Academic Council Meeting No. and Date: 8/ September 04, 2023

Agenda Number: 02 **Resolution Number:** 34,35 /2.16, 2.37

Vidya Prasarak Mandal's
B. N. Bandodkar College of Science
(Autonomous), Thane

Syllabus for

Programme: Master of Science

Specific Programme:

[M.Sc. Chemistry (Semester I and II)]

Level 6.0

CHOICE BASED GRADING SYSTEM

Revised under NEP and Autonomy

From academic year 2023-24

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B. N. Bandodlar College of Science, (AUTONOMOUS)-Thane											
Master program in Chemistry											
Year (2 Yrs)	**LEVEL**	**SEMESTER**	**Major**				**Research Methodology**	**On Job Training / Field project**	**Research project**	**Cum Credits**	**Degrees**
			Mandatory		**Electives anyone**						
I	**6.0**	SEM-I	**3*4 + 2 = 14**		Credits 4		**Credits 4**	NA	NA	22	PG Diploma in Chemistry (After 3 Yrs. degree UG)
			Course 1	Credits 4	Course 1= Credits 4						
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2 = Credits 4						
			Course 4	Credits 2	**OR**						
		SEM-II	Course 1	Credits 4	Course 1 = Credits 4		NA	**Credits 4**	NA	**22**	
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2 = Credits 4						
			Course 4	Credits 2	**OR**						
Cum Cr.for 1 Yr. PG Diploma			**28**		8		4	4		44	
II	**6.5**	SEM- III	Course 1	Credits 4	Course 1	Credits 4	NA	NA	**Credits 4**	22	Master program in Chemistry (After 3 Yrs. degree UG)
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2	Credits 4					
			Course 4	Credits 2	**OR**						
		SEM IV	Course 1	Credits 4	Course 1	Credits 4	NA	NA	**Credits 6**	**22**	
			Course 2	Credits 4	**OR**						
			Course 3	Credits 4	Course 2	Credits 4					
					OR						
Cum Cr. for integrated 1 Yr. PG Degree			**26**		**8**				**10**	**44**	
Cum Cr. for 2 Yr. PG Degree			**44**		**16**		**4**	**4**	**10**	**88**	

Preamble

The Chemistry Syllabus for M.Sc. Degree covers two academic years consisting of four semesters. The present curriculum of M.Sc-I Sem I and Sem II is prepared to furnish sound knowledge and skill in chemistry to get employability to the postgraduate students. The goal of the syllabus is to equipping the students for potential contribution to academic and industrial environments. The syllabus has been prepared in the view of NEP2020 framework in a participatory manner in the Board of studies, after discussions with the subject expertise with social and industrial approach and after referring the existing syllabi.

Sufficient emphasis is given in the Mandatory subject, Electives subject and Research Methodology syllabus. For Electives subject, choice based is given among three elective subjects. In practical session, training in laboratory skills and instrumentation, case studies on job training apprenticeship and internship etc. A list of reference books is provided at the end of the Curriculum.

Specific Programme outcome:

- Learner gains the knowledge of chemistry through theoretical and scientific experiments for application of industrial and academics purpose.
- To develop systematic way to problem solving skills, address societal issues and environmental concern and to have preparedness in lifelong learning of technological change.
- Analytical Thinking, Critical analysis and ethical professional behaviors with multidisciplinary approach develops scientific theories , concepts and ideas advances the chemistry
- Approach of learners towards the improving quality of life by attitude and aptitude of chemistry and its allied branches using ICT and Communication skill.

Sr. No.	Heading	Particulars
1	**Title of Course** **Specific Programme**	**M.Sc. Organic Chemistry** **Semester I and II**
2	**Eligibility for Admission**	The B.Sc. chemistry or equivalent qualification from other recognized university as per relevant ordinance.
3	**Passing marks**	**Minimum D Grade or equivalent minimum marks for passing at the Graduation level.**
4	**No. of Years/Semesters**	**One year/Two semester**
5	**Level**	**6.0**
6	**Pattern**	**Semester**
7	**Credits**	**22**
8	**Status**	**Revised**
9	**To be implemented from Academic year**	**2023-2024**
10	i) Cum Cr. for integrated 1 Yr. PG Degree Chemistry (After 4 Yrs. degree UG Chemistry) ii) PG Diploma in Chemistry (After 3 Yrs. degree UG) and Cum Cr. for 2 Yr. PG Degree iii) Master program in Chemistry (After 3 Yrs. degree UG)	

Pedagogy:

$ Assignment Desk work, internal tests, Assignments, Quiz, ppt presentation You tube videos, referencing , MOOC, Problem solving, Project work, Industrial Visit, internship etc Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/ course projects/ problem or project based learning/ case studies/self-study like seminar, term paper or MOOC

$ Every course needs to include assessment for higher order thinking skills (Applying/ Analyzing/ Evaluating/ Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e. assessment for learning)

Assessment: Weightage for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	40 %	60 %
Practical	-	100 %
Project	-	100%
Experimental learning	-	100 %
Internship	-	100 %

VPM's B. N. Bandodkar College of Science (Autonomous), Thane.
Reframing of COs and Mapping of COs with POs.
DEPARTMENT OF CHEMISTRY (M. Sc. I)

Subject: Chemistry								
Course Name: Inorganic Chemistry								
Course Code: 23BPCH1T01								
	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Describe hybridization, involvement of d orbitals in various types pf hybridization, critical analysis of VBT.	**CO 1**	1	0	0	0	0	0
CO 2	Recognize MOT for diatomic species, polyatomic species considering σ bonding.	**CO 2**	1	0	0	0	0	0
CO 3	Illustrate Symmetry criterion of optical activity, Concepts of Groups, Sub-groups.	**CO 3**	1	0	0	0	0	0
CO 4	Discuss Representation of Groups, Applications of group theory.	**CO 4**	1	1	0	0	0	0
CO 5	Describe Electronic structure of solids and band theory, Structures of Compounds of the type: AB, AB_2.	**CO 5**	1	0	0	0	0	0
CO 6	Describe Methods of preparation for inorganic solids, nanomaterials.	**CO 6**	1	0	1	0	0	0
0CO 7	Discuss characterization of co-ordination compounds by using different spectroscopic methods.	**CO 7**	1	0	0	0	0	0
CO 8	Illustrate Spectral calculations, calculation of electronic parameters, Determination of formation constants of metal complexes.	**CO 8**	1	0	0	0	0	0

Subject: Chemistry								
Course Name : Organic Chemistry								
Course Code: 23BPCH1T02								
	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Illustrate the thermodynamic and kinetic requirements of reaction.	**CO 1**	1	0	0	0	0	0
CO 2	Determine mechanism of a reaction, describe acids and bases.	**CO 2**	1	0	0	0	0	0
CO 3	Discuss nucleophilic substitution reactions.	**CO 3**	1	0	0	0	0	0
CO 4	Describe the concept of aromaticity.	**CO 4**	0	1	0	0	0	0
CO 5	Elaborate concept of chirality, molecules with two or more chiral centers, molecules with tri- and tetra- coordinate centers.	**CO 5**	1	0	0	0	0	0
CO 6	Elucidate axial and planar chirality and prochirality.	**CO 6**	1	1	0	0	0	0
CO 7	Discuss the concept of oxidation and oxidation of various functional groups.	**CO 7**	1	1	0	0	0	0
CO 8	Describe the concept of reduction and reduction of various of various functional groups.	**CO 8**	1	0	0	0	0	0

Subject: Chemistry								
Course Name: Analytical Chemistry								
Course Code: 23BPCH1T03								
	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Discuss language of analytical chemistry.	**CO 1**	1	0	0	0	0	0
CO 2	Describe quality in analytical chemistry.	**CO 2**	1	0	0	0	0	0
CO 3	Solve the numerical based on Concentration of a solution, Calculations of ppm, ppb and dilution of the solutions, concept of mmol.	**CO 3**	1	0	0	0	0	0
CO 4	Determine the pH, concept of formation constant, oxidation number, stoichiometry of redox titration.	**CO 4**	0	1	0	0	0	0
CO 5	Explain FTIR, Molecular Ultraviolet and Visible Spectroscopy.	**CO 5**	1	0	0	0	0	0
CO 6	Illustrate Infrared Absorption Spectroscopy.	**CO 6**	1	0	0	0	0	0
CO 7	Discuss the thermal methods, comparison between TGA and DTA., Differential Scanning Calorimetry.	**CO 7**	1	0	0	0	0	0
CO 8	Elaborate the applications of different thermodynamic parameters, Automation in chemical analysis.	**CO 8**	1	0	0	0	0	0

0

Subject: Chemistry								
Course Name: Green Chemistry and Catalyst Chemistry								
Course Code: 23BPCH1T04								
	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Discuss 12 principles of green chemistry, green catalysts.	**CO 1**	1	0	0	0	0	0

CO 2	Describe synthesis, structure determination, uses of zeolites, catalysts in fine chemicals and pharmaceutical industries	**CO 2**	1	0	0	0	0	0
CO 3	Explain green synthesis of industrially important molecules.	**CO 3**	1	0	0	0	0	0
CO 4	Illustrate microwave assisted reactions in water.	**CO 4**	0	0	0	0	0	1

Subject: Chemistry

Course Name: Analytical Biochemistry

Course Code: 23BPCH1T05

	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Understand metabolic pathways, including glycolysis, fermentation, and the Krebs cycle, along with the role of ATP. Analyze the structure, classification, and biological significance of biomolecules.	**CO 1**	1	0	0	0	1	0
CO 2	Explain enzyme classification, mechanisms, and regulation, including coenzymes, cofactors, and inhibitors. Evaluate the biochemical functions .	**CO 2**	1	0	0	0	1	0
CO 3	Analyze the composition and functions of blood, the process of coagulation, and methods for blood collection and preservation.	**CO 3**	1	0	0	0	1	0
CO 4	Explain the process of urine formation and its composition. Perform the collection, preservation, and biochemical analysis of normal and pathological urine samples to assess physiological and clinical conditions.	**CO 4**	2	0	0	0	2	0

Subject: Chemistry

Course Name: Physical Chemistry

Course Code: 23BPCH1T06

	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Understand the principles of reaction kinetics, including rate laws, steady-state approximation, and rate-determining steps. Analyze the mechanisms of	**CO 1**	1	0	0	0	1	0

	chain reactions, organic decompositions, and gas-phase combustion, along with explosion limits and their influencing factors.							
CO 2	Examine the kinetics of stepwise and free radical polymerization, including the degree of polymerization and kinetic chain length. Evaluate theories of unimolecular reactions, such as Lindemann-Hinshelwood, RRK, and RRKM, in explaining reaction dynamics	**CO 2**	1	0	0	0	1	0
CO 3	Understand the basics of electrochemistry, including the Debye-Hückel theory, activity coefficients, and the Debye-Hückel limiting law with its extension to higher concentrations through mathematical derivations	**CO 3**	1	0	0	0	1	0
CO 4	Analyze the principles of electrolytic conductance, ionic interactions, and relaxation effects.	**CO 4**	1	0	0	0	1	0

Subject: Chemistry

Course Name: **Research Methodology**

Course Code: 23BPRM1T01

	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Understand and differentiate primary, secondary, and tertiary sources of chemical information. Analyze various print and digital resources, including journals, abstracts, monographs, and online databases, for accessing and evaluating scientific literature.	**CO 1**	1	0	0	0	1	0
CO 2	Utilize digital tools, search engines, and electronic resources such as SciFinder, Scopus, and Google Scholar for literature search and citation analysis.	**CO 2**	1	0	0	0	1	0
CO 3	Understand the principles of scientific methods, experimental design, and SI unit usage.	**CO 3**	1	0	0	0	1	0
CO 4	Apply statistical tools such as descriptive statistics, ANOVA, correlation, regression, and curve fitting for chemical data analysis.	**CO 4**	1	0	0	0	1	0
CO 5	Develop skills in reporting practical and project work, conducting literature surveys, writing reviews, and presenting scientific information through posters and oral presentations.	**CO 5**	1	0	0	0	0	0
CO 6	Understand the structure and components of scientific papers, including methodology, conclusions, and bibliography.	**CO 6**	1	0	0	0	0	0
CO 7	Understand safe working procedures, protective measures, emergency protocols, and first aid in the laboratory.	**CO 7**	1	0	0	0	0	0

CO 8	Evaluate proper methods for the storage, disposal, recovery, recycling, and transportation of hazardous chemicals.		**CO 8**	1	0	0	0	0	0

