optical Biosensors. Present & Future. Editors: F. Ligler, C. Rowe Taitt, Elsevier, 2002.
9. Introduction to Bioanalytical Sensors, Alice Cunningham, John Wiley& Sons, 1998.
10. Chemical Sensors and Biosensors for Medical and Biological Applications, Ursula Spichiger-Keller,Wiley-VCH, 19985.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-18

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth
	Physical Chemistry Special V	
Course Code: **1020216**	**Course Title: Computational Chemistry**	**Theory**

Course Objectives: To help them to learn Computational chemistry.

Course Outcomes (CO's):

CO1. Ability to understand Ab initio Calculations and its strengths and weaknesses .
CO2. Understanding semiempirical calculations.
CO3. Ability to know density functional calculations.
CO4. Describing molecular mechanics and its uses.

Credits: 4	**Elective**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Ab initio Calculations: Basic Principles, Hartree SCF Method, Hartree-Fock Equations, Introduction to BasisSets, Gaussian Functions, Direct SCF, Types of Basis Sets and Their Uses,Post-Hartree-Fock Calculations: Electron Correlation, Møller-Plesset Approach toElectron Correlation, Configuration Interaction Approach to Electron Correlation. TheCoupled Cluster Method, Applications of The Ab initio Method, Geometry, Energies Frequencies and Vibrational Spectra, Properties Arising from Electron, Distribution Moments, Charges, Bond Orders, Atoms-in-Molecules, Ionization, Energies and Electron Affinities, Strengths and Weaknesses of Ab intio Calculations	**15**
II	Semiempirical Calculations: Basic Principles, Pariser-Parr-Pople (PPP) method, Complete Neglect of Differential Overlap (CNDO) Method, Intermediate Neglect of Differential Overlap (INDO) Method, Neglect of Diatomic Differential Overlap (NDDO) Methods, Applications Of Semiempirical Methods, Geometry, Energies, Frequencies and Vibrational Spectra, Properties Arising from Electron Distribution–Dipole Moments, Charges, Bond Orders, Atoms-in-Molecules, Ionization Energies and Electron Affinities, Strengths and Weaknesses of semiempirical methods.	**15**
III	Density Functional Calculations: Basic Principles, Thomas-Fermi-Dirac model and shortcoming, DFT Methods: Kohn-Sham Approach, Kohn-Sham Energy and the KS Equations, Solving the KS Equations, Applications of Density Functional Theory, Geometry, Energies, Frequencies and Vibrational Spectra, Properties Arising from	**15**

	Electron Distribution–Dipole Moments, Charges, Bond Orders, Atoms-in-Molecules, Ionization Energies and Electron Affinities, Electronegativity, Strengths and Weaknesses of DFT Project Report writing	
IV	Molecular mechanics: Introduction of force field, developing a Force field, Parameterizing a Forcefield, Calculation Using our Forcefield, Use of Molecular Mechanics, Obtain Reasonable Input Geometries for Lengthier (ab Initio, Semiempirical or Density Functional) Kinds of Calculations, Obtain (Often Excellent) Geometries, Obtain (Sometimes Excellent) Relative Energies, Strengths and Weaknesses of Molecular Mechanics.	**15**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Quantum Chemistry and Spectroscopy 4th Edition, by Thomas Engel, Pearson
2. Molecular Quantum Mechanics 4th Edition, by Peter Atkins and Ronald Friedman, OxfordInternational
3. Computational Chemistry Introduction to the Theory and Applications of Molecular anQuantum Mechanics, 3rd Edition by Errol G. Lewars, Springer International
4. Introduction to Computational Chemistry, 3rd Edition by Frank Jensen, John Wiley & Sons,Ltd.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE- 19

Programme/Class: M.Sc.	**Year:** P.G. IInd Year or UG in Research Fifth Year	**Semester:** Fourth/Tenth
	Physical Chemistry Special Practical	

Course Code: 1020282	Course Title: Lab IV Physical Chemistry	Practical

Course Objectives: To help them to learn experimental techniques of physical chemistry.

Course Outcomes (CO's):

CO1. Ability to determine chemical kinetics and rate constant for chemical reactions.

CO2. Understanding conductometry experiments to determine cell constant, conductance and equivalent conductance.

