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: Organic Chemistry

Programme Code: BPCH

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

Level 6.0

CHOICE BASED GRADING SYSTEM

Revised under NEP

From academic year 2023-24

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B. N. Bandodkar College of Science, (AUTONOMOUS)-Thane											
Master Program in Organic 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 Organic 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 2	NA	NA	**Credits 6**	**22**	
			Course 2	Credits 4		**OR**					
			Course 3	Credits 2		Course 2 Credits 2					
			Course 4	Credits 2							
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.

Scope

Scope of Master of Organic Chemistry:

The Master of Organic Chemistry programme under the NEP framework provides advanced theoretical knowledge and practical training in the synthesis, reactivity, and mechanistic understanding of organic compounds with applications in pharmaceuticals, agrochemicals, materials science, and fine chemicals. The curriculum emphasizes structure–property relationships, stereochemistry, heterocyclic chemistry, spectroscopy, and modern synthetic methodologies, along with green and sustainable chemical practices. It equips learners with strong research aptitude, problem-solving skills, and analytical competence necessary for careers in chemical industries, research and development, quality control, academics, and higher studies such as Ph.D. programmes. The programme also fosters interdisciplinary learning, innovation, and ethical scientific practices, aligning graduates with national and global needs in chemical sciences.

Dr. Anita Goswami-Giri
BOS Chairperson

Master of Science
Organic Chemistry
(To be implemented from the academic year 2023-2024)

SEMESTER I and SEMESTER II

SYLLABUS FOR APPROVAL

Sr. No.	Heading	Particulars
1	Title of the Course	M.Sc. (Organic Chemistry)
2	Eligibility for Admission	The B.Sc. Chemistry or equivalent qualification from other recognized university as per relevant ordinance
3	Passing Marks	40%
4	No. of Years / Semesters	Sem I and II
5	Level	P.G.
6	Pattern	Semester
7	Status	Revised under NEP
8	To be implemented from Academic Year	2023-24
9	Name & Sign of BOS Chairperson	**Dr. Anita Goswami-Giri**

PROGRAMME OUTCOMES (POs) OF MASTERS IN SCIENCE (M.Sc.)

The Postgraduate Programmes of Science are intended to cater quality education and attain holistic development of learners through the following programme outcomes:

PO1 – Domain Knowledge
Comprehend and demonstrate domain knowledge in specialized branch of science. Instil ability to apply it in upgrading professional, social and personal life.

PO2 – Development of Research Competence
Imbibe skills related to identification of research problem, formulating hypothesis, execution of research process, analysing data, interpreting the data, drawing conclusion and presenting research work. Encourage learners for doctoral studies.

PO3 - Digital Literacy
Enhance ability to access, select and use a variety of relevant information e-resources for creating new knowledge resources.

PO4 - Sensitization towards Environment
Build cohesive bond with nature by respecting natural resources, encouraging eco-friendly practices and creating awareness about sustainable development.

PO5 - Individuality and Team work
Encourage learner to work independently or in collaboration for achieving effective results through practical experiments, project work and research activities.

PO6 – Competence for Employment
Promote field work, internships, industrial training, research projects, research paper presentations and publications to develop competence for adapting towards dynamic socio-economic changes and make learner employable.

Programme Specific Outcomes (PSOs)

M.Sc. Organic Chemistry (First & Second Year)

PSO1 – Advanced Organic Knowledge
Demonstrate in-depth understanding of advanced organic chemistry concepts including reaction mechanisms, stereochemistry, heterocyclic chemistry, pericyclic reactions, and structure–reactivity relationships. (L4)

PSO2 – Synthetic and Practical Skills
Apply modern organic synthesis techniques, purification methods, and spectroscopic tools (UV-Vis, IR, NMR, MS) for the synthesis, characterization, and analysis of organic compounds. (L3)

PSO3 – Research and Problem-Solving Ability
Develop research aptitude by analyzing experimental data, interpreting literature, designing synthetic pathways, and solving complex chemical problems using logical and mechanistic reasoning. (L5)

PSO4 – Green and Sustainable Chemistry
Integrate principles of green chemistry and sustainability in organic synthesis by minimizing waste, reducing toxicity, improving atom economy, and adopting environmentally benign methodologies. (L5)

PSO5 – Professional and Industrial Readiness
Demonstrate competence for careers in pharmaceuticals, agrochemicals, fine chemicals, quality control, and R&D by understanding industrial processes, regulatory practices, and safety standards. (L4)