SEM II

Subject: Chemistry	
Course Name: Inorganic Chemistry	
Course Code: 23BPCH2T01	

	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Analyze ligand substitution reactions in octahedral and square planar complexes, including mechanisms, trans-effects, and the role of isotopic labeling.	**CO 1**	1	0	0	0	1	0
CO 2	Study the stereochemical aspects of substitution reactions in octahedral complexes, focusing on isomerization and racemization. Explore the inner and outer sphere mechanisms of redox reactions and their complementary and non-complementary nature.	**CO 2**	1	0	0	0	1	0
CO 3	Understand the principles of the 18-electron and 16-electron rules, along with electron counting methods.	**CO 3**	1	0	0	0	1	0
CO 4	Apply Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) to understand the structure and bonding in organometallic compounds.	**CO 4**	1	0	0	0	1	0

CO 5	Understand the structure, bonding, and chemistry of various inorganic cluster and cage compounds, including boranes, heteroboranes, carboranes, and metal clusters.	**CO 5**	1	0	0	0	0	0
CO 6	Study the chemistry of metal clusters using concepts like electron count, metal-metal bonding, and the isolobal analogy. Explore inorganic ring and chain compounds, including silicates, polysilicates, phosphazenes, and polyanionic and polycationic compounds.	**CO 6**	1	0	0	0	0	0
CO 7	Explain the structures and mechanisms of biological oxygen carriers such as hemoglobin, myoglobin, hemerythrene, and hemocyanin..	**CO 7**	**1**	0	0	0	0	0
CO 8	Explore the activation of oxygen in biological systems, focusing on enzymes like mono-oxygenases and oxidases..	**CO 8**	**1**	0	0	0	0	0

Subject: Chemistry

Course Name: **Organic Chemistry**

Course Code: 23BPCH2T02

	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Discuss the generation and alkylation of carbon nucleophiles, including carbanions, dianions, enolates, enamines, and imines. Explore medium effects, the role of oxygen versus carbon as the alkylation site, and the alkylation.	**CO 1**	1	0	0	0	1	0
CO 2	Analyze the mechanisms of acid and base-catalyzed aldol condensations, the Mannich reaction, Knoevenagel reaction, and intramolecular aldol reactions.	**CO 2**	1	0	0	0	1	0
CO 3	Understand and apply key organic reactions such as Baylis-Hilman, McMurry Coupling	**CO 3**	1	0	0	0	1	0
CO 4	Analyze and explain various anionic rearrangements, including the Brook, Neber, Wittig, Gabriel–Colman, and Payne reactions.	**CO 4**	1	0	0	0	1	0
CO 5	Understand the formation of molecular orbitals (σ and π) using the LCAO method, and the concept of nodal planes and energy levels in π-MOs.	**CO 5**	1	0	0	1	1	0

C6	Explore the principles and applications of UV and IR spectroscopy for analyzing organic compounds.	**CO 6**	1	0	0	0	1	0
CO 7	Understand the principles and applications of proton NMR and 13C NMR spectroscopy, including factors affecting chemical shifts and spin-spin coupling	**CO 7**	1	0	0	0	1	0
CO 8	Apply mass spectrometry principles, including molecular ion peaks, fragmentation patterns, and isotopic abundance to determine molecular formulas. Use combined NMR and mass spectrometry data to deduce the structure of organic compounds	**CO 8**	1	0	0	0	1	0

Subject: Chemistry

Course Name: **Analytical Chemistry**

Course Code: 23BPCH2T03

	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Classify different chromatographic techniques.	**CO 1**	1	0	0	0	1	0
CO 2	Discuss chromatography by using plate and rate theory.	**CO 2**	1	0	0	0	1	0
CO 3	Understand use of GC, HPLC techniques and selection of columns.	**CO 3**	1	0	0	0	1	0
CO 4	Apply theory, instrumentation and applications of X-ray, Mass spectroscopy and Radioanalytical techniques.	**CO 4**	1	0	0	0	1	0
CO 5	Elaborate the basic principle, instrumentation and applications of Atomic spectroscopy based on plasma sources.	**CO 5**	1	0	0	0	1	0
CO 6	Understand the theory and operating principles of different surface analytical techniques of SEM, TEM, STM, ESCA and Auger.	**CO 6**	1	0	0	0	1	0
CO 7	Apply Electroanalytical techniques like Ion selective potentiometry.	**CO 7**	1	0	0	0	1	0
CO 8	Discuss the Polarography, Electrogravimetry and Coulometry.	**CO 8**	1	0	0	0	1	0

Subject: Chemistry								
Course Name: **Polymer Chemistry**								
Course Code: 23BPCH2T04								
	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Understand the mechanisms and kinetics of different polymerization processes, including step-growth, radical chain growth, ionic chain (cationic and anionic), and coordination polymerizations.	**CO 1**	1	0	0	0	1	0
CO 2	Study the physical, thermal, flow, and mechanical properties of various polymers. Learn the preparation, structure, properties, and applications of polymers.	**CO 2**	1	0	0	0	1	0
CO 3	Understand the concept of crystallization and crystallinity in polymers, and the factors affecting crystalline melting points.	**CO 3**	1	0	0	0	1	0
CO 4	Explain different methods for determining the molecular weight of polymers, such as end-group analysis, viscometry, light scattering, and osmotic pressure	**CO 4**	1	0	0	0	1	0

Subject: Chemistry								
Course Name: **Environmental Chemistry**								
Course Code: 23BPCH2T05								
	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Understand the importance of quality control in pharmaceuticals, identify sources of impurities in pharmaceutical chemicals, and apply common methods of assay for the analysis of finished products	**CO 1**	1	0	0	0	1	0

CO 2	Classify common drugs and their therapeutic uses, including analgesics, anthelmintics, antibiotics, anti-inflammatory agents, antimalarials, narcotics, expectorants, sedatives, and vitamins	**CO 2**	1	0	0	0	1	0
CO 3	Understand the causes, effects, and control measures for various types of pollution, including air, water, soil, marine, noise, thermal, and nuclear pollution	**CO 3**	1	0	0	0	1	0
CO 4	Describe the significance of natural resources, including forests, water, minerals, food, energy, and land resources	**CO 4**	1	0	0	0	1	0

Subject: Chemistry

Course Name: **Physical Chemistry**

Course Code: 23BPCH2T06

	Course Outcome		**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**
CO 1	Understand the concepts of fugacity and its determination in real gases. Learn to calculate equilibrium constants for real gases using fugacity, and explore the Gibbs energy, entropy, and enthalpy of mixing.	**CO 1**	1	0	0	0	1	0
CO 2	Explain the thermodynamics of surfaces, including the pressure difference across curved surfaces, vapor pressure of droplets, and key isotherms such as Gibbs adsorption and BET.	**CO 2**	1	0	0	0	1	0
CO 3	Understand the kinetics of enzyme-catalyzed reactions, including the Michaelis-Menten model and various graphical analyses such as Lineweaver-Burk and Eadie analyses.	**CO 3**	1	0	0	0	1	0
CO 4	Describe the kinetics of reactions in the solid state, understanding factors affecting reaction rates and applying various rate laws.	**CO 4**	1	0	0	0	1	0

Credit Distribution Structure

VPM's B.N. Bandodkar College of Science (Autonomous), Thane

M.Sc.-I (Level 6.0) Structure of Programme

SEMESTER 1			
Course Code	**Course Title**	**No. of lectures in Hrs.**	**Credits**
I] Mandatory 3*4+2 =14			**14**
23BPCH1T01	Inorganic Chemistry	**60**	4
23BPCH1T02	Organic Chemistry	**60**	4
23BPCH1T03	Analytical Chemistry	**60**	4
23BPCH1P01	Chemistry Practical -1 (Organic Chemistry + Analytical Chemistry)	**60**	2
II] Electives (2+2) **Note: Select Any One subject among the electives given below**			**4**
23BPCH1T04	**Green Chemistry and Catalyst Chemistry**	**30**	2
23BPCH1P02	**Practical**	**60**	2
OR			
23BPCH1T05	**Analytical Biochemistry**	**30**	2
23BPCH1P03	**Practical**	**60**	2
OR			
23BPCH1T06	**Physical Chemistry**	**30**	2
23BPCH1P04	**Practical** (Inorganic Chemistry + Physical Chemistry)	**60**	2
III] Research Methodology			**4**
23BPRM1T01	Research Methodology	**60**	4
		Total	**22**

Credit Distribution Structure

SEMESTER II			
Course Code	**Course Title**	**No. of lectures in Hrs.**	**Credits**
I] Mandatory 3*4+2 =14			**14**
23BPCH2T01	Inorganic Chemistry	**60**	4
23BPCH2T02	Organic Chemistry	**60**	4
23BPCH2T03	Chemistry Analytical	**60**	4
23BPCH2P01	Chemistry Practical -1 (Organic Chemistry + Analytical Chemistry)	**60**	2
II] Electives (2+2) **Note: Select Any One subject among the electives given below**			**4**
23BPCH2T04	**Polymer Chemistry**	**30**	2
23BPCH2P02	**Practical**	**60**	2
OR			
23BPCH2T05	**Environmental Chemistry**	**30**	2
23BPCH2P03	**Practical**	**60**	2
OR			
23BPCH2T06	**Physical Chemistry**	**30**	2
23BPCH2P04	**Practical** (Inorganic Chemistry + Physical Chemistry)	**60**	2
	III] ON JOB TRAINING OR FIELD PROJECT		**4**
23BPCH2P05	**ON JOB TRAINING OR FIELD PROJECT**	**120**	4
		Total	**22**

Semester I

Mandatory Courses

23BPCH 1T01	Course Title Inorganic Chemistry	Credits 4	No. of lectures in hrs.

Aim and objective

The curriculum for inorganic chemistry is framed in such a manner that students are able to prepare and appear for various Competitive exams such as NET/SET/GATE. The paper is exploring application of molecular orbital theory in Chemical bonding, use of molecular symmetry in molecular structure determination. To have basic understanding and knowledge of material synthesis the Nonmaterial's and nanotechnology have been introduced to enable students to determine their career path in research institution and Chemical Industries. Nanomaterials and nanotechnology are the expanding branches of inorganic chemistry that promise advances in sensing and catalysis also. To make characterization of material easier the course offers to learn different techniques like IR, ESR NMR etc.

Course Learning Outcome:

After successful completion of the course, the learner will be able to:

1) Describe hybridization, involvement of d orbitals in various types pf hybridization, critical analysis of VBT.
2) Recognize MOT for diatomic species, polyatomic species considering σ bonding.
3) Illustrate Symmetry criterion of optical activity, Concepts of Groups, Sub-groups.
4) Discuss Representation of Groups, Applications of group theory.
5) Describe Electronic structure of solids and band theory, Structures of Compounds of the type: AB, AB_2.
6) Describe Methods of preparation for inorganic solids, nanomaterials.
7) Discuss characterization of co-ordination compounds by using different spectroscopic methods.
8) Illustrate Spectral calculations, calculation of electronic parameters, Determination of formation constants of metal complexes.

Unit I	**Chemical Bonding:** **1.1 Recapitulation of hybridization** Derivation of wave functions for *sp*, sp^2, *sp3* orbital hybridization types considering only sigma bonding. **1.2** Discussion of involvement of *d* orbitals in various types of hybridizations. Concept of resonance, resonance energy derivation expected. Formal charge with examples. **1.3** Critical analysis of VBT. **1.4** Molecular Orbital Theory for diatomic species of First transition Series.	**[15L]**

	1.5 Molecular Orbital Theory for Polyatomic species considering σ bonding for SF_6, CO_2, B_2H_6, I_3^- molecular species. **1.6** Weak forces of attraction: Hydrogen bonding – concept, types, properties, methods of detection and importance. Van der Waal‟s forces, ion-dipole, dipole-dipole, London forces.	

Unit II	**Molecular Symmetry and Group Theory:** **2.1.** Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules. **2.2.** Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups. **2.3.** Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C_2v, C_3v and D_{2h}, structure of character tables. **2.4.** Applications of Group Theory **(a)** Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in AB_n (Ammonia, CH_4) molecule. **(b)** Determination of symmetry species for translations and rotations. **(c)** Mulliken"s notations for irreducible representations. **(d)** Reduction of reducible representations using reduction formula. **(e)** Group-subgroup relationships. **(f)** Descent and ascent in symmetry correlation diagrams showing relationship between different groups.	**[15L]**
Unit III	**Materials Chemistry and Nanomaterials:** **Solid State Chemistry** **3.1.1.** Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones. **3.1.2.** Structures of Compounds of the type: AB [nickel arsenide (NiAs)], AB_2 [fluorite (CaF_2) and anti-fluorite structures, rutile (TiO_2) structure and layer structure [cadmium chloride and iodide ($CdCl_2$, CdI_2)]. **3.1.3.** Methods of preparation for inorganic solids: Ceramic method, precursor method, sol-gel method (applications in Biosensors), microwave synthesis (discussion on principles, examples, merits and demerits are expected) **3.2 Nanomaterials** **3.2.1.** Preparative methods: Chemical methods, Solvothermal, Combustion synthesis, Microwave, Co-precipitation, Langmuir Blodgett(L-B) method, Biological methods: Synthesis using microorganisms. **3.2.2.** Applications in the field of semiconductors, solar cells	**[15L]**

Unit IV	**Characterization of Coordination compounds** **4.1.** Formation, thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic methods. **4.2.** Spectral calculations using Orgel and Tanabe-Sugano diagram, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio. **4.3.** Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectral methods.	
	REFERENCES:	
	1. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014. **2.** W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993. **3.** B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015. **4.** C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2nd Edition 2005. **5.** J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry– Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993. **6.** P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967. **7.** R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989. **8.** G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004. **9.** R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001. **10.** C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985. **11.** J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978. **12.** G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997. **Unit II** **1.** F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd., 1989. **2.** H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1996. **3.** R. L. Carter, Molecular Symmetry and Group Theory, John Wiley &	

Sons, New York, 1998.