CO3. Ability to know about conductometric titrations.

CO4. Describing to perform Potentiometry, Thermodynamic experiments.

CO5. Understanding computational methods and spectroscopic methods.

Credits: 4	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 40

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 120 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	Chemical kinetics • Determine the specific rate constant for the acid catalysed hydrolysis of methyl acetate by the Initial Rate Method. Study the reaction at two different temperatures and calculate the thermodynamic parameters. • Compare the strengths of HCl and H_2SO_4 by studying the rate of hydrolysis of methyl acetate. • Study the saponification of ethyl acetate with sodium hydroxide volumetrically. • Study the kinetics of the iodination of acetone in the presence of acid by Initial Rate Method. • Determine the specific reaction rate of the acid Potassium per sulphate iodide reaction by the Initial Rate Method. • Determine the specific rotation constant for sucrose.	20

	• Study the acid catalysed inversion of cane sugar, and find out the order with respect to sucrose, the rate constant, compare kinetically the strengths of two acids (HCl and H_2SO_4)	
II	Conductometry • Determine the Cell constant of the given conductivity cell at room temperature and study the equivalent conductance versus square root of concentration relationship of a strong electrolyte (KCl or NaCl) and weak electrolyte (acetic acid). • Determine the equivalent conductance at infinite dilution for acetic acid by applying Kohlrausch's law of independent migration of ions. • Determine the equivalent conductance, degree of dissociation and dissociation constant (Ka) of acetic acid. • Study the conductometric titration of hydrochloric acid with sodium carbonate and determine the concentration of sodium carbonate in a commercial sample of soda ash. • Study the conductometric titration of (i) Acetic acid versus sodium hydroxide (ii) Acetic acid versus ammonium hydroxide (iii) Sodium acetate versus HCl. • Study the stepwise neutralization of a polybasic acid e.g. oxalic acid, citric acid, succinic acid by conductometric titration and explain the variation in the plots. • Study the conductometric titration of a mixture of a strong and weak acid. • Study the estimation of potassium sulphate solution by conductometric titration.	**20**
III	Potentiometry • Prepare and test the Calomel Electrode. • Titrate hydrochloric acid and sodium hydroxide potentiometrically. • Determine the dissociation constant of acetic acid potentiometrically. • Titrate oxalic acid and sodium hydroxide Potentiometrically. • Titrate a mixture of	**20**

	(i) strong and weak acids (HCl and acetic acid) (ii) weak acid (acetic acid) and dibasic acid (oxalic acid) (iii) strong acid (hydrochloric acid) and dibasic acid (oxalic acid) versus sodium hydroxide. • Titrate a solution of Mohr's salt against potassium permanganate potentiometrically. • Titrate a solution of Mohr's salt and potassium dichromate potentiometrically.	
IV	Thermodynamics • Determination of partial molar volume of solution (e.g. KCl) and solvent in a binary mixture. • Determination of the dependence of the solubility of a compound in two solvents having similar intermolecular interactions (benzoic acid in water and in DMSO-water mixture) and calculate the partial molar heat of solution.	**15**
V	Spectroscopy • Determination of pKa of an indicator (e.g. methyl red) in (a) aqueous and (b) micellar media. • Determination of stoichiometry and stability constant of inorganic (e.g. rerric-salicylic acid) and organic (e.g. amine-iodine) complexes. • Characterization of the complexes by electronic and IF spectral data.	**15**
VI	Computational Methods Familiarity with word processing, electronic spreadsheets, data processing, mathematical packages, chemical structure drawing and molecular modelling.	**30**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
2. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
3. Findley's Practical Physical chemistry, B.P. Levitt, Longman.
4. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill

5. Advanced Physical Chemistry by Gurtu and Gurtu, Pragati Prakashan.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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COURSE-20

Programme/Class: M.Sc.	**Year:** P.G. Ist Year or UG in Research Fourth Year	**Semester:** Second/Eight
Course Code: **1020265**	**Course Title: Project IV**	**Theory**

Course Objectives: To help them to learn data collection, paper presentation, project report writing and project report presentation skill.

Course Outcomes (CO's):

CO1. Ability to understand data collection, its analysis, presentation and applicability.
CO2. Understanding how to write an impressive paper.
CO3. Ability to know how to explore data by project writing.
CO4. Ability to understand Presentation a paper in seminar/workshop/conference.
CO5. Understanding Project Report writing.
CO6. Ability to know Submission and Presentation of project Report.