PSO6 – Communication, Ethics, and Lifelong Learning
Exhibit scientific communication skills, ethical research practices, teamwork, and lifelong learning abilities essential for academic pursuits, doctoral research, and interdisciplinary collaboration. (L5)

ASSESSMENT: WEIGHTAGE FOR ASSESSMENTS (IN PERCENTAGE) FOR MANDATORY AND ELECTIVE COURSE

Type of Course	**Formative Assessment / Internal Assessment**	**Summative Assessment**
Theory	40%	60%
Practical	-	100%

Assignments/ Tutorials/Class Test	Ppt/video Presentation or any other activities	Active Participation & Leadership qualities	Total
15	15	10	40

VPM's B. N. Bandodkar College of Science (Autonomous), Thane
M.Sc. Environmental Science
Structure of Programme
SEMESTER I

Course Code	Course Title	No. of Lectures	Credits
MANDATORY COURSES			
23BPCH1T01	Inorganic Chemistry-I	**60**	**4**
23BPCH1T02	Organic Chemistry-I	**60**	**4**
23BPCH1T03	Analytical Chemistry-I	**60**	**4**
23BPCH1P01	Practicals based on 23BPCH1T02 and 23BPCH1T03	**60 Hours**	**2**
ELECTIVE COURSES			
23BPCH1T04	Green Chemistry and Catalyst Chemistry	**30**	**2**
23BPCH1P02	Practical based on 23BPCH1T04	**60 Hours**	**2**
OR			
23BPCH1T05	Analytical Biochemistry	**30**	**2**
23BPCH1P03	Practical based on 23BPCH1T05	**60 Hours**	**2**
OR			
23BPCH1T06	**Physical Chemistry-I**	**30**	2
23BPCH1P04	Practical based on 23BPCH1T01 and 23BPCH1T06	**60**	2
RESEARCH METHODOLOGY (RM)			
23BPRM1T01	Research Methodology for Chemistry and Environmental Science	**60**	**4**
	Total Credits		**22**

VPM's B. N. Bandodkar College of Science (Autonomous), Thane
M.Sc. Environmental Science
Structure of Programme
SEMESTER II

Course Code	Course Title	No. of Lectures	Credits
MANDATORY COURSES			
23BPCH2T01	Inorganic Chemistry-II	**60**	**4**
23BPCH2T02	Organic Chemistry-II	**60**	**4**
23BPCH2T03	Analytical Chemistry- II	**60**	**4**
23BPCH2P01	Practicals based on 23BPCH2T02 and 23BPCH2T03	**60 Hours**	**2**
ELECTIVE COURSES			
23BPCH2T04	Polymer Chemistry	**30**	**2**
23BPCH2P02	Practicals based on 23BPCH2T04	**60 Hours**	**2**
OR			
23BPCH2T05	Environmental Chemistry	**30**	**2**
23BPCH2P03	Practicals based on 23BPCH2T05	**60 Hours**	**2**
OR			
23BPCH2T06	Physical Chemistry-II	30	2
23BPCH2P04	Practicals based on 23BPCH1T01 and 23BPCH1T06	60	2
ON-JOB TRAINING (OJT) / FIELD PROJECT (FP)			
23BPCH2P05	Internship/On-Job Training/Field Project related to Chemistry	**120 Hours**	**4**
	Total Credits		**22**
	Total Semester I & Semester II Credits		**44**