4. K. V. Reddy. Symmetry and Spectroscopy of Molecules, 2nd Edition, New Age International Publishers, New Delhi, 2009.
5. A. Salahuddin Kunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2012.
6. P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House. 2014.
7. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.

Unit III

1. Solid State Chemistry Introduction, Lesley E. Smart, Elaine A. Moore, ISBN 0-203- 49635-3, Taylor & Francis Group, LLC.
2. Nanomaterials & Nanochemistry, 2007, Catherine Brechignac, Philippe Houdy, Marcel Lahmani, ISBN 978-3-540-72992-1 Springer Berlin Heidelberg New York.
3. Nanomaterials Chemistry, Recent Developments and New Directions C.N.R. Rao, Muller, and A.K. Cheetham, ISBN 978-3-527-31664-9, 2007 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.
4. Nano-Surface Chemistry, 2001, Morton Rosoff, ISBN: 0-8247-0254-9, Marcel Dekker Inc. New York.
5. The Chemistry of Nanomaterials, CNR Rao, Muller Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.
6. Semiconductor Nanomaterials, Challa S.S.R. Kumar, ISBN: 978-3-527-32166-7, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010.

Unit IV

1. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006.
2. D. Banerjea ,Coordination Chemistry
3. Geary Coordination reviews
4. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, 2006.
5. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999,
6. B. Douglas, D. McDaniel and J. Alexander. *Concepts and Models of Inorganic Chemistry*(3rd edn.), John Wiley & Sons (1994).

23BPCH1T 02	**Course Title** Organic Chemistry	**Credits** **4**	**No. of lectures in hrs.**

Aim and objective

The syllabus is designed in such a manner that students gets trained with a detailed knowledge base in Chemistry of potential utility in academia as well as Industry through advanced course work and laboratory work in the department and a project work in industries or premier institutions. It is the study of the structure, properties, composition, reactions mechanism action, and preparation of carbon-containing compounds.

Course Learning Outcome: After successful completion of the course, the learner will be able to:

1) Illustrate the thermodynamic and kinetic requirements of reaction.
2) Determine mechanism of a reaction, describe acids and bases.
3) Discuss nucleophilic substitution reactions.
4) Describe the concept of aromaticity.
5) Elaborate concept of chirality, molecules with two or more chiral centers, molecules with tri- and tetra- coordinate centers.
6) Elucidate axial and planar chirality and prochirality.
7) Discuss the concept of oxidation and oxidation of various functional groups.
8) Describe the concept of reduction and reduction of various of various functional groups.

Unit I	**Physical Organic Chemistry:** **1.1. Thermodynamic and kinetic requirements of a reaction:** rate and equilibrium constants, reaction coordinate diagram, transition state (activated complex), nature of activated complex, Hammond postulate, Reactivity *vs* selectivity, Curtin-Hammett Principle, Microscopic reversibility, Kinetic *vs* thermodynamic control of organic reactions. **1.2. Determining mechanism of a reaction:** Product analysis, kinetic studies, use of isotopes (Kinetic isotope effect – primary and secondary kinetic isotope effect). Detection and trapping of intermediates, crossover experiments and stereochemical evidence. **1.3. Acids and Bases:** Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity and solvation. Comparative study of acidity and basicity of organic compounds on the basis of pKa values, Leveling effect and non-aqueous solvents. Acid and base catalysis – general and specific catalysis with examples. *[Reference Books: 1, 2, 3, 16]*	**[15L]**

Unit II	**Nucleophilic substitution reactions and Aromaticity** **2.1. Nucleophilic substitution reactions: (9 L)** 2.1.1. **Aliphatic nucleophilic substitution:** S_N1, S_N2, S_N^i reactions, mixed S_N1 and S_N2 and SET mechanisms. S_N reactions involving NGP - participation by aryl rings, α- and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. S_NcA, S_N1‟ and S_N2‟ reactions. S_N at sp^2 (vinylic) carbon. 2.1.2. **Aromatic nucleophilic substitution:** S_NAr, S_N1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. 2.1.3. **Ester hydrolysis:** Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples. **2.2. Aromaticity: (6 L)** 2.2.1. Structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity. 2.2.2. Application of HMO theory to monocyclic conjugated systems. Frost-Musulin diagrams. Huckel‟s (4n+2) and 4n rules. 2.2.3. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C_{60}). [Reference Books: 4-15]	**[15L]**
Unit III	**STEREOCHEMISTRY:** **Concept of Chirality:** Recognition of symmetry elements. **3.2. Molecules with tri- and tetra-coordinate centers:** Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centers, relative configurational stabilities. **3.3. Molecules with two or more chiral centers:** Constitutionally unsymmetrical molecules: erythro-threo and syn-anti systems of nomenclature. Interconversion of Fischer, Sawhorse, Newman and Flying wedge projections. Constitutionally symmetrical molecules with odd and even number of chiral centers: enantiomeric and meso forms, concept of stereogenic, chirotopic, and pseudoasymmetric centres. R-S nomenclature for chiral centres in acyclic and cyclic compounds. **3.4. Axial and planar chirality:** Principles of axial and planar chirality. Stereochemical features and configurational descriptors (R, S) for the following classes of compounds: allenes, alkylidene	**[15L]**

	cycloalkanes, spirans, biaryls (buttressing effect) (including BINOLs and BINAPs), ansa compounds, cyclophanes, trans-cyclooctenes. **3.5. Prochirality:** Chiral and prochiral centres; prochiral axis and prochiral plane. Homotopic, heterotopic (enantiotopic and diastereotopic) ligands and faces. Identification using substitution and symmetry criteria. Nomenclature of stereoheterotopic ligands and faces. Symbols for stereoheterotopic ligands in molecules with i) one or more prochiral centres ii) a chiral as well as a prochiral centre, iii) a prochiral axis iv) a prochiral plane v) pro-pseudoasymmetric centre. Symbols for enantiotopic and diastereotopic faces. [Reference Books: 6-8]	
Unit IV	**Oxidation and Reduction:** **4.1. Oxidation:** General mechanism, selectivity, and important applications of the following: **4.1.1. Dehydrogenation:** Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ). **4.1.2. Oxidation of alcohols to aldehydes and ketones:** Chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-pyridine (Collin"s reagent), PCC (Corey"s reagent) and PDC (Cornforth reagent), hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation), Corey-Kim oxidation - advantages over Swern and limitations; and Pfitzner-Moffatt oxidation-DCC and DMSO and Oppenauer oxidation. **4.1.3. Oxidation involving C-C bonds cleavage:** Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using ozone, $KMnO_4$, CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$. **4.1.4. Oxidation involving replacement of hydrogen by oxygen:** oxidation of CH_2 to CO by SeO_2, oxidation of arylmethanes by CrO_2Cl_2 (Etard oxidation). **4.1.5. Oxidation of aldehydes and ketones:** with H_2O_2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) **4.2.Reduction:** General mechanism, selectivity, and important applications of the following reducing reagents: **4.2.1. Reduction of CO to CH_2 in aldehydes and ketones-** Clemmensen reduction, Wolff- Kishner reduction and Huang-Minlon modification. **4.2.2. Metal hydride reduction:** Boron reagents ($NaBH_4$, $NaCNBH_3$, diborane, 9-BBN, $Na(OAc)_3BH$, aluminium reagents ($LiAlH_4$, DIBAL-H, Red Al, L and K- selectrides). **4.2.3.** NH_2NH_2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzsch dihydropyridine). **4.2.4. Dissolving metal reductions:** using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3	[15L]

	mediated reduction (Birch reduction) of aromatic compounds and acetylenes. [Reference Books: 17, 18, 14]	
	REFERENCES:	
	1. Physical Organic Chemistry, Neil Isaacs **2.** Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty **3.** Comprehensive Organic chemistry, Barton and Ollis, Vol 1 **4.** Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press. **5.** Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press. **6.** Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi. **7.** Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley. **8.** Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd. **9.** March‟s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley. **10.** Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education. **11.** Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press. **12.** Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press. **13.** Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press. **14.** Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes. **15.** Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education. **16.** Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards. **17.** Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press. **18.** Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan	

23BPCH1T 03	Course Title **Analytical Chemistry**	Credits 4	No. of lectures in hrs.

Aim and objective

Analytical chemistry deals with the both quantitative and qualitative aspects of real samples. As analytical chemists, the students should be familiar with the fundamental terms and procedures of analytical chemistry. This course focuses terms on basic quality systems, quality audit, quality management, and laboratory staff roles, duties and understanding of different concentration units. Types of instruments its components and working, fiber optics, Fourier transform techniques. It also covers analytical methods and their classification. The fundamental theories, equipment, and applications of GC, HPLC, Partition Chromatography, IR, and UV-Visible Spectroscopy, thermal methods were also covered throughout the course.

Outcome

1) Discuss language of analytical chemistry.
2) Describe quality in analytical chemistry.
3) Solve the numerical based on Concentration of a solution, Calculations of ppm, ppb and dilution of the solutions, concept of mmol.
4) Determine the pH, concept of formation constant, oxidation number, stoichiometry of redox titration.
5) Explain FTIR, Molecular Ultraviolet and Visible Spectroscopy.
6) Illustrate Infrared Absorption Spectroscopy.
7) Discuss the thermal methods, comparison between TGA and DTA., Differential Scanning Calorimetry.
8) Elaborate the applications of different thermodynamic parameters, Automation in chemical analysis.

Unit I	**Language of Analytical Chemistry [8 L]** **1.1.1** Analytical perspective, Common analytical problems, terms involved in analytical chemistry (analysis, determination, measurement, techniques, methods, procedures and protocol) **1.1.2** An overview of analytical methods, types of instrumental methods, instruments for analysis, data domains, electrical and non-electrical domains, detectors, transducers and sensors, selection of an analytical method, accuracy, precision, selectivity, sensitivity, detection limit and dynamic range. **1.1.3** Errors, determinate and indeterminate errors. Types of determinate errors, tackling of errors. **1.1.4** Quantitative	**[15L]**

	methods of analysis: calibration curve, standard addition and internal standard method. **Quality in Analytical Chemistry: [7 L]** **1.2.1 Quality Management System (QMS):** Evolution and significance of Quality Management, types of quality standards for laboratories, total quality management (TQM), philosophy implementation of TQM (reference of Kaizen, Six Sigma approach & 5S), quality audits and quality reviews, responsibility of laboratory staff for quality and problems. **1.2.2 Safety in Laboratories**: Basic concepts of Safety in Laboratories, Personal Protection Equipment (PPE), OSHA, Toxic Hazard (TH) classifications, Hazardous Chemical Processes (including process calorimetry / thermal build up concepts). **1.2.3 Accreditations:** Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark) **1.2.4 Good Laboratory Practices (GLP)** Principle, Objective, OECD guidelines, The US FDA 21CFR58, Klimisch score	
Unit II	**Calculations based on Chemical Principles [15 L]** **The following topics are to be covered in the form of numerical problems only.** **a)** Concentration of a solution based on volume and mass units. **b)** Calculations of ppm, ppb and dilution of the solutions, concept of mmol. **c)** Stoichiometry of chemical reactions, concept of kg mol, limiting reactant, theoretical and practical yield. **d)** Solubility and solubility equilibria, effect of presence of common ion. **e)** Calculations of pH of acids, bases, acidic and basic buffers. **f)** Concept of formation constants, stability and instability constants, stepwise formation constants. **g)** Oxidation number, rules for assigning oxidation number, redox reaction in term of oxidation number, oxidizing and reducing agents, equivalent weight of oxidizing and reducing agents, stoichiometry of redox titration (Normality of a solution of a oxidizing / reducing agent and its relationship with molarity).	**[15L]**