Credits: 4	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100** **Minimum Marks: 40**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 0-0-8 (Eight Hours in a week) or 120 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Data collection and its comparison with previous reports in literature	**20**
II	Research paper writing to publish	**20**
III	Presentation of paper in seminar/conference/workshop	**20**
IV	Presentation a paper in seminar/workshop/conference	**20**
V	Project Report writing	**20**
VI	Submission and Presentation of project Report	**20**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. How to write and Publish by Robert A. Day and Barbara Gastel, (Cambridge University Press).
2. Survival skills for Scientists by Federico Rosei and Tudor Johnson, (Imperial College Press).
3. How to Research by Loraine Blaxter, Christina Hughes and Malcum Tight, (Viva Books).
4. Probability and Statistics for Engineers and Scientists by Sheldon Ross, (Elsevier Academic Press).
5. The Craft of Scientific Writing by Michael Alley, (Springer).
6. A Students's Guide to Methodology by Peter Clough and Cathy Nutbrown, (Sage Publications).
7. Research Methodology - A Step-By-Step Guide for Beginners, Kumar, R., Pearson Education, Delhi (2006).
8. Design & Analysis of Experiments, Montgomery, D. C., 5th Ed., Wiley India (2007).
9. Research Methodology-Methods and Techniques, Kothari, C. K., 2nd Ed., New Age International, New Delhi

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions: .....

Detailed Syllabus

For

Post Graduate Diploma in Research in Chemistry

as per NEP 2020

Or

Pre-Ph.D. Course Work in Chemistry

Course-1		
Programme/Class: M.Sc.	**Year:** Pre-Ph.D. Course Work in Chemistry Ist year	**Semester:** First/Eleventh
Course Code: 1120201	**Course Title: Research Methodology & Computer Applications**	**Theory**
Course Objectives: Acquiring ability for Research methodology and Scientific Research. **Course Outcomes (CO's):** **CO1.** Ability to learn Errors in measurements and statistical methods. **CO2.** Knowing Ethics in Science, intellectual property right and Patent regime. **CO3.** Understanding Laboratory practices and safety guidelines. **CO4.** Describing Computer applications in scientific writing skills.		
Credits: 4	**Core Compulsory**	**Max Marks** **(Int. + Ext.): 25+75** **Total = 100** **Minimum Marks: 55**

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 3-1-0 (Four Hours in a week) or 60 Lecture Hours in a Semester		
Unit	**Course Topic**	**No. of Lectures Hours**
I	Research methodology: Definition of Research, Components of Research Problem, Various Steps in Scientific Research-Hypotheses, Research Purposes, Research Design, Literature searching, Literature Survey, defining the question and formulating hypothesis/ hypothesizes, Collection of research data, tabulating and cataloging. Sampling and methods of data analysis.	**12**
II	Errors in measurements and statistical methods: Types of errors; mean deviation, standard deviation and probable errors; propagation of errors with summation, difference, product and quotient. Probability Theories: Conditional Probability, Poisson Distribution, Binomial Distribution and Properties of Normal Distributions, Estimates of Means and Proportions; Chi-Square Test, Association of Attributes: t-Test, Standard deviation, Co-efficient of variations, Correlation and Regression Analysis, plotting of graphs.	**12**
III	Laboratory practices and safety guidelines: Safe working procedure and protective environment, Laboratory safety measures, Handling radiation, Chemical hazards and their types, Safe chemical use, Proper storage and disposal of hazardous materials, Bio-hazardous and other toxic experimental materials, Maintenance and handling of Laboratory equipment.	**12**
IV	Computer applications in scientific writing skills: Applications of Microsoft Excel, power point and origin for data processing and data analysis, research paper –presentation using power point (which include texts, graphs, pictures, tables, references etc.)(oral in power point/poster); Curve fitting, Method of least square fit, least square fit (straight line) to linear equations and equation reducible to linear equations. Non-linear curve fitting, back ground correction and mathematical manipulation in data using origin. Structure and Components of Research Report, Types of Report: research papers, thesis, Research Project Reports, Pictures and Graphs, citation styles, writing manuscript in Latex, Steps to better writing.	**12**