Mode of Conduct: Laboratory practical / Offline lecture / Hybrid lecture

V P M's B. N. Bandodkar College of Science (Autonomous), Thane

Curriculum Structure for the Post graduate Degree Programme 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-I	√	-	-	-	-	-	-
23BPCH1T02	Organic Chemistry-I	√	-	√	-	-	-	-
23BPCH1T03	Analytical Chemistry-I	√	-	√	-	-	-	-
23BPCH1P01	Practicals based on 23BPCH1T02 and 23BPCH1T03	√	-	√	-	-	-	√
Elective Course Title								
23BPCH1T04	Green Chemistry and Catalyst Chemistry	√	-	√	√	--	--	√
23BPCH1P02	Practical based on 23BPCH1T04	√	-	√	-	-	-	-
OR								
23BPCH1T05	Analytical Biochemistry	--	--	√	--	--	--	√
23BPCH1P03	Practical based on 23BPCH1T05	√	-	√	-	-	-	-
OR								
23BPCH1T06	**Physical Chemistry-I**	√	--	--	--	--	-	--
23BPCH1P04	Practical based on 23BPCH1T01 and 23BPCH1T06	√	-	√	--	-	-	-
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-II	√	-	-	--	--	--	--
23BPCH2T02	Organic Chemistry-II	√	-	√	--	--	--	--
23BPCH2T03	Analytical Chemistry- II	√	-	√	--	--	--	--
23BPCH2P01	Practicals based on 23BPCH2T02 and 23BPCH2T03	√	-	√	--	--	--	√
	Elective Course Title							
23BPCH2T04	Polymer Chemistry	√	--	√	-	--	--	--
23BPCH2P02	Practicals based on 23BPCH2T04	√	-	√	-	--	--	--
OR								
23BPCH2T05	Environmental Chemistry	√	--	-	--		√	√
23BPCH2P03	Practicals based on 23BPCH2T05	√	-	√	-	--	--	--
OR								
23BPCH2T06	Physical Chemistry-II	√	--	--	--	--	--	--
23BPCH2P04	Practicals based on 23BPCH1T01 and 23BPCH1T06	√	-	√	-	--	--	--
23BPCH2P05	Internship/Training/Field Project in Chemistry	√	√	√	√	--	--	√
	Total	**11**	**1**	**8**	**1**	**00**	**1**	**3**

Dr. Anita Goswami-Giri
BOS Chairman & Head Dept. Of Chemistry

SEMESTER I

MANDATORY COURSES

Course Code **23BPCH1T01**	**Course Title** Inorganic Chemistry-I	**Credits** **4**	**No. of lectures**

Course Outcomes:
After completing this course learner will be able to:

CO 1	Describe hybridization, involvement of d orbitals in various types of hybridization, critical analysis of VBT and Recognize MOT for diatomic species, polyatomic species considering σ bonding.	*L4*
CO 2	Illustrate Symmetry criterion of optical activity, Concepts of Groups, Sub-groups and Discuss Representation of Groups, Applications of group theory.	*L4*
CO 3	Describe Electronic structure of solids and band theory, Structures of Compounds of the type: AB, AB_2. and Describe Methods of preparation for inorganic solids, nanomaterials.	*L3*
CO 4	Discuss characterization of co-ordination compounds by using different spectroscopic methods. And Illustrate Spectral calculations, calculation of electronic parameters, Determination of formation constants of metal complexes.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	1	0	0	2
CO2	3	3	1	0	0	2
CO3	3	2	0	1	0	3
CO4	3	3	1	0	0	3

Grading will be as:
3: High (>60%);2: Moderate (40%-60%); 1: Low (<40%); 0: No Mapping

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.	**15**

	1.4 Molecular Orbital Theory for diatomic species of First transition Series. **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.	**15**
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**	**15**

	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	
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. Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectral methods.	**15**

Texts/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).

Course Code 23BPCH1T02	Course Title Organic Chemistry-I	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Illustrate the thermodynamic and kinetic requirements of reaction, determine mechanism of a reaction as well as describe concepts of acids and bases.	*L4*
CO 2	Discuss nucleophilic substitution reactions and aromaticity.	*L4*
CO 3	Elaborate concept of chirality and prochirality, molecules with two or more chiral centers, molecules with tri- and tetra- coordinate centers.	*L4*
CO 4	Describe the concept of oxidation and reduction of various functional groups by using different reagents.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	0	0	2
CO2	3	3	0	0	0	2
CO3	3	3	0	0	0	2
CO4	3	2	0	1	3	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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.	**15**

UNIT II	**Nucleophilic substitution reactions and Aromaticity** **2.1. Nucleophilic substitution reactions: (9 L)** **2.1.1. Aliphatic nucleophilic substitution:** S_Ni1, S_N2, S_N 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]	**15**
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	**15**

	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 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)	**15**

	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). **Dissolving metal reductions:** using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3 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

Course Code 23BPCH1T03	Course Title Analytical Chemistry-I	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Apply analytical techniques and quality practices, including error analysis, safety measures, accreditation standards, and GLP, for reliable chemical analysis.	*L3*
CO 2	Apply chemical principles to solve numerical problems in solution chemistry, stoichiometry, equilibria, pH, formation constant and redox systems for accurate quantitative analysis.	*L3*
CO 3	Apply principles of UV–Visible and IR spectroscopy, including FT and laser techniques, to interpret molecular absorption data for qualitative and quantitative analysis.	*L4*
CO 4	Utilize thermal analytical techniques and automated instrumentation to evaluate material properties, monitor chemical processes, and achieve precise quantitative and qualitative measurements.	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	1	3
CO2	3	2	0	0	0	2
CO3	3	3	1	0	0	3
CO4	3	3	2	1	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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	**15**