Unit III	**Unit III** **Optical Methods[15 L]** **3.1 Recapitulation and FT Technique [3 L]** **3.1.1** Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers. **3.1.2** Laser as a source of radiation, Fibre optics **3.1.3** Introduction of Fourier Transform **3.2 Molecular Ultraviolet and Visible Spectroscopy [6 L]** **NUMERICALS ARE EXPECTED** **3.2.1** Derivation of Beer- Lambert‟s Law and its limitations, factors affecting molecular absorption, types of transitions [emphasis on charge transfer absorption], pH, temperature, solvent and effect of substituents. Applications of Ultraviolet and Visible spectroscopy: **1)** On charge transfer absorption **2)** Simultaneous spectroscopy **3)** Derivative Spectroscopy **3.2.2** Dual spectrometry – Introduction, Principle, Instrumentation and Applications **3.3 Infrared Absorption Spectroscopy [6 L]** **3.3.1** Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument**05 L** **3.3.2** FTIR and its advantages **3.3.3** Applications of IR [Mid IR, Near IR, Far IR]: Qualitative with emphasis on “Finger print” region, Quantitative analysis, Advantages and Limitations of IR **3.3.4** Introduction and basic principles of diffuse reflectance spectroscopy.	**[15L]**
Unit IV	**4.1 Thermal Methods: [9 L]** **4.1.1 Introduction,** Recapitulation of types of thermal methods, comparison between TGA and DTA. **4.1.2 Differential Scanning Calorimetry-** Principle, comparison of DTA and DSC, Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting curves (sample size, sample shape, pressure). **4.1.3 Applications -** Heat of reaction, Specific heat, Safety screening, Polymers, liquid crystals, Percentage cystallinity, oxidative stability, Drug analysis, Magnetic transition. e.g. Analysis of Polyethylene for its crystallinity. **4.2 Automation in chemical analysis: [6 L]** Need for automation, Objectives of automation, An overview of	

	automated instruments and instrumentation, process control analysis, flow injection analysis, discrete automated systems, automatic analysis based on multilayered films, gas monitoring equipment's, Automatic titrators.	
	REFERENCES:	
	1. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education **2.** Principles of Instrumental Analysis-Skoog, Holler and Nieman, 5th Edition, Ch: 1. **3.** Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004, Ch: 5. **4.** Undergraduate Instrumental Analysis, 6th Edition, J W Robinson, Marcel Dekker, Ch:1. **5.** ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Chapter: 3 & 4) **6.** Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, Ch: 5, Ch: 6 &Ch: 7. **7.** Quality Management, Donna C S Summers, Prentice-Hall of India, Ch:3. **8.** Quality in Totality: A Manager‟s Guide To TQM and ISO 9000, ParagDiwan, Deep &Deep Publications, 1st Edition, 2000. **9.** Quality Control and Total Quality Management - P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5. **10.** Industrial Hygiene and Chemical Safety,M.HFulekar,Ch:9,Ch:11& Ch:15. **11.** Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher, Ch:4, Ch:5 & Ch:19. **12.** Staff, World Health Organization (2009) Handbook: Good Laboratory Practice (GLP) **13.** OECD Principles of Good Laboratory Practice (as revised in 1997)". OECD Environmental Health and Safety Publications. OECD. **1**. 1998. **14.** Klimisch, HJ; Andreae, M; Tillmann, U (1997). "A systematic approach for evaluating the quality of experimental toxicological and eco-toxicological data". doi:10.1006/rtph.1996.1076. PMID 9056496. **Unit II** **1.** 3000 solved problems in chemistry, Schaums Solved problem series, David E. Goldbers, Mc Graw Hill international Editions, Chapter 11,15,16,21,22 **Unit III** **1.** D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5th Edition, Harcourt Asia Publisher. Chapter 6, 7. **2.** H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6 th Edition, CBS Publisher. Chapter 2. **3.** R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 8.	

4. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5 th Edition, Harcourt Asia Publisher. Chapter 13, 14.
5. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6 th Edition, CBS Publisher. Chapter 2.
6. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 5.
7. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5 th Edition, McGraw Hill Publisher, Chapter 3.
8. M. Ito, The effect of temperature on ultraviolet absorption spectra and its relation to hydrogen bonding, J. Mol. Spectrosc.4 (1960)106- 24.
9. A. J. Somnessa, The effect of temperature on the visible absorption band of iodine inseveral solvents, Spectrochim. Acta. Part A: Molecular Spectroscopy, 33 (1977) 525- 528.
10. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5 th Edition, Harcourt Asia Publisher. Chapter 16, 17.
11. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 12
12. Z. M. Khoshhesab (2012). Infrared Spectroscopy- Materials Science, Engineering and Technology. Prof. Theophanides Theophile (Ed.). ISBN: 978-953- 51-0537- 4, InTech,(open access)

Unit IV

1. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. Graw Hill (1987): Chapter 27
2. Thermal Analysis-theory and applications by R. T. Sane, Ghadge, Quest Publications
3. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 25
4. Instrumental Analysis, 5 th Edition, Skoog, Holler and Nieman: Chapter 31
5. Quantitative Chemical Analysis, 6 th Edition, Vogel: Chapter 12
6. Analytical Chemistry by Open Learning: Thermal Methods by James W. Dodd & Kenneth H. Tonge
7. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 26
8. Instrumental Analysis, 5th Edition, Skoog, Holler and Nieman: Chapter 33
9. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. GrawHill (1987): Chapter 28

23BPCH1P01	Course Title **Organic Chemistry + Analytical Chemistry**	Credits 2	No. of lectures in hrs.

Course Outcomes:

1 To enhance skills in the various reaction preparations

2 To understand Planning of organic synthesis,

3. To understand chemical structure, reactivity and physical properties.

Unit I — **[15L]**

Organic Chemistry Practical (Any Four)

One-step preparation (1.0 g scale)

1. Bromobenzene to p-nitrobromobenzene
2. Anthracene to anthraquinone
3. Benzoin to benzil
4. *o*-Phenylenediamine to 2-methylbenzimidazole
5. 2-Naphthol to BINOL
6. p-Benzoquinone to 1,2,4-triacetoxybenzene
7. Ethyl acetoacetate to 3-methyl-1-phenyl pyrazole-5-one
8. Urea and benzil to 5,5-diphenylhydantoin

Learning points:

1. Planning of synthesis, the effect of reaction parameters including stoichiometry, and safety aspects including MSDS should be learnt.
2. Purify the product by crystallization. Formation and purity of the product should be checked by TLC
3. Report the mass and melting point of the purified product.

Unit II — **[15L]**

Analytical Chemistry Practical (Any Four)

1. To carry out an assay of the sodium chloride injection by Volhard's method. Statistical method.
2. To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.
3. To determine the breakthrough capacity of a cation exchange resin.
4. To determine number of nitro groups in the given compound using $TiCl_3$.
5. To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.
6. To determine the lead and tin content of a solder alloy by titration with EDTA.
7. To determine amount of Cu(II) present in the given solution

	containing a mixture of Cu(II) and Fe(II).	
	REFERENCES:	
Unit I	**1.** Experimental Organic Chemistry for Postgraduate (ISST)Mumbai **2.** Systematic Qualitative organic analysis, H. Middleton (Orient Longman) **3.** A Handbook of Organic Analysis, H.T. Clark (Orient Longman) **4.** Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York) **5.** Practical Organic Chemistry by Mann and Saunders. **6.** Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication	
Unit II	**1.** Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964) **2.** Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, Thomas, Pearson education **3.** Standard methods of chemical analysis, F. J. Welcher **4.** Standard Instrumental Methods of Chemical Analysis, F. J. Welcher **5.** W.W.Scott."Standard methods of Chemical Analysis", Vol.I,Van Nostrand Company, Inc.,1939. **6.** E.B.Sandell and H.Onishi, "Spectrophotometric Determination of Traces of Metals", Part- II,4th Ed.,A Wiley Interscience Publication, New York,1978.	

Semester I

II] ELECTIVES COURSES

23BPCH1T04	Course Title Green Chemistry and Catalyst Chemistry	Credits 2	No. of lectures in hrs.
Course Outcomes: Upon completion of this course, students will acquire knowledge about and be able to – **After successful completion of the course, the learner will be able to:** **1** Discuss 12 principles of green chemistry, green catalysts . **2** Describe synthesis, structure determination, uses of zeolites, catalysts in fine chemicals and pharmaceutical industries **3** Explain green synthesis of industrially important molecules. **4** Illustrate microwave assisted reactions in water..			
Unit I	**Green Chemistry and Catalyst** **Principles and Concepts of Green Chemistry:** Sustainable development and green chemistry, Atom economy, examples of atom economic and atom un-economic reactions, reducing toxicity. Comparison of catalyst types, heterogeneous catalysts, zeolites composition and structures, synthesis of zeolites, structure determination, uses of zeolites, zeolites as catalyst, zeolites and the bulk chemical industry, catalysts in fine chemicals and pharmaceutical industries		**[15L]**
Unit II	**Examples of Green Synthesis/ Reactions and some real world cases** **Green Synthesis of the following compounds:** Adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis) **Microwave assisted reactions in water:** Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction		**[15L]**

	REFERENCES: **1** Anastas, P.T. & Warner, J.K.: Green Chemistry - Theory and Practical, Oxford University Press (1998). **2** Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001). Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000). **3** Ryan, M.A. & Tinnesand, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002). **4** Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition, 2010. **5** Kirchoff, M. & Ryan, M.A. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002). **6** Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013). **7** Cann, M. C. & Thomas, P. Real world cases in Green Chemistry, American Chemical Society (2008). Lancaster, M. Green Chemistry:	

	An Introductory Text RSC Publishing, 2nd Edition, 2010. **8** Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach, W.B.Saunders, 1995.	

23BPCH1P02	**Course Title** **Practical Green Chemistry and Catalyst Chemistry**	**Credits 2**	**No. of lectures in hrs.**

PRACTICALS Preparation & Characterization

1. **Biodiesel -** Preparation
2. **Soap -** Preparation & Characterization
3. **Cosmetics -** Lipstick making
4. **Atom economy** -Traditional & green synthesis comparison
5. **Pesticide -** mode of action
6. **Polyme**r - Synthesis & mol. wt. determination
7. **Food -** Adulteration drinking (milk)
8. **Drug -** Indian pharmacopeia procedure for analysis (Ape)
9. **Water -** Drinking water parameters
10. Noise pollution testing
11. Industrial waste water Analysis.

References

1. Biodiesel production Feedstacks , catalyst and technology 2022 by Samuel Wiley publication ISBN:978-1-119-77133-3
2. The handbook of Soap manufacture 2007 by H.A. Appleton,W.H. Simmons
3. Surface Sciences and Adhesion Cosmetics 2021 by K.L Mittal, H.S.Bui
4. Green Processes,by Chao-Jun Li, Paul T. AnastasVolume 7Green Synthesis ISBN:9783527688494
5. Polymer Synthesis and Characterization A Laboratory Manual By Stanley R. Sandler, Wolf Karo, JoAnne Bonesteel, Eli M. Pearce · 1998
6. Food & Beverage Adulteration and Its Implications Theory & Practice By Gajanan Shirke · 2022 Notion Press and shroff publishiners
7. Handbook of Pharmaceutical Excipients By American Pharmacists Association · 2009 Paul J. Sheskey, Raymond C. Rowe 9781582121352
8. Advanced Air and Noise Pollution Control by Lawrence K. Wang, Norman C. Pereira, Yung-Tse Hung Volume 2 2005 SBN:9781592597796
9. Industrial Wastewater Treatment, Recycling and Reuse By Vivek V. Ranade, Vinay M Bhandari · 2014 ISBN:9780444634030 published by Elsevier Science

Course Code 23BPCH1T05	Course Title (Elective Chemistry- Analytical Biochemistry)	Credits 2	No. of lectures in hrs.
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to - 1. Understand metabolic pathways, including glycolysis, fermentation, and the Krebs cycle, along with the role of ATP. Analyze the structure, classification, and biological significance of proteins, lipids, and polysaccharides. **2.** Explain enzyme classification, mechanisms, and regulation, including coenzymes, cofactors, and inhibitors. Evaluate the biochemical functions of lipids, lipoproteins, and hormones in cellular and physiological processes. 3. Understand the composition and functions of blood, the process of coagulation, and methods for blood collection and preservation. Analyze and interpret biochemical parameters such as blood sugar, urea, creatinine, cholesterol, and bilirubin in health and disease. 4. Explain the process of urine formation and its composition. Perform the collection, preservation, and biochemical analysis of normal and pathological urine samples to assess physiological and clinical conditions.			
Unit I	**1. Carbohydrates:** Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Isolation and characterization of polysaccharides. **2. Proteins:** Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins. **3. Lipids:** Classification. Biological importance of triglycerides, phosphoglycerides, and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins. Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones. **4. Enzymes:** Nomenclature, Characteristics (mention of Ribozymes), and Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors.		**[15]**