V	Ethics in Science: The source of ethical issues in science: examples from different disciplines. Ethical issues in science research and reporting: objectivity and integrity, the problem of plagiarism and related issues, international norms and standards, Scientific temper and virtues, expectations from scientific community. IPR and Patent regime: Recording and storage/retention of recorded materials. Management and use responsibilities in proper utilization of the facilities. Socio-legal issues, originality.	12

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. How to write and Publish by Robert A. Day and Barbara Gastel, (Cambridge University Press).
2. Survival skills for Scientists by Federico Rosei and Tudor Johnson, (Imperial College Press).
3. How to Research by Loraine Blaxter, Christina Hughes and Malcum Tight, (Viva Books).
4. Probability and Statistics for Engineers and Scientists by Sheldon Ross, (Elsevier Academic Press).
5. The Craft of Scientific Writing by Michael Alley, (Springer).
6. A Students's Guide to Methodology by Peter Clough and Cathy Nutbrown, (Sage Publications).
7. Research Methodology - A Step-By-Step Guide for Beginners, Kumar, R., Pearson Education, Delhi (2006).
8. Design & Analysis of Experiments, Montgomery, D. C., 5th Ed., Wiley India (2007).
9. Research Methodology-Methods and Techniques, Kothari, C. K., 2nd Ed., New Age International, New Delhi

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

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Further Suggestions:

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Course-2

Programme/Class: M.Sc.	Year: Pre-Ph.D. Course Work in Chemistry Ist year	Semester: First/Eleventh
Course Code: 1120202	**Course Title: Instrumentation and Applications**	**Theory**

Course Objectives: Acquiring ability for understanding instrumentation and application.

Course Outcomes (CO's):

CO1. Ability to learn Electroanalytical and optical methods of analysis.

CO2. Understanding spectroscopic methods of analytical techniques and diffraction.

CO3. Describing separation methods in research.

Credits: 2	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 55

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 2-0-0 (Two Hours in a week) or 30 Lecture Hours in a Semester

Unit	Course Topic	No. of Lectures Hours
I	**Electroanalytical methods:** Electrochemical impedance spectroscopy (EIS), coulometry and anode stripping voltammetry. **Optical methods:** UV/Visible, X-ray photoelectron spectroscopy (XPS), Auger Electron Spectroscopy (AES), ESCA,.	08

II	**Spectroscopic Methods:** Infrared Spectroscopy, Dispersive and Fourier Transformed Raman, Resonance Raman and Surface Enhanced Raman Spectroscopy- Dispersive and Fourier Transformed. **Other Spectroscopic methods:** NMR, ESR, MS (EI, FAB, MALDI-TOF). Hyphenated Techniques: GC-IR, TG-IR Spectroscopy, GC-Mass Spectroscopy Diffraction **Diffraction Methods:** Single crystal and Powder X–Ray Diffraction and their applications for Inorganic Compounds, Neutron Diffraction and Electron Diffraction.	**16**
III	**Separation Methods:** Theory and applications of separation methods in analytical chemistry: solvent extraction, ion exchangers including liquid ion exchangers and chromatographic methods for identification and estimation of multicomponent systems (such as TLC, GC, HPLC, etc.).	**06**