	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. **1.2.2Safety 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). **1.2.3Accreditations:** Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark) **1.2.4Good 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	**15**

	solution of a oxidizing / reducing agent and its relationship with molarity).	
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.	**15**

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.	**15**

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

Course Code 23BPCH1P01	Course Title Practicals based on 23BPCH1T02 and 23BPCH1T03	Credits 2

Course Outcomes:
After completing this course learner will be able to:

CO 1	Plan and perform one-step organic syntheses considering reaction stoichiometry, parameters, and safety aspects (MSDS).	*L4*
CO 2	Purify synthesized compounds by crystallization and evaluate product formation and purity using TLC, mass, and melting point analysis.	*L4*
CO 3	Perform quantitative estimation of metal ions and functional groups using volumetric and complexometric titration methods.	*L3*
CO 4	Analyze and interpret experimental data statistically to evaluate accuracy, precision, and efficiency of analytical techniques.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	2	1	3
CO2	3	3	1	0	1	3
CO3	3	2	0	0	1	3
CO4	3	3	2	0	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

Unit I

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

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:

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

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

ELECTIVE COURSES

Course Code 23BPCH1T04	Course Title Green Chemistry and Catalyst Chemistry	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Discuss 12 principles of green chemistry, green catalysts .	*L2*
CO 2	Describe synthesis, structure determination, uses of zeolites, catalysts in fine chemicals and pharmaceutical industries	*L3*
CO 3	Explain green synthesis of industrially important molecules.	*L3*
CO 4	Illustrate microwave assisted reactions in water.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	0	3	0	1
CO2	3	2	1	2	0	3
CO3	3	2	0	3	0	3
CO4	3	2	1	3	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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	**15**
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.	**15**

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.

Course Code 23BPCH1P02	**Practicals based on 23BPCH1T04**	**2 Credit**

Course Outcomes:
After completing this course learner will be able to:

CO 1	Perform preparation of biodiesel, soap, polymers, and cosmetics using standard laboratory procedures.	*L3*
CO 2	Characterize synthesized products and analyze samples such as food, drugs, water, and wastewater.	*L4*
CO 3	Assess environmental parameters including pesticide action, noise pollution, and water quality.	*L5*
CO 4	Apply chemical principles to compare green vs traditional synthesis and solve practical analytical problems	*L4*

CO-PO Mapping Table:

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);

0: No Mapping

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	0	2	1	3
CO2	3	3	1	1	0	3
CO3	3	2	0	3	0	2
CO4	3	2	1	3	0	2

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. **Polymer -** 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	Elective Course Title Analytical Biochemistry	Credits 2	No. of Lectures 30

Course Outcomes:
After completing this course learner will be able to:

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 proteins, lipids, and polysaccharides.	*L4*
CO 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.	*L5*
CO 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.	*L4*
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.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	0	0	0	2
CO2	3	3	1	0	0	3
CO3	3	3	1	0	0	3
CO4	3	2	1	0	1	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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** **Practical based on 23BPCH1T05**	**2 Credit**

Course Outcomes:
After completing this course learner will be able to:

CO 1	Perform qualitative and quantitative identification tests for carbohydrates, lipids, proteins, and nucleic acids.	*L3*
CO 2	Estimate biochemical parameters such as iodine number, saponification number, cholesterol, and protein content using standard reactions.	*L3*
CO 3	Isolate biomolecules like proteins and evaluate their characteristics through biochemical assays.	*L4*
CO 4	Apply biochemical analytical techniques to interpret results and assess the composition of biological samples.	*L4*

CO-PO Mapping Table:

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	0	0	1	3
CO2	3	2	0	0	1	3
CO3	3	3	1	0	1	3
CO4	3	3	1	0	0	3

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.