Unit II	**Biochemistry of disease: A diagnostic approach by blood/ urine analysis.** 1. **Blood:** Composition and functions of blood, blood coagulation. Blood collection and preservation of samples. Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin. 2. **Urine:** Collection and preservation of samples. Formation of urine. Composition and estimation of constituents of normal and pathological urine.	**[15]**

	REFERENCES: **1.** Analytical Biochemistry 3rd Edition by David J. Holme, Hazel Peck Pearson College Div; 3rd edition (1998) ISBN 978-0582294387 **2.** Biochemical Testing Clinical Correlation and Diagnosis 2020 ISBN:9781789850857 published by Intech open UK **3.** Principles of Biochemistry Albert L. Lehninger · 1987 **4.** Biochemistry By Jeremy M. Berg, John Tymoczko, Gregory Gatto, Lubert Stryer · 2019 ISBN:9781319114657 published by Macmillan Learning		
Course Code 23BPCH1P03	**Practical** **(Elective Chemistry- Analytical Biochemistry)**	**Credits 2**	**Lectures in Hrs**
	Identification and estimation of the following: (**Any Six**) **1.** Carbohydrates – qualitative and quantitative. **2.** Lipids – qualitative. **3.** Determination of the iodine number of oil. **4.** Determination of the saponification number of oil. **5.** Determination of cholesterol using Liebermann- Burchard reaction. **6.** Proteins – qualitative. **7.** Isolation of protein. **8.** Determination of protein by the Biuret reaction. **9.** Determination of nucleic acids.		**60**
	References: **1** Cooper, T.G. Tool of Biochemistry. Wiley-Blackwell (1977). **2** Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009). **3** Varley, H., Gowenlock, A.H & Bell, M.: Practical Clinical Biochemistry, Heinemann, London(1980). **4** Devlin, T.M., Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons,2010. **5** Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002. **6** Talwar, G.P. & Srivastava, M. Textbook of Biochemistry and Human Biology, 3rd Ed. PHI Learning. **7** Nelson, D.L. & Cox, M.M. Lehninger Principles of Biochemistry, W.H. Freeman, 2013. **8** O. Mikes, R.A. Chalmers: Laboratory Handbook of Chromatographic Methods, D. Van Nostrand & Co., 1961. **9** BIOCHEMISTRY LABORATORY MANUAL published by Academic publisher, Kolkata ISBN:9789383420674		
OR			
	Apprenticeship/internship/Field project /case studies /on job training		**60 Hrs**

Course Code 23BPCH1T06	Course Title ELECTIVE (Physical Chemistry)	Credits 2	No. of lectures in hrs.
Course Outcomes: • Understand the principles of reaction kinetics, including rate laws, steady-state approximation, and rate-determining steps. Analyze the mechanisms of chain reactions, organic decompositions, and gas-phase combustion, along with explosion limits and their influencing factors. • Examine the kinetics of stepwise and free radical polymerization, including the degree of polymerization and kinetic chain length. Evaluate theories of unimolecular reactions, such as Lindemann-Hinshelwood, RRK, and RRKM, in explaining reaction dynamics • Understand the basics of electrochemistry, including the Debye-Hückel theory, activity coefficients, and the Debye-Hückel limiting law with its extension to higher concentrations through mathematical derivations • Analyze the principles of electrolytic conductance, ionic interactions, and relaxation effects. Derive and evaluate the Debye-Hückel-Onsager equation, its validity for aqueous and non-aqueous solutions, deviations from the Onsager equation, and the Debye-Falkenhagen effect.			
Unit I	**Chemical Dynamics-I** **1.1 Composite Reactions:** Recapitulation: Rate laws, Differential rate equations Consecutive reactions, Steady state Approximation, rate determining steps, Microscopic Reversibility and Detailed Balanced Chain reactions-chain initiation processes. Some inorganic mechanisms: formation and decomposition of phosgene, decomposition of ozone,Reaction between Hydrogen and Bromine and some general examples Organic **Decompositions:** Decomposition of ethane, decomposition of acetaldehyde Gas phase **Combustion:** Reaction between hydrogen and oxygen, Semenov – Hinshelwood and Thompson mechanism, Explosion limits and factors affecting explosion limits. **1.2 Polymerization reactions:** Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization,Kinetic chain length and estimation of average no .of monomer units in the polymer produced by chain polymerization. **1.3 Reaction in Gas Phase** **Unimolecular Reactions**: Lindeman-Hinshelwood theory, Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory. [Ref. 2 and 15, 17, 18]		**[15]**

Unit II	**Electrochemistry [15L]** **Recapitulation –** basics of electrochemistry**.** **2.1** Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and it‟s extension to higher concentration (derivations are expected) **2.2** Electrolytic conductance and ionic interaction, relaxation effect,. Debye-Hückel-Onsager equation (derivation expected). Validity of this equation for aqueous and non- aqueous solution, deviations from Onsager equation, Debye -Falkenhagen effect (dispersion of conductance at high frequencies), Wien effect. **2.3 Batteries:** Alkaline fuel cells, Phosphoric acid fuel cells,	**[15]**

	High temperature fuel cells[Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells] **2.4 Bio-electrochemistry:** Introduction, cells and membranes, membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems, adsorption of proteins onto metals from solution, electron transfer from modified metals to dissolved protein in solution, enzymes as electrodes, electrochemical enzyme-catalysed oxidation of styrene. Goldmann equation. (derivations are expected) [Ref: 14 and 16, 17, 18] [Note: Numerical and theoretical problems from each unit are expected]	
	REFERENCES: **1.** Peter Atkins and Julio de Paula, Atkin‟s Physical Chemistry, 7 th Edn., Oxford University Press, 2002. **2.** K.J. Laidler and J.H. Meiser, Physical Chemistry, 2 nd Ed., CBS Publishers and Distributors, New Delhi, 1999. **3.** Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3 rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002. **4.** Ira R. Levine, Physical Chemistry, 5 th Edn., Tata McGraw-Hill New Delhi, 2002. **5.** G.W. Castellan, Physical Chemistry, 3 rd Edn., Narosa Publishing House, New Delhi,1983. **6.** S. Glasstone, Text Book of Physical Chemistry, 2 nd Edn., McMillan and Co. Ltd.,London, 1962 **7.** B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003. **8.** A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994. **9.** R.K. Prasad, Quantum Chemistry, 2 nd Edn., New Age International Publishers, 2000. **10.** S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi,1964. **11.** W.G. Davis, Introduction to Chemical Thermodynamics – A Non– Calculus Approach, Saunders, Philadelphia, 19772. **12.** Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983. **13.** Ira N. Levine, Quantum Chemistry, 5 th Edn., Pearson Education(Singapore)Pte.Ltd.,IndianBranch,New Delhi, 2000. **14.** Thomas Engel and Philip Reid, Physical Chemistry, 3 rd Edn., Pearson Education Limited 2013. **15.** D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1 st Edn., 1992.	

	16. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998. 17. Physical Chemistry by Gurtu and Gurtu 18. A Text book of Physical Chemistry by K L kapoor Vol 5, 2 nd Edn	
Course Code 23BPCH1P04	**Practical ELECTIVE (Physical Chemistry+ Inorganic Chemistry) Credits 2**	**Lectures in Hrs**
Unit I	1. To determine the mean ionic activity coefficient of an electrolyte by e.m.f.measurement. 2. To study the effect of substituent on the dissociation constant of acetic acid conductometrically. 3. To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode. 4. To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperature. 5. To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of CaSO4 at room temperature.	**60**
Unit II	**Inorganic Preparations (Synthesis and Characterization)** 1) Bis-(tetraethylammonium) tetrachloro Cuprate (II)$(Et_4N)_2[CuCl_4]$ 2) Bis-(tetraethylammonium) tetrachloro Nickelate (II)$(Et_4N)_2[NiCl_4]$ 3) Bis (ethylenediamine) Copper (II) Sulphate $[Cu(en)_2]SO_4$ 4) Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^- system	
	References **UNIT I** 1. Peter Atkins and Julio de Paula, Atkin's Physical Chemistry, 7th Edn., Oxford University Press, 2002. 2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999. 3. Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002. 4. Ira R. Levine, Physical Chemistry, 5th Edn., Tata McGraw-Hill New Delhi, 2002. 5. G.W. Castellan, Physical Chemistry, 3rd Edn., Narosa Publishing House, New Delhi, 1983. 6. S. Glasstone, Text Book of Physical Chemistry, 2nd Edn., McMillan and Co. Ltd., London, 1962	

7. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.
8. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.
9. R.K. Prasad, Quantum Chemistry, 2nd Edn., New Age International Publishers, 2000.
10. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.
11. W.G. Davis, Introduction to Chemical Thermodynamics – A Non– Calculus Approach, Saunders, Philadelphia, 19772.
12. Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.
13. Ira N. Levine, Quantum Chemistry, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
14. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
16. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
17. Physical Chemistry by Gurtu and Gurtu
18. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2nd Edn

Unit II

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur & Sons Pvt Ltd
2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly
3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

23BPRM1 T01	III Course Title Research Methodology	Credits 4	No. of lectures in hrs.

Course Outcomes:

1. Understand and differentiate primary, secondary, and tertiary sources of chemical information. Analyze various print and digital resources, including journals, abstracts, monographs, and online databases, for accessing and evaluating scientific literature.To understand primary, secondary data ,copyrights, patents IPR ,trademarks etc
2. Utilize digital tools, search engines, and electronic resources such as SciFinder, Scopus, and Google Scholar for literature search and citation analysis. Apply information technology and library resources to effectively find, access, and cite published chemical information.
3. Understand the principles of scientific methods, experimental design, and SI unit usage. Develop skills in making and recording accurate measurements while applying an investigative approach to chemical research
4. Apply statistical tools such as descriptive statistics, ANOVA, correlation, regression, and curve fitting for chemical data analysis. Utilize chemometric techniques and multiple linear regression to interpret and present experimental results effectively.
5. Develop skills in reporting practical and project work, conducting literature surveys, writing reviews, and presenting scientific information through posters and oral presentations.
6. Understand the structure and components of scientific papers, including methodology, conclusions, and bibliography. Apply ethical writing practices, avoid plagiarism, and adhere to publication standards in scientific communication.
7. Understand safe working procedures, protective measures, emergency protocols, and first aid in the laboratory. Apply best practices for handling hazardous, flammable, and explosive substances, including gases at varying pressures.
8. Implement proper methods for the storage, disposal, recovery, recycling, and transportation of hazardous chemicals. Follow regulations for waste segregation, disposal in sanitary sewer systems, and incineration while ensuring environmental and workplace safety.

Unit I	**Print: [5L]** Primary, Secondary and Tertiary sources. **Journals:** Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. **Digital: [5L]** Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E- books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki- databases, ChemSpider, Science Direct, SciFinder, Scopus. **Information Technology and Library Resources: [5L]** The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	**[15]**

Unit II	**DATA ANALYSIS [15L]** **The Investigative Approach:** Making and recording Measurements, SI units and their use, Scientific methods and design of experiments. **Analysis and Presentation of Data**: Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.	**[15]**
Unit III	**METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS [15L]** Reporting practical and project work, Writing literature surveys and Reviews, organizing a poster display, giving an oral presentation. **Writing Scientific Papers:** Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of	**[15]**

	Scientific work, writing ethics, avoiding plagiarism.	
Unit IV	**Unit IV: CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS** Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	[15]
	References: 1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), Practical skills in Chemistry, 2 nd Ed., Prentice Hall, Harlow. 2. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press. 3. Topping, J., (1984) Errors of Observation and their Treatment 4 thEd., Chapman Hill, London. 4. Harris, D. C. (2007) Quantative Chemical Analysis 6th Ed., Freeman Chapters 3-5 5. Levie, R. De. (2001) How to use Excel in Analytical Chemistry and in general scientific data analysis Cambridge University Press. 6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press. 7. OSU Safety manual 1.01	

SEMESTER II

Mandatory Courses

23BPCH2 T01	Course Title Inorganic Chemistry	Credits 4	No. of lectures in hrs.

Aim and objective

The paper is exploring the understanding of inorganic reaction mechanism, structure and bonding of organometallic compounds, biological implication of radioactive materials and the role of different metalloproteins in biological processes. To have basic understanding and knowledge of metals with respect to their toxicity and impact on environment and to sensitize students for remediation processes the Environmental chemistry topic is introduced.