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Analytical Chemistry, Christian, G. D., 6th Ed., John Wiley & Sons, Inc. (2004).
2. Principles of Instrumental Analysis, Skoog D. A., West D. M., Holler R. J & Nieman T. A., Saunders Golden Sunburst Series (1997).
3. Instrumental Methods of Analysis, Willard H. H., Merritt,L. L., Dean J. A. & Settle F. A., 7th Ed., Wadsworth Publishing (1988)
4. Powder X-Ray Diffraction, Cullity, B.D. & Stock, S.R., 3rd edition, Kindle Publisher 2001.
5. X- Ray structure Determination A Practical Guide, Stout, G.H. & Jensen, L. H., IIed (John Wiley & Sons), 1989.
6. An Introduction to Separation Science, B.L. Karger, L.R. Snyder and C. Howarth, 2nd Edition (1973), John Wiley, New York.
7. Chemical Methods of Separation, E.W. Berg, 1st Edition (1963), McGraw Hill, New York.
8. Separation and Measurements, D.G. Peters, J.M. Hayes and C.M. Hieftj, Chemical 2nd Edition (1974), Saunders Holt, London.
9. Separation Process Principles, J.D. Seader and E.J. Henley, 1st Edition (1998), John Wiley & Sons. Inc., New York.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Course-3		
Programme/Class: M.Sc.	**Year:** Pre-Ph.D. Course Work in Chemistry I[st] year	**Semester:** First/Eleventh
Course Code: 1120203	**Course Title: Advances in Chemistry**	**Theory**
Course Objectives: Acquiring ability for understanding advances in chemistry. **Course Outcomes (CO's):** **CO1.** Ability to learn the emerging green chemistry. **CO2.** Describing the chemistry of molecular recognition. **CO3.** Understanding Nano-Chemistry and advances in polymers.		
Credits: 2	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 55**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 2-0-0 (Two Hours in a week) or 30 Lecture Hours in a Semester		
Unit	**Course Topics**	**No. of Lectures Hours**
I	**Emerging Green Chemistry:** Green chemistry, introduction, 12 principles, Solvent-free synthesis, environmentally benign solvents: Water and Ionic liquids as green solvents and catalysts in organic synthesis. Microwave in chemical synthesis: Basic principles, advantages and examples. Sonochemistry and green aspects.	**06**

II	**Nano-Chemistry:** Introduction, Nucleation and growth, heterogeneous nucleation, Size effect, Synthesis and assembly, techniques, General methods of preparation and synthesis. Types of nano materials, their properties and applications. Carbon nanotube, micro- and mesoporous materials.	10
III	**The chemistry of molecular recognition: Host and Guest Chemistry.** Supramolecular interactions and their characterization, Supramolecular catalysis and transport processes, Cyclodextrin- a naturally occurring cyclic host, calixarene- a versatile host, Chemosensor, Electrochemical sensors, Origin and source of chirality, chiral ligands, chiral drugs, **Polymers:** Spectroscopic characterization and testing of polymers. Measurement of molecular weights: viscosity, light scattering, osmotic and size exclusion chromatographic method. Properties and applications of commercial polymers: polyamides, polyesters, phenolic resins, epoxy resins and silicones. Fire retarding polymers, conducting polymers, and biocompatible polymers	14
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		

Suggested Readings:

1. Green Chemistry: An Introductory Text, Mike Lancaster, Royal Society of Chemistry, 2002.
2. The new Chemistry, Nina Hall (Editor-in-chief), Cambridge university Press, 2000.
3. The Chemistry of Nano Materials, CNR Rao, Muller and Cheetham, Vol.I & II, Wiley-VCH (2005)
4. Nano Chemistry, Geoffrey A. Ozin, and Andre Arsentte, RSC Publishing, 2005

5. Nano Crystalline Materials, S.C. Tjong, Elsevier, 2006
6. Modern Organic Synthesis - An Introduction, George S. Zweifel, Michael H. Nantz, 1st Edition, 2007; Ed. W. H.Freeman
7. Supramolecular chemistry- fundamentals and applications, Ariga Katsuhiko, Kunitake Toyoki, Iwanami Shoten Publishers, Tokyo, 2006.
8. Supramolecular chemistry: concepts and perspective, Jean Marie Lehn, Wiley-VCH (June 1995).
9. Supramolecular chirality, Topics in current Chemistry, Crego-Calama, Mercedes Reinhoudt, Davis N. Ed., vol 265, 2006, Springer Verlag.
10. Advanced Inorganic Chemistry, F. A. Cotton and G. Wilkinson, 6th Edn., (1999), John-Wiley & Sons, New York.
11. Catalysis: Principles and Application, editor(s) : B. Viswanathan, S. Sivasanker, A.V. Ramaswamy ISBN: 978-81-7319-375-0: (2007).
12. Comprehensive Asymmetric Catalysis I-III; Jacobsen, E.N., Pfaltz, A.; Yamamoto, H. (ed), Springer Verlag: Berlin, 1999.
13. Textbook of Polymer Sciences, F. W. Billmeyer Jr, WileyPolymer Sciences, V. R. Gwariker, N. V. Vishwanathan and J. Sreedhar, Willey-Eastern.
14. Functional Monomers and Polymers, K. Takemoto, Y. Inaki and R. M. Ottanbrite.
15. Contemporary Polymer Chemistry, H. R. Alcock and F. W. Lambe, Prentice Hall.
16. Physics and Chemistry of Polymers, J. M. G. Cowie, Blackie Academic and Professional.