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
10. Academic publisher, Kolkata ISBN:9789383420674

Course Code 23BPCH1T06	Elective Course Title Physical Chemistry-I	Credits 2	No. of Lectures 30

Course Outcomes:

After completing this course learner will be able to:

CO 1	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.	*L4*
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	*L5*
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	*L4*
CO 4	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.	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	1	0	2
CO2	3	3	1	0	0	3
CO3	3	3	1	0	0	2
CO4	3	3	1	0	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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	**15**

	.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]	
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. **Batteries:** Alkaline fuel cells, Phosphoric acid fuel cells, 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]	**15**
	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**	**ELECTIVE** **Practical** **Practicals based on 23BPCH1T01 and 23BPCH1T06**	**2 Credit**

Course Outcomes:
After completing this course learner will be able to:

CO 1	Determine electrochemical and thermodynamic parameters such as ionic activity coefficients, dissociation constants, pKa values, heat of solution, and solubility products using potentiometric, conductometric, and solubility measurements.	*L4*
CO 2	Perform synthesis and characterization of coordination compounds such as tetraethylammonium metal complexes and bis(ethylenediamine) copper(II) sulfate.	*L3*
CO 3	Apply instrumental and analytical techniques to evaluate equilibrium constants and understand ionic equilibria in solution.	*L4*
CO 4	Interpret experimental data to relate theoretical chemical principles with experimentally determined thermodynamic and equilibrium properties.	*L5*

CO-PO Mapping Table:

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	0	0	3
CO2	3	2	0	0	1	3
CO3	3	3	1	0	0	3
CO4	3	3	1	0	0	3

Unit-I

Identification and estimation of the following: (**Any Four**)

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.

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

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 Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

23BPRM1T01	III **Course Title** Research Methodology for Chemistry and Environmental Science	**Credits** **4**	**No. of lectures in hrs.**

Course Outcomes:

CO 1	Identify and evaluate primary, secondary, and tertiary chemical information sources using print, digital databases, and advanced literature-search tools.	**L5**
CO 2	Apply scientific methodology, experimental design, and statistical techniques to analyze, interpret, and present chemical research data.	**L4**
CO 3	Prepare scientific reports, literature reviews, posters, and presentations while following ethical writing standards and avoiding plagiarism.	**L6**
CO 4	Implement safe laboratory practices, handle hazardous chemicals responsibly, and follow proper procedures for chemical storage, disposal, and environmental safety	**L3**

CO-PO Mapping Table:
Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	3	3	0	0	0
CO2	3	3	1	0	1	0
CO3	2	3	2	0	0	2
CO4	3	3	0	3	0	1

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 Scientific work, writing ethics, avoiding plagiarism.	**[15]**
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	**[15]**

	segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	
	References: 1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), Practical skills in Chemistry, 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

Course Code 23BPCH2T01	Course Title Inorganic Chemistry-II	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Analyze ligand substitution reactions in octahedral and square planar complexes, including mechanisms, trans-effects, and the role of isotopic labeling and 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 , stereochemistry of substitution reactions of octahedral complexes.	*L6*
CO 2	Understand the principles of the 18-electron and 16-electron rules, along with electron counting methods , preparation and properties of various OMCs. Apply Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) to understand the structure and bonding in organometallic compounds.	*L2, L5*
CO 3	Understand the structure, bonding, and chemistry of various inorganic cluster and cage compounds and Study the chemistry of metal clusters. Explore inorganic ring and chain compounds.	*L5*
CO 4	Explain the structures and mechanisms of biological oxygen carriers and explore the activation of oxygen in biological systems, focusing on enzymes like mono-oxygenases and oxidases enzymes, concept of nitrogen fixation, metal ion transport and storage, medicinal application of cis platin and related compounds.	*L2, L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	2	3
CO2	3	3	2	3	2	3
CO3	3	3	3	3	2	3
CO4	3	3	3	3	2	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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.	**15**

	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.)	
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 **(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).	**15**
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.	**15**

UNIT IV	**Bioinorganic Chemistry** **4.1.** 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. **4.2.** 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. **4.3.** Copper containing enzymes- superoxide dismutase, tyrosinase and laccase: catalytic reactions and the structures of the metal binding site **4.4.** Nitrogen fixation-nitrogenase, hydrogenases **4.5.** Metal ion transport and storage:Ionophores, transferrin, ferritin and metallothionins 4.6. edicinal applications of cis-platin and related compounds	**15**

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. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.
5. R.C Mehrotra and A.Singh, Organometallic Chemistry- A

a. R. W. Hay, *Bioinorganic Chemistry,* Ellis Harwood, England, 1984.
b. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry*,* First South Indian Edition, Viva Books, New Delhi, 1998.

6. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014

Course Code 23BPCH2T02	Course Title Organic Chemistry-II	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Discuss the generation and alkylation of carbon nucleophiles and analyze the mechanisms of aldol, Mannich, Knoevenagel, and intramolecular aldol reactions.	*L4*
CO 2	Understand reactions such as Baylis-Hilman, McMurry coupling, Corey-Fuchs, Nef, Passerini reaction and concerted, cationic, anionic rearrangement reaction with mechanisms, stereochemistry (if applicable) and applications.	*L2*
CO 3	Understand the formation of molecular orbitals (σ and π) using the LCAO method, including nodal planes and energy levels in π-MOs, and explore the principles and applications of UV and IR spectroscopy in the analysis of organic compounds.	*L3*
CO 4	Understand the principles and applications of proton NMR, 13C NMR spectroscopy, and mass spectrometry. Use combined NMR and mass spectrometry data to deduce the structure of organic compounds.	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	0	0	3
CO2	3	2	0	0	0	2
CO3	3	3	1	0	0	3
CO4	3	3	2	0	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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;	**15**

	Mannich reaction. **1.2.3.** Amine catalyzed condensation reaction: Knoevenagel reaction. Acylation of carbanions. [Reference Books: 1-11]	
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]	**15**
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,	**15**

	(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 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	**15**

	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.

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Course Code 23BPCH2T03	Course Title Analytical Chemistry-II	Credits 4	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

CO 1	Apply chromatographic principles, including GC and HPLC techniques, to achieve efficient separation, detection, and quantitative/qualitative analysis of chemical mixtures.	*L4*
CO 2	Employ X-ray spectroscopic, mass spectrometric, and radioanalytical methodologies for precise structural elucidation, quantitative determination, and characterization of chemical entities.	*L4*
CO 3	Utilize advanced surface and atomic spectroscopic techniques, including SEM, TEM, STM, ESCA, Auger, AAS, and plasma-based methods, for high-resolution structural and compositional analysis of materials.	*L4*
CO 4	Apply electroanalytical techniques, including potentiometry, polarography, electrogravimetry, and coulometry, to solve quantitative numerical problems and achieve precise chemical analysis.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	0	0	3
CO2	3	2	2	0	0	3
CO3	3	3	2	1	0	3
CO4	3	2	1	1	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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. Optimization of chromatographic conditions**.[5 L]** **1.3 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]** **High Performance Liquid Chromatography (HPLC):** Normal	**15**

	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] **Radioanalytical Methods –** recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. **[5 L]**	**15**
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.	**15**
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]**	**15**

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

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)

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).

Course Code 23BPCH2P01	Course Title Practicals based on 23BPCH2T02 and 23BPCH2T03	Credits 2

Course Outcomes:
After completing this course learner will be able to:

CO 1	Separate components of binary mixtures using micro-scale, physical, and chemical separation techniques.	*L3*
CO 2	Characterize, purify, and confirm the identity of separated components through derivative preparation and determination of physical constants.	*L4*
CO 3	Determine composition and purity of substances using potentiometric, pH-metric, conductometric, and spectrophotometric techniques.	*L4*
CO 4	Apply electroanalytical and spectroscopic methods to analyze mixtures of metal ions and acids with accuracy and precision.	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	0	0	0	3
CO2	3	3	1	0	0	3
CO3	3	3	1	0	0	3
CO4	2	2	1	1	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

Unit 1

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.

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 $BaCl_2$.

5. To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titration with perchloric acid in a non aqueous medium using glass calomel system potentiometrically.
6. To determine the amount of nitrite present in the given water sample colorimetrically.
7. Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically.
8. To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method

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

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

ELECTIVE COURSES

Course Code 23BPCH2T04	ELECTIVE Course Title **Polymer Chemistry**	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

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.	*L4*
CO 2	Study the physical, thermal, flow, and mechanical properties of various polymers. Learn the preparation, structure, properties, and applications of polymers.	*L3*
CO 3	Understand the concept of crystallization and crystallinity in polymers, and the factors affecting crystalline melting points.	*L3*
CO 4	Explain different methods for determining the molecular weight of polymers, such as end-group analysis, viscometry, light scattering, and osmotic pressure.	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	0	0	3
CO2	3	2	0	1	0	3
CO3	3	2	0	0	0	2
CO4	3	3	1	0	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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.	