Outcome

- Understand the factors affecting reaction rates and techniques for determining the rate of reactions. Analyze ligand substitution reactions in octahedral and square planar complexes, including mechanisms, trans-effects, and the role of isotopic labeling.Acquire skills to tackle the social issues by basic understanding of core topics in Inorganic chemistry
- Study the stereochemical aspects of substitution reactions in octahedral complexes, focusing on isomerization and racemization. Explore the inner and outer sphere mechanisms of redox reactions and their complementary and non-complementary nature.Explore new areas of research in medicinal and biological fields of science and technology
- Understand the principles of the 18-electron and 16-electron rules, along with electron counting methods. Analyze the preparation, properties, and applications of various organometallic complexes, including alkyl, aryl, and alkene derivatives of Pd and Pt, as well as carbenes, carbynes, and other key compounds
- Apply Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) to understand the structure and bonding in organometallic compounds, including Zeise's salt, ferrocene, and other notable complexes like bis(triphenylphosphine)diphenylacetylene platinum(0), diallylnickel(II), and bis(arene)chromium(0).
- Understand the structure, bonding, and chemistry of various inorganic cluster and cage compounds, including boranes, heteroboranes, carboranes, and metal clusters. Analyze electron-precise compounds and their relation to clusters, as well as the concepts of metal-metal bonding and electron counting
- Study the chemistry of metal clusters using concepts like electron count, metal-metal bonding, and the isolobal analogy. Explore inorganic ring and chain compounds, including silicates, polysilicates, phosphazenes, and polyanionic and polycationic compounds.
- Explain the structures and mechanisms of biological oxygen carriers such as hemoglobin, myoglobin, hemerythrene, and hemocyanin. Analyze cooperativity of oxygen binding, pH dependence, and implications in oxygen affinity, as well as the differences between hemoglobin and myoglobin.
- Explore the activation of oxygen in biological systems, focusing on enzymes like mono-oxygenases and oxidases. Study copper-containing enzymes, nitrogen fixation, and metal ion transport, and understand the medicinal applications of cis-platin and related compounds.

Unit I	**Inorganic Reaction Mechanism:** **1.1** Rate of reactions, factors affecting the rate of reactions, techniques for determination of rate of reaction (Direct chemical analysis, spectrophotometric method, electrochemical and flow methods). **1.2** Ligand substitution reactions of: **a)** Octahedral complexes without breaking of metal-ligand bond (Use of isotopic labelling method) **b)** Square planar complexes, trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions. **1.3** Redox reactions: inner and outer sphere mechanisms, complimentary and non- complimentary reactions. **1.4** Stereochemistry of substitution reactions of octahedral complexes. (Isomerization and racemization reactions and applications.)	**[15L]**
Unit II	**Organometallic Chemistry of Transition metals: [15 L]** **2.1.** Eighteen and sixteen electron rule and electron counting with examples. **2.2.** Preparation and properties of the following compounds **(a)** Alkyl and aryl derivatives of Pd and Pt complexes **(b)** Carbenes and carbynes of Cr, Mo and W **(c)** Alkene derivatives of Pd and Pt **(d)** Alkyne derivatives of Pd and Pt	**[15L]** **36**

	(e) Allyl derivatives of nickel **(f)** Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo. 2.3 Structure and bonding on the basis of VBT and MOT in the following organometallic compounds: Zeise‟s salt, bis(triphenylphosphine)diphenylacetylene platinum(0) [$Pt(PPh_3)_2(HC{\equiv}CPh)_2$], diallylnickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl (η^2-butadiene) iron(0).	
Unit III	**3.1. Inorganic cluster and cage compounds** **(i)** Introduction (**ii**) Bonding in boranes (**iii**) Heteroboranes (**iv**) Carboranes (**v**) Cluster compounds (**vi**) Electron precise compounds and their relation to clusters. **3.2. Chemistry** of **Metal clusters** **(a)** Metal-Metal Bonding and Metal Clusters. **(b)** Electron Count and Structures of Clusters. **(c)** Isolobal Analogy. **3.3. Inorganic ring and chain compounds** (a) Silicates, polysilicates and aluminosilicates. (b) Phosphazenes and phosphazene polymers. (c) Polyanionic and polycationic compounds.	**[15L]**
Unit IV	**Bioinorganic Chemistry** 41. Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- structure of metal active center and differences in mechanism of oxygen binding, Differences between hemoglobin and myoglobin: Cooperativity of oxygen binding in hemoglobin and Hill equation, pH dependence of oxygen affinity in hemoglobin and myoglobin and it‟s implications. 42. Activation of oxygen in biological system with examples of mono-oxygenases, and oxidases- structure of the metal center and mechanism of oxygen activation by these enzymes. 43. Copper containing enzymes- superoxide dismutase, tyrosinase and laccase: catalytic reactions and the structures of the metal binding site 44. Nitrogen fixation-nitrogenase, hydrogenases 45. Metal ion transport and storage:Ionophores, transferrin, ferritin and metallothionins 46. Medicinal applications of cis-platin and related compounds	
	References **1.** P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.	

2. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.
3. W. H. Malik, G. D./ Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd.
4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002
6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house, 2012
7. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
8. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.
9. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001.
10. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd Ed., Oxford University Press 2008.

Unit II

1. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.
2. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded, New Age International Pvt Ltd, 2000.
3. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000.
4. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.
5. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd.

Unit III

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
2. W. H. Malik, G. D./ Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd.
3. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
4. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002
5. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house, 2012
6. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.

	7. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967. **8.** R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001. **Unit IV** **1.** R. W. Hay, *Bioinorganic Chemistry*, Ellis Harwood, England, 1984. **2.** I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First South Indian Edition, Viva Books, New Delhi, 1998. **3.** J. A. Cowan, *Inorganic Biochemistry-An introduction*, VCH Publication, 1993. **4.** S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Publications, Mill Valley, Caligronic, 1994. **5.** G.N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri & Sons, Calcutta, 1988. **6.** J.Chem. Educ. (Special issue), Nov, 1985. **7.** E.Frienden, J.Chem. Educ., 1985, 62. **8.** Robert R.Crechton, Biological Inorganic Chemistry – An Introduction, Elsevier **9.** J. R. Frausto da Silva and R. J. P. Williams *The Biological Chemistry of the Elements*, Clarendon Press, Oxford, 1991. **10.** JM. D. Yudkin and R. E. Offord *A Guidebook to Biochemistry*, Cambridge University Press, 1980.	

23BPCH2T 02	Course Title **Organic Chemistry**	Credits 4	No. of lectures in hrs.

Course Outcomes:

1 Aim and objective

The paper is exploring the understanding advance concept in organic reaction mechanism, Molecular Orbital Theory different rearrangement reactions and spectroscopic techniques. The syllabus is designed in such a manner that learners apply basic knowledge of Organic Chemistry in academia and Industry to meet the employability skill as per standard. Through the advanced course work and laboratory work in the department and a project work students accomplish a solution to problems encountered in the field of research.

Course Outcomes: After completion of course students able to-

1 Discuss the generation and alkylation of carbon nucleophiles, including carbanions, dianions, enolates, enamines, and imines. Explore medium effects, the role of oxygen versus carbon as the alkylation site, and the alkylation.

2 Analyze the mechanisms of acid and base-catalyzed aldol condensations, the Mannich reaction, Knoevenagel reaction, and intramolecular aldol reactions.

3 Understand and apply key organic reactions such as Baylis-Hilman, McMurry Coupling

4 Analyze and explain various anionic rearrangements, including the Brook, Neber, Wittig, Gabriel–Colman, and Payne reactions.

5 Understand the formation of molecular orbitals (σ and π) using the LCAO method, and the concept of nodal planes and energy levels in π-MOs.

6 Explore the principles and applications of UV and IR spectroscopy for analyzing organic compounds.

7 Understand the principles and applications of proton NMR and 13C NMR spectroscopy, including factors affecting chemical shifts and spin-spin coupling

8 Apply mass spectrometry principles, including molecular ion peaks, fragmentation patterns, and isotopic abundance to determine molecular formulas. Use combined NMR and mass spectrometry data to deduce the structure of organic compounds

Unit I	**1.1. Alkylation of Nucleophilic Carbon Intermediates: (7 L)** **1.1.1.** Generation of carbanion, kinetic and thermodynamic **1.1.2.** Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation. **1.1.3.** Alkylation of aldehydes, ketones, esters, amides and nitriles. **1.1.4.** Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines. **1.1.5.** Alkylation of carbon nucleophiles by conjugate addition (Michael reaction). **1.2. Reaction of carbon nucleophiles with carbonyl groups: (8 L)** **1.2.1.** Mechanism of Acid and base catalyzed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol reaction & Robinson annulation. **1.2.2.** Addition reactions with amines and iminium ions; Mannich reaction. **1.2.3.** Amine catalyzed condensation reaction: Knoevenagel reaction. Acylation of carbanions. [Reference Books: 1-11]	**[15L]**

Unit II	**Reactions and Rearrangements: (15 L)** Mechanisms, stereochemistry (if applicable) and applications of the following: **2.1. Reactions:** Baylis-Hilman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction. **2.2. Concerted rearrangements:** Hofmann, Curtius, Lossen, Schmidt, Wolff, Boulton- Katritzky. **2.3. Cationic rearrangements:** Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein. **2.4. Anionic rearrangements:** Brook, Neber, Von Richter, Wittig, Gabriel–Colman, Payne. [Reference Books: 19-22]	**[15L]**
Unit III	**3.1. Introduction to Molecular Orbital Theory for Organic Chemistry: (7 L)** **3.1.1. Molecular orbitals:** Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allyl cation, anion and radical. Concept of nodal planes and energies of π-MOs **3.1.2. Introduction to FMOs:** HOMO and LUMO and significance of HOMO-LUMO gap in absorption spectra as well as chemical reactions. MOs of formaldehyde: The effect of electronegativity perturbation and orbital polarization in formaldehyde. HOMO and LUMO (π and π* orbitals) of formaldehyde. A brief description of MOs of nucleophiles and electrophiles. Concept of „donor-acceptor" interactions in nucleophilic addition reactions on formaldehyde. Connection of this HOMO-LUMO interaction with „curved arrows" used in reaction mechanisms. The concept of hardness and softness and its application to electrophiles and nucleophiles. Examples of hard and soft nucleophiles/ electrophiles. Identification of hard and soft reactive sites on the basis of MOs. **3.1.3.** Application of FMO concepts in (a) S^2 reaction, ($_N$b) Lewis acid base adducts (BF - NH_3 complex), (c) ethylene dimerization to butadiene, (d) Diels-Alder cycloaddition, (e) regioselective reaction of allyl cation with allyl anion (f) addition of hydride to formaldehyde. **3.2. Applications of UV and IR spectroscopy: (8 L)** **3.2.1. Ultraviolet spectroscopy:** Recapitulation, UV spectra of dienes, conjugated polyenes (cyclic and acyclic), carbonyl and	**[15L]**

	unsaturated carbonyl compounds, substituted aromatic compounds. Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, and solvent polarity. Calculation of absorption maxima for above classes of compounds by Woodward-Fieser rules (using Woodward-Fieser tables for values for substituents). **3.2.2. Infrared spectroscopy:** Fundamental, overtone and combination bands, vibrational coupling, factors affecting vibrational frequency (atomic weight, conjugation, ring size, solvent and hydrogen bonding). Characteristic vibrational frequencies for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides, lactones, lactams and conjugated carbonyl compounds.	
Unit IV	**NMR spectroscopy and Mass spectrometry (15 L)** **4.1. Proton magnetic resonance spectroscopy:** Principle, Chemical shift, Factors affecting chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence, Chemical shift values and correlation for protons bonded to carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal and long range coupling (allylic and aromatic). First order spectra, Karplus equation. **4.2. ^{13}C NMR spectroscopy:** Theory and comparison with proton NMR, proton coupled and decoupled spectra, off-resonance decoupling. Factors influencing carbon shifts, correlation of chemical shifts of aliphatic, olefin, alkyne, aromatic and carbonyl carbons. **4.3. Mass spectrometry:** Molecular ion peak, base peak, isotopic abundance, metastable ions. Nitrogen rule, Determination of molecular formula of organic compounds based on isotopic abundance and HRMS. Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels-Alder reaction, ortho effect. **4.4.** Structure determination involving individual or combined use of the above spectral techniques. [Reference Books: 13-18]	

	REFERENCES:	
	1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press. **2.** Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no. 713-769, and B, Plenum Press. **3.** March‟s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley. **4.** Organic Chemistry, R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, Pearson Publication (7^{th} Edition) **5.** Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education. **6.** Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press. **7.** Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press. **8.** Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press. **9.** Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes. **10.** Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education. **11.** Mechanism in Organic Chemistry, Peter Sykes, 6th **12.** Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley **13.** Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks. **14.** Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, John Wiley and Sons. **15.** Organic Spectroscopy, William Kemp, W.H. Freeman & Company. **16.** Organic Spectroscopy-Principles and Applications, Jagmohan, Narosa Publication. **17.** Organic Spectroscopy,V.R.Dani, Tata McGraw Hill Publishing Co. **18.** Spectroscopy of Organic Compounds, P.S.Kalsi,NewAge International Ltd. **19.** Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parasher, Alpha Science International, 2011. **20.** Reactions, Rearrangements and Reagents by S. N. Sanyal **21.** Name Reactions, Jie Jack Li, Springer **22.** Name Reactions and Reagents in Organic Synthesis, Bradford P. Mundy, M.G. Ellerd, and F.G. Favaloro, John Wiley & Sons.	