Suggested Continuous Evaluation Methods:

Continuous internal evaluation through internal tests, quizzes and Presentation.

Suggested equivalent online courses:

There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc

Further Suggestions:

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Course-4

Programme/Class: M.Sc.	**Year:** Pre-Ph.D. Course Work in Chemistry Ist year	**Semester: First/Eleventh**

Course Code: 1120204	Course Title: Molecular Magnets and Liquid Crystals	Theory

Course Objectives: Acquiring ability for understanding Molecular Magnets and Liquid Crystals.

Course Outcomes (CO's):

CO1. Ability to learn the emerging Molecular Magnets.

CO2. Describing the chemistry of Liquid Crystals.

Credits: 2	Core Compulsory	Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 55

Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 2-0-0 (Two Hours in a week) or 30 Lecture Hours in a Semester

Unit	Course Topics	No. of Lectures Hours
I	**Molecular Magnets:** Magnetization and magnetic susceptibility, Molecules containing a unique magnetic centre with and without first order orbital momentum, low spin-high spin transition, some selected examples, magnetic long-range ordering in molecular compounds: Design of molecular based magnets.	15
II	**Liquid Crystals:** Basic concepts, types of mesophases, design and synthesis of low molecular weight metallomesogens and matallomesogenic polymers, structural and mesophase characterization, Physical properties and applications of metallomesogens.	15

Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc

Suggested Readings:

1. Molecular Magnetism - Oliver Kahn, VCH, Weinheim, Germany
2. Metallomesogens - J.L.Serrano, VCH, Weinheim, Germany
3. Principles of physical chemistry / Puri, B.R.; Sharma, L.R. & Pathania, Madan S.

Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL, E-contents from different online libraries, e-PG Pathshaala etc
Further Suggestions: .....

Course-5		
Programme/Class: M.Sc.	**Year:** Pre-Ph.D. Course Work in Chemistry Ist year	**Semester: First/Eleventh**
Course Code: 1120205	**Course Title: Emerging Methodologies in Organic Synthesis**	**Theory**
Course Objectives: Acquiring ability for understanding Molecular Magnets and Liquid Crystals. **Course Outcomes (CO's):** **CO1.** Ability to learn the emerging greener methodologies. **CO2.** Describing the chemistry of Organic solvents. **CO3.** Describing the catalysis		
Credits: 2	**Core Compulsory**	**Max Marks (Int. + Ext.): 25+75 Total = 100 Minimum Marks: 55**
Teaching Hours = Lecture-Tutorial-Practical (L-T-P) : 2-0-0 (Two Hours in a week) or 30 Lecture Hours in a Semester		
Unit	**Course Topics**	**No. of Lectures Hours**

I	**Emerging greener methodologies:** Sonochemistry and green aspects; Microwave in chemical synthesis: Basic principles, advantages and examples; Electrochemical synthesis: concepts and examples.	**10**
II	**Organic solvents:** Environmentally benign solvents, Solvent-free synthesis; Water as a reaction solvent; Ionic liquids	**10**
III	**Phase transfer catalysis:** Definition, Mechanism, Types of phase transfer catalysts, Transition metal catalyzed organic reactions & Organocatalysis	**10**
Teaching Learning Process: Class discussions/ demonstrations, Power point presentations, using e-content, Class activities/ assignments, etc		
Suggested Readings: 1. Green Chemistry: An Introductory Text by Mike Lancaster, Royal Society of Chemistry, 2002. 2. The new Chemistry, Editor-in-chief: Nina Hall, Cambridge university Press, 2000. 3. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York. 4. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic chemistry, Oxford University press INC, New York, 2001		
Suggested Continuous Evaluation Methods: Continuous internal evaluation through internal tests, quizzes and Presentation.		
Suggested equivalent online courses: There are online courses on the channels such as Swayam Prabha, Moocs and NPTEL. E-contents from different online libraries, e-PG Pathshaala etc		
Further Suggestions:		

Mukesh Chand
(Convener)