Course Code **23BPCH2P02**	**Practicals based on 23BPCH2T04**	**2 Credits**

Course Outcomes:
After completing this course learner will be able to:

CO 1	Synthesize polymers using various polymerization methods after purifying monomers.	*L3*
CO 2	Determine polymer molecular weight and structural features using viscometry, end-group analysis, and mechanical testing.	*L4*
CO 3	Analyze polymer structure and composition using instrumental techniques such as IR spectroscopy and electrophoresis.	*L4*
CO 4	Perform quantitative polymer analyses, including hydroxyl number and formaldehyde estimation, to interpret polymer properties.	*L4*

CO-PO Mapping Table:

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%); 1: Low (<40%);
0: No Mapping

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	0	1	1	3
CO2	3	3	1	0	0	3
CO3	3	3	1	0	0	3
CO4	3	3	1	0	0	3

(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.NaNO2 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 23BPCH2T05	ELECTIVE Course Title Environmental Chemistry	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

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	*L3*
CO 2	Classify common drugs and their therapeutic uses, including analgesics, anthelmintics, antibiotics, anti-inflammatory agents, antimalarials, narcotics, expectorants, sedatives, and vitamins	*L2*
CO 3	Understand the causes, effects, and control measures for various types of pollution, including air, water, soil, marine, noise, thermal, and nuclear pollution	*L3*
CO 4	Describe the significance of natural resources, including forests, water, minerals, food, energy, and land resources	*L2*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	0	3
CO2	3	1	0	0	0	2
CO3	3	2	0	3	0	2
CO4	3	1	0	3	0	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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**

UNIT II	**ENVIRONMENTAL POLLUTION** **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 23BPCH2P03	**PRACTICAL** **Based on 23BPCH2T05**	**2 Credit**
	Internship /Field project/ current case studies	

Course Outcomes:
After completing this course learner will be able to:

CO 1	Apply theoretical knowledge in real-world professional environments through hands-on internship experience.	*L3*
CO 2	Develop practical skills, technical competencies, and problem-solving abilities relevant to industry requirements.	*L4*
CO 3	Demonstrate professional behavior, teamwork, and effective communication in workplace settings.	*L3*
CO 4	Analyze workplace tasks, document findings, and prepare structured reports based on internship activities	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	3
CO2	3	3	1	0	1	3
CO3	2	1	1	0	3	3
CO4	2	3	2	0	1	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

Course Code 23BPCH2T06	Elective Course Title Physical Chemistry-II	Credits 2	No. of lectures

Course Outcomes:
After completing this course learner will be able to:

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.	*L4*
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.	*L4*
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.	*L4*
CO 4	Describe the kinetics of reactions in the solid state, understanding factors affecting reaction rates and applying various rate laws.	*L3*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	0	0	2
CO2	3	3	1	1	0	2
CO3	3	3	1	0	0	3
CO4	3	2	0	0	0	2

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

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). 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**
	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. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013. 11. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.	

Course Code 23BPCH2P04	Practicals based on 23BPCH2T01 and 23BPCH2T06	2 Credit

Course Outcomes:
After completing this course learner will be able to:

CO 1	Analyze chemical reactions and physical phenomena through non-instrumental experiments such as polar plots, phase diagrams, and reaction kinetics.	*L4*
CO 2	Apply instrumental techniques like potentiometry, conductometry, pH measurement, and spectrophotometry for quantitative chemical analysis.	*L3*
CO 3	Perform qualitative and quantitative analysis of alloys and metal ions using methods like iodometry and potentiometry.	*L3*
CO 4	Interpret experimental data to determine chemical constants, compositions, and reaction parameters, linking theory with practical observations.	*L4*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	0	0	2
CO2	3	2	1	0	0	3
CO3	3	2	0	0	1	3
CO4	3	3	1	0	0	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

Unit I	**Non – instrumental: (Any two)** Polar plots of atomic orbitals such as 1*s*, 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.	30

Unit II	**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.	
	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.	