23BPCH2T03	Course Title **Analytical Chemistry**	Credits 4	No. of lectures in hrs.

Aim and objective

This course focuses on different types of chromatographic techniques. Chromatography with instrumental details is essential for students to comprehend the significance of these techniques in various chemical and other industries. Spectroscopy is most important branch of chemical analysis. The basic theory, general instrumental design of X-ray, mass spectroscopies is covered . Radioanalytical techniques are finds their unique position in research laboratories. Surface characterization of the materials is generally carried out with SEM, TEM, STM and ESCA. The theory, instrumentation and applications of surface characterization is covered in Unit III. It is covered in great detail in module IV. This will train the students to use this versatile technique. Applied electro analytical techniques are widely used for specific estimations in industry, environmental sciences and research.

1. Classify different chromatographic techniques.
2. Discuss chromatography by using plate and rate theory
3. Understand use of GC, HPLC techniques and selection of columns
4. Apply theory, instrumentation and applications of X-ray, Mass spectroscopy and Radioanalytical techniques.
5. Elaborate the basic principle, instrumentation and applications of Atomic spectroscopy based on plasma sources
6. Understand the theory and operating principles of different surface analytical techniques of SEM, TEM, STM, ESCA and Auger
7. Apply Electroanalytical techniques like Ion selective potentiometry.
8. Discuss the Polarography, Electrogravimetry and Coulometry.

Unit I	**Chromatography [15 L]** **1.1 Recapitulation of basic concepts in chromatography**: Classification of chromatographic methods, requirements of an ideal detector, types of detectors in LC and GC, comparative account of detectors with reference to their applications (LC and GC respectively), qualitative and quantitative analysis**.[2 L]** **1.2** Concept of plate and rate theories in chromatography: efficiency, resolution, selectivity and separation capability. Van Deemter equation and broadening of chromatographic peaks.	**[15L]**

	Optimization of chromatographic conditions**.[5 L]** 13 **Gas Chromatography**: Instrumentation of GC with special reference to sample injection systems – split/splitless, column types, solid/ liquid stationary phases, column switching techniques, temperature programming, Thermionic and mass spectrometric detector, Applications. **[3 L]** 14 **High Performance Liquid Chromatography (HPLC):** Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. Chiral and ion chromatography. **[5 L]**	
Unit II	**2.1** **X-ray spectroscopy**: principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. **[4 L]** **2.2** **Mass spectrometry**: recapitulation, instrumentation, ion sources for molecular studies, electron impact, field ionization, field absorption, chemical ionization and fast atom bombardment sources. Mass analyzers: Quadrupole, time of flight and ion trap. Applications.[6 L] **2.3** **Radioanalytical Methods –** recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. **[5 L]**	**[15L]**
Unit III	**3.1 Surface Analytical Techniques – [9 L]** Introduction, Principle, Instrumentation and Applications of: **3.1.1** Scanning Electron Microscopy (SEM) **3.1.2** Scanning Tunneling Microscopy (STM) **3.1.3** Transmission Electron Microscopy (TEM) **3.1.4** Electron Spectroscopy (ESCA and Auger) **3.2 Atomic Spectroscopy [6 L]** **3.2.1** Advantages and Limitations of AAS **3.2.2** Atomic Spectroscopy based on plasma sources – Introduction, Principle, Instrumentation and Applications.	**[15L]**

Unit IV	**Electroanalytical Methods (Numericals are Expected)** **4.1 Ion selective potentiometry and Polarography: [10 L]** Ion selective electrodes and their applications (solid state, precipitate, liquid –liquid, enzyme and gas sensing electrodes), ion selective field effect transistors, biocatalytic membrane electrodes and enzyme based biosensors. **Polarography:** Ilkovic equation, derivation starting with Cottrell equation, effect of complex formation on the polarographic waves. **4.2 Electrogravimetry**: Introduction, principle, instrumentation, factors affecting the nature of the deposit, applications**.[3 L]** **4.3 Coulometry:** Introduction, principle, instrumentation, coulometry at controlled potential and controlled current **[2 L]**	
	REFERENCES:	
	Unit I 1. Instrumental Analysis, Skoog, Holler & Crouch 2. HPLC Practical and Industrial Applications, 2 nd Ed., Joel K. Swadesh, CRC Press **Unit II** **1.** Essentials of Nuclear Chemistry, H J Arnikar, New Age Publishers (2005) **2.** Fundamentals of Radiochemistry D. D. Sood , A. V. R. Reddy and N. Ramamoorthy **3.** Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 12 **4.** Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 20 **Unit III** **1.** Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition, (2003), ISBN-10: 8131505421, ISBN-13: 978-8131505427 **2.** Physical Principles of Electron Microscopy, An Introduction to TEM, SEM, and AEM **3.** Authors: Ray F. Egerton, ISBN: 978-0- 387-25800- 3 (Print) 978-0-387-26016- 7(Online) **4.** Modern techniques of surface science by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994 **5.** Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, NewYork, 1993. **6.** 5. Transmission Electron Microscopy: A text book for Material Science, David B Williams and C., Barry Carter, Springer **7.** Modern Spectroscopy, by J.M. Hollas, 3rd Edition (1996), John Wiley, New York	

	8. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998. 9. Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition (2003), ISBN10: 8131505421, ISBN-13: 978-8131505427 **Unit IV** 1. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th Edition, Harcourt College Publishers, 1998. Chapters - 23, 24, 25. 2. Analytical Chemistry Principles – John H Kennnedy, 2nd edition, Saunders College Publishing (1990). 3. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000). 4. Vogel‟s Text book of quantitative chemical analysis, 6th edition, Pearson Education Limited, (2007). 5. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980). 6. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7th edition, CBS publishers.	

23BPCH2P 01	Course Title **Organic Chemistry + Analytical Chemistry**	Credits 2	No. of lectures in hrs.
Course Outcomes: After completion of this course the learner will be able to learn **1.** Type of mixture, separation, purification and characterization of separated organic molecule. **2.** To handle instruments, concepts of qualitative and quantitative techniques. **3.** To deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods. **4.** To develop scientific temperament and research-based skills accomplish to encountered in the field of research			
Unit I	**Separation of Binary mixture using micro-scale technique** **1.** Separation of binary mixture using physical and chemical methods. **2.** Characterization of one of the components with the help of chemical analysis and confirmation of the structure with the help of derivative preparation and its physical constant. **3.** Purification and determination of mass and physical constant of the second component. **The following types are expected:** **(i)** Water soluble/water insoluble solid and water insoluble solid, **(ii)** Non-volatile liquid-Non-volatile liquid (chemical separation) **(iii)** Water-insoluble solid-Non-volatile liquid. Minimum two mixtures from each type and a total of five mixtures are expected.		**[15L]**
Unit II	**Analytical Chemistry** **1.** To determine percentage purity of sodium carbonate in washing soda pH metrically. **2.** To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically. **3.** To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically. **4.** To determine the percentage composition of HCl and H_2SO_4 on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$.		**[15L]**
	REFERENCES:		
Unit I	**1.** Systematic Qualitative organic analysis, H.Middleton (Orient Longman) **2.** A Handbook of Organic Analysis, H.T. Clark (Orient Longman) **3.** Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York) **4.** Practical Organic Chemistry by Mann and Saunders. **5.** Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication		**48 / 60**

Unit II	**1.** Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964) **2.** Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, **3.** Thomas, Pearson education **4.** Standard methods of chemical analysis, F. J. Welcher **5.** Standard Instrumental methods of Chemical Analysis, F. J. Welcher **6.** W.W.Scott."Standard methods of Chemical Analysis",Vol.I, Van Nostrand Company, Inc.,1939. **7.** E.B.Sandell and H.Onishi,"Spectrophotometric Determination of Traces of Metals",Part- II, 4th Ed.,A Wiley Interscience Publication,New York,1978	

II] Elective Courses

Course Code 23BPCH 2T04	Course Title ELECTIVE **Polymer Chemistry**	Credits 2	No. of lectures in hrs

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

1. Understand the mechanisms and kinetics of different polymerization processes, including step-growth, radical chain growth, ionic chain (cationic and anionic), and coordination polymerizations.
2. Study the physical, thermal, flow, and mechanical properties of various polymers. Learn the preparation, structure, properties, and applications of polymers.
3. Understand the concept of crystallization and crystallinity in polymers, and the factors affecting crystalline melting points.
4. Explain different methods for determining the molecular weight of polymers, such as end-group analysis, viscometry, light scattering, and osmotic pressure.

Unit I :	**Introduction, importance classification of polymer (03)** Benchmarks for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction, and degree of polymerization. Bi-functional systems, Poly-functional systems. **Kinetics of Polymerization (05)** Mechanism and kinetics of step-growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques. **Properties of Polymer (07)** (Physical, thermal, Flow & Mechanical Properties) **Preparation, structure, properties and application of the following polymers:** polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoropolymers, **Polyamides and related polymers.** Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].	**[15]**

Unit II :	**Crystallization and crystallinity (7L)** Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, and Factors affecting crystalline melting point. **Determination of molecular weight of polymers (8L)** (Mn, Mw, etc) by end-group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.	**[15]**

	References **1** R.B. Seymour & C.E. Carraher: Polymer Chemistry: An Introduction, Marcel Dekker, Inc. New York, 1981. **2** G. Odian: Principles of Polymerization, 4th Ed. Wiley, 2004. **3** F.W. Billmeyer: Textbook of Polymer Science, 2nd Ed. Wiley Interscience, 1971. **4** P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education, 1991. **5** R.W. Lenz: Organic Chemistry of Synthetic High Polymers. Interscience Publishers, New York, 1967.	
23BPCH 2P02	**Practical - Polymer Synthesis**	
	(Any Six) **1.** Purification of monomer **2.** Preparation of nylon 66/6 **3.** Redox polymerization of acrylamide **4.** Precipitation polymerization of acrylonitrile **5.** Preparation of urea-formaldehyde resin **Polymer characterization** **6.** Determination of molecular weight by viscometry: **a.** Polyacrylamide-aq.$NaNO_2$ solution **b.** (Poly vinyl proplylidine (PVP) in water **7.** Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer. **8. Determination of molecular weight by end group analysis:** Polyethylene glycol (PEG) (OH group). **9.** Testing of mechanical properties of polymers. **10.** Determination of hydroxyl number of a polymer using colorimetric method. **Polymer analysis** **11.** Estimation of the amount of HCHO in the given solution by sodium sulphite method **12.** Instrumental Techniques **13.** IR studies of polymers **14.** Preparation of polyacrylamide and its electrophoresis	
	References: **1** M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999. **2** H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice- Hall (2003) **3** F.W. Billmeyer, Textbook of Polymer Science, 3rd ed.	

	Wiley-Interscience (1984) **4** J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003) **5** P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002) **6** L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005) **7** M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005). **8** Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).	

Course Code 23BPCH 2T05	**Course Title** **ELECTIVE** **Environmental Chemistry**	**Credits** **2**	**No. of lectures in hrs.**
Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to **1.** Understand the importance of quality control in pharmaceuticals, identify sources of impurities in pharmaceutical chemicals, and apply common methods of assay for the analysis of finished products **2.** Classify common drugs and their therapeutic uses, including analgesics, anthelmintics, antibiotics, anti-inflammatory agents, antimalarials, narcotics, expectorants, sedatives, and vitamins **3.** Understand the causes, effects, and control measures for various types of pollution, including air, water, soil, marine, noise, thermal, and nuclear pollution **4.** Describe the significance of natural resources, including forests, water, minerals, food, energy, and land resources			
Unit I :	**Chemistry in Contemporary Society** **Pharmaceuticals:** Importance of quality control, drugs and pharmaceuticals, sources of impurities in pharmaceutical chemicals, analytical quality control in finished / final products, common methods of assay. **Common drugs and their uses: Analgesics** – aspirin, paracetamol; Antheimentics – mebendazole ; Antiallergies – chlorpenneramine malleate; Antibiotics-pencillin, chloromecytin; Anti-inflammatory agents-oxyphenbutazone; Antimalarials – primaquine phosphate; Antituberculosists – INH; Narcotics – nicotine, morphine; Expectorants – Benadryl; Sedatives – diazepam; Vitamins – B1, B2, B6, niacin and folic acid.		**15**
	ENVIRONMENTAL POLLUTION		**15**

Unit II	**Definition (3L)** a) Air pollution b) Water pollution c) Soil pollution d) Marine pollution e) Noise pollution f) Thermal pollution g) Nuclear pollution **Solid waste management (4L)** Causes, effects and control measures of urban and industrial wastes. Environmental impact assessment. **Natural resources and non-renewable resources (8L)** An overview of natural resources and associated problems with references to a) Forest resources b) Water resources c) Mineral resources d) Food resources e) Energy resources f) Land resources	**15**

	References Pharmaceutical Analysis, T. Higuchi and E.B. Hanseen, John Wiley and Sons, New York. 2. Quantitative Analysis of drugs, P.D. Sethi, 3rd edition, CBS Publishers, New Delhi, 1997.		
Course Code 23BPCH 2P03	**PRACTICAL**	**Credits 2**	
	Internship /Field project/ current case studies		**60**

Course Code 23BPCH 2T06	**Course Title (Elective Physical Chemistry)**	**Credits 2**	**No. of lectures in hrs.**

Course Outcomes: Upon completion of this course, students will acquire knowledge about and able to

1. Understand the concepts of fugacity and its determination in real gases. Learn to calculate equilibrium constants for real gases using fugacity, and explore the Gibbs energy, entropy, and enthalpy of mixing.
2. Explain the thermodynamics of surfaces, including the pressure difference across curved surfaces, vapor pressure of droplets, and key isotherms such as Gibbs adsorption and BET.
3. Understand the kinetics of enzyme-catalyzed reactions, including the Michaelis-Menten model and various graphical analyses such as Lineweaver-Burk and Eadie analyses.
4. Describe the kinetics of reactions in the solid state, understanding factors affecting reaction rates and applying various rate laws.

Unit I :	**Chemical Thermodynamics II [15 L]** **1.1.** Fugacity of real gases, Determination of fugacity of real gases using graphical method and from equation of state. Equilibrium constant for real gases in terms of fugacity. Gibbs energy of mixing, entropy and enthalpy of mixing. **1.2. Real solutions:** Chemical potential in non ideal solutions excess functions of non ideal solutions calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation. **1.3. Thermodynamics of surfaces**, Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected). **1.4.** Bioenergetics: standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.	**15**

Unit II	**Chemical Kinetics and Molecular Reaction Dynamics [15 L]** 3.1. **Elementary Reactions in Solution:-** Solvent Effects on reaction rates, Reactions between ions- influence of solvent Dielectric constant, influence of ionic strength, Linear free energy relationships Enzyme action **3.2. Kinetics of reactions catalyzed by enzymes -** Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses**.** 3.3. **Inhibition of Enzyme action**: Competitive, Noncompetitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes. 3.4. **Kinetics of reactions in the Solid State:-** Factors affecting reactions in solids 3.5. **Rate laws for reactions in solid**: The parabolic rate law, The first order rate Law, the contracting sphere rate law, Contracting area rate law, some examples of kinetic studies. (Ref: 7 and 2)	**15** **15**
	References 1. Peter Atkins and Julio de Paula, Atkin"s *Physical Chemistry*, 7th Edn., Oxford University Press, 2002. 2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999. 3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002. 4. Ira R. Levine, *Physical Chemistry*, 5th Edn., Tata McGraw-Hill New Delhi, 2002. 5. G.W. Castellan, *Physical Chemistry*, 3rd Edn., Narosa Publishing House, New Delhi, 1983. 6. S. Glasstone, *Text Book of Physical Chemistry*, 2nd Edn., McMillan and Co. Ltd., London, 1962. 7. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007. 8. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964. 9. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772. 10. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.	

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<tr><td></td><td colspan="2">11. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
12. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
13. Solid State Chemistry [An Introduction], 3rd Ed., Lesley E. Smart & Elaine A. Moore, Taylor & Francis, 2010.
14. Principles of physical Chemistry,Marrown and Prutton 5th edi
15. Essentials of Physical Chemistry , Arun Bahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.</td><td></td></tr>
<tr><td>Course Code

23BPCH 2P04</td><td>PRACTICAL

Physical Chemistry +Inorganic Chemistry</td><td>Credits

2</td><td></td></tr>
<tr><td>Unit I</td><td colspan="2">Non – instrumental: (Any two)
Polar plots of atomic orbitals such as 1s, and 3 orbitals by using angular part of hydrogen atom wave functions.
1. To study the influence of ionic strength on the base catalyzed hydrolysis of ethylacetate.
2. To study the phase diagram of three component system water – chloroform /toluene - acetic acid.
3. To determine the rate constant of the decomposition reaction of diacetone alcohol by dilatometric method.
Instrumental: (Any two)
1. To determine the formula of silver ammonia complex by potentiometric method.
2. To determine CMC of sodium Lauryl Sulphate from the measurement of conductivities at different concentrations.
3. To determine Hammett constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.
4. To determine the Michaelis – Menten‟s constant value (Km) of the enzyme Beta Amylase spectrophotometrically.</td><td>60</td></tr>
<tr><td>Unit II</td><td colspan="2">Inorganic Chemistry Practical
1) Analysis of Devarda’s alloy
2) Analysis of Cu – Ni alloy
3) Analysis of Tin Solder alloy
4) Estimation of Copper using Iodometric method Potentiometrically.</td><td></td></tr>
</table>

	References **1** Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005. **2** Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974. **3** Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.		
23BPCH 2P05	**III] On Job Training or Fiend Project**	**Credits 2**	**No. of lectures in hrs**
	Apprenticeship/internship/Field project /case studies /on job Training		**60 hrs**

Evaluation Scheme 60:40

Internals Based on Unit 1 / Unit 2 / Unit 3/ Unit 4

Assignments/ Tutorials	Seminar	Ppt/video Presentation	Group discussion	Active Participation & Leadership qualities	Total
10	10	10	05	05	40

Theory Examinations: For Paper 1, Paper 2 , Paper 3 and Research Methodology

Suggested Format of Question paper

Duration: 2½ Hours **Total Marks: 60**

- **All questions are compulsory**

Q. 1	Answer ***any three*** of the following-		**12**
	a	Based on Unit I	
	b	Based on Unit I	
	c	Based on Unit I	
	d	Based on Unit I	
	e	Based on Unit I	
	f	Based on Unit I	
Q. 2	Answer ***any three*** of the following-		**12**
	a	Based on Unit II	
	b	Based on Unit II	

	c	Based on Unit II	
	d	Based on Unit II	
	e	Based on Unit II	
	f	Based on Unit II	
Q. 3	Answer ***any three*** of the following-		**12**
	a	Based on Unit III	
	b	Based on Unit III	
	c	Based on Unit III	
	d	Based on Unit III	
	e	Based on Unit III	
	f	Based on Unit III	
Q. 4	Answer ***any three*** of the following-		
	a	Based on Unit IV	
	b	Based on Unit IV	
	c	Based on Unit IV	
	d	Based on Unit IV	
	e	Based on Unit IV	
	f	Based on Unit IV	
Q. 5	Answer ***any three*** of the following		**12**
	a	Based on Unit I	
	b	Based on Unit I	
	c	Based on Unit II	
	d	Based on Unit II	
	e	Based on Unit III	
	f	Based on Unit III	
	g	Based on Unit IV	
	h	Based on Unit IV	

Theory Examinations: For ELECTIVE Paper

Duration: 1.0 Hours **Total Marks: 30**

- **All questions are compulsory**

Q. 1	Answer ***any three*** of the following-		**10**
	a	Based on Unit I	
	b	Based on Unit I	
	c	Based on Unit I	
	d	Based on Unit I	
	e	Based on Unit I	
	f	Based on Unit I	
Q. 2	Answer ***any three*** of the following-		**10**
	a	Based on Unit II	

	b	Based on Unit II	
	c	Based on Unit II	
	d	Based on Unit II	
	e	Based on Unit II	
	f	Based on Unit II	
Q. 3	Answer ***any Two*** of the following-		**10**
	a	Based on Unit I	
	b	Based on Unit I	
	c	Based on Unit II	
	d	Based on Unit II	

Semester End Practical Examination:

Semester _____Practical Examination "Month & Year '

Paper Code:- _____

Duration: - 03.00 hrs. **Total Marks**: - 50

Particulars	**Duration**	**Semester end external examination**
Laboratory work	2 Hrs + 2 Hrs	20 + 20
Viva		05
Journal		05
Total		**50**

Marks Distribution and Passing Criterion for Each Semester

Theory						**Practical**		
Course Code SEMI / SEM II	Internal	Min marks for passing	Theory Examination	Min marks for passing	Total	Course Code	Practical Examination	Min marks for passing
23BPCH	40	16	60	24	100	-	-	-

1T1 / 2T1								
23BPCH 1T2 / 2T2	40	16	60	24	100	-	**-**	**-**
23BPCH 1T3 / 2T3	40	16	60	24	100	-	**-**	**-**
Laboratory 1	-	-	**-**	**-**	-	23BPCH 1P1/2P1	**50**	**20**
ELECTIVE	20	08	30	12	50			
Laboratory 2	-	-	**-**	**-**	-	23	**50**	**20**
Research Methodology 23BPRM1T1 / **On Job Training**	40	16	60	24	100	23BPCH2P 5	**100**	**40**

Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/ course projects/ problem or project based learning/ case studies/self-study like seminar, term paper or MOOC

$ Every course needs to include assessment for higher order thinking skills (Applying/ Analyzing/ Evaluating/ Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e. assessment for learning)

Date **Subject Committee Chairperson**

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VPM'sB.N.BandodkarCollegeofScience(Autonomous),Thane

CurriculumStructureforthe Post graduateDegreeProgramme M.Sc.I Chemistry

	SEMESTER–I	**Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)**			**Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)**			
Course Code	**Course Title**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
23BPCH1T01	Inorganic Chemistry	√	-	-	-	-	-	-
23BPCH1T02	Organic Chemistry	√	-	√	-	-	-	-
23BPCH1T03	Analytical Chemistry	√	-	√	-	-	-	-
23BPCH1P01	Chemistry Practical -1 (Organic Chemistry + Analytical Chemistry)	√	-	√	-	-	-	√
Optional ElectivesSemester1-								
23BPCH1T04	Green Chemistry and Catalyst Chemistry	√	-	√	√	--	--	√
23BPCH1P02	Practical based on **23BPCH1T04**	√	-	√	-	-	-	-
OR								
23BPCH1T05	Analytical Biochemistry	--	--	√	--	--	--	√
23BPCH1P03	Practical based on **23BPCH1T05**	√	-	√	-	-	-	-
OR								
23BPCH1T06	Physical Chemistry	√	--	--	--	--	-	--
23BPCH1P04	Practical (Inorganic Chemistry + Physical Chemistry)	√	-	√	--	-	-	-
23BPRM1T01	**III] Research Methodology**	√	√	√	√	-	-	√
	Total	**10**	**1**	**9**	**2**	**0**	**--**	**4**

	SEMESTER–II	Course imparts Employability (EM), Entrepreneurship (EN), Skill Development (SD)			Course integrates with Professional Ethics (PE), Gender Equity (GE), Human Value (HV), Environmental Sustainability (ES)			
Course Code	**CourseTitle**	**EM**	**EN**	**SD**	**PE**	**GE**	**HV**	**ES**
	I] MANDATORY							
23BPCH2T01	Inorganic Chemistry	√	-	-	--	--	--	--
23BPCH2T02	Organic Chemistry	√	-	√	--	--	--	--
23BPCH2T03	Chemistry Analytical	√	-	√	--	--	--	--
23BPCH2P01	**Chemistry Practical -1 (Organic Chemistry + Analytical Chemistry)**	√	-	√	--	--	--	√
OptionalElectivesSemesterIV-II] ELECTIVES (2T+2P) Note: Select Any One subject among the electives given below								
23BPCH2T04	**Polymer Chemistry**	√	--	√	-	--	--	--
23BPCH2P02	**Practical based on 23BPCH2T04**	√	-	√	-	--	--	--
OR								
23BPCH2T05	**Environmental Chemistry**	√	--	-	--		√	√
23BPCH2P03	**Practical based on 23BPCH2T05**	√	-	√	-	--	--	--
OR								
23BPCH2T06	**Physical Chemistry**	√	--	--	--	--	--	--
23BPCH2P04	**Practical (Inorganic Chemistry + Physical Chemistry)**	√	-	√	-	--	--	--
23BPCH2P05	**III] ON JOB TRAINING OR FIELD PROJECT**	√	√	√	√	--	--	√
	Total	**11**	**1**	**8**	**1**	**00**	**1**	**3**

Sign & Name of _____
BOS Chairman & Head Dept. Of Chemistry