23BPCH2P05	Internship/Training/Field Project in Chemistry	Credits 4	No. of Hours: 120

Course Outcomes:
After completing this course learner will be able to:

CO 1	Apply theoretical knowledge to real-world workplace practices through hands-on exposure in professional settings.	*L3*
CO 2	Develop practical skills, technical competencies, and problem-solving abilities relevant to industry requirements.	*L4*
CO 3	Demonstrate effective communication, teamwork, and professional ethics during field or on-job training activities.	*L3*
CO 4	Analyze workplace challenges and propose solutions through field projects, case studies, or internship experiences	*L5*

CO-PO Mapping Table:

COs (Course Outcomes)	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	0	1	3
CO2	3	3	1	0	1	3
CO3	2	1	1	0	3	3
CO4	2	3	2	0	1	3

Grading will be as:
3: High (>60%);
2: Moderate (40%-60%);
1: Low (<40%);
0: No Mapping

General Guidelines:

1. The OJT/FP topic may be undertaken from any topic relevant to organic chemistry with a precise objective.
2. Each of the student must undertake an OJT/FP individually based on field-work/field-survey/laboratory work.
3. Student must remain presented at the time of review meeting scheduled by research guide.
4. Structure of report should contain the following chapter: Title; Abstract; Aim, Objectives, and Rationale; Introduction and Review of Literature; Materials and Methodology; Observation and Result; Discussion and Conclusion; References.
5. Student should prepare a PowerPoint presentation (PPT) of research project and it should be presented in front of external examiner.
6. Duly signed hard copy of report and PPT should be submitted to the Department/College.
7. In case of OJT, detail report of attendance, record and acknowledgement /certificate issued from the organization to be submitted in college.

Evaluation and Examination Scheme

Evaluation Scheme 60 (Theory):40 (Internal)
Internals Based on Unit 1 / Unit 2 / Unit 3/ Unit 4

Assignments/ Tutorials/Class Test	Ppt/video Presentation or any other activities	Active Participation & Leadership qualities	Total
15	15	10	40

Theory Examinations: For Paper 1, Paper 2, Paper 3 and Elective

Suggested Format for Mandatory Question paper

23BPCH_T0_/0_/20_

Duration: 2 hr. 30 min **Total Marks: 60**

N.B.

1. **All questions are compulsory**
2. **Draw neat labelled diagram wherever necessary**
3. **All questions carry equal marks**

Q.1.	**(A)**		**Attempt any two** **CO 1**	**8**
		(I)		
		(II)		
		(III)		
		(IV)		
Q.1.	**(B)**	**(I)**	**Attempt any one**	**4**
		a		
		b		
		(II)	**Attempt any one**	**3**
		a		
		b		
Q.2.	**(A)**		**Attempt any two** **CO 2**	**8**
		(I)		
		(II)		
		(III)		
		(IV)		
Q.2.	**(B)**	**(I)**	**Attempt any one**	**4**
		a		
		b		
		(II)	**Attempt any one**	**3**
		a		

		b		
Q.3.	(A)		Attempt any one CO 3	8
		(I)		
		(II)		
		(III)		
		(IV)		
Q.3.	(B)	(I)	Attempt any one	4
		a		
		b		
		(II)	Attempt any one	3
		a		
		b		
Q.4.	(A)		Attempt any one CO 4	8
		(I)		
		(II)		
		(III)		
		(IV)		
Q.4.	(B)	(I)	Attempt any one	4
		a		
		b		
		(II)	Attempt any one	3
		a		
		b		
			**********	

Suggested Format for Elective Question paper:

23BPCH_T0_/0_/20_

Duration: 1 hr. 30 min **Total Marks: 30**

N.B.

1. **All questions are compulsory**
2. **Draw neat labelled diagram wherever necessary**
3. **All questions carry equal marks**

Q.1.	(A)		Attempt any two CO 1	8
		(I)		
		(II)		
		(III)		
		(IV)		
Q.1.	(B)	(I)	Attempt any one CO 2	4
		a		
		b		
		(II)	Attempt any one	3

		a		
		b		
Q.2.	**(A)**		**Attempt any two** **CO 3**	**8**
		(I)		
		(II)		
		(III)		
		(IV)		
Q.2.	**(B)**	**(I)**	**Attempt any one** **CO 4**	**4**
		a		
		b		
		(II)	**Attempt any one**	**3**
		a		
		b		

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Semester End Practical Examination:
Practical examination of each paper for 50 marks will be held for 4 hours.

VPM's B. N. BANDODKAR COLLEGE OF SCIENCE (AUTONOMOUS), THANE
DEPARTMENT OF ENVIRONMENTAL SCIENCE
M.Sc. I CHE Regular Practical Examination Semester-I _____Month_____Year

Date: Time: Max. Marks: 50

Paper Course Code:
Paper Course Title:

Distribution of marks

Q.1. Perform the given experiment and interpret the results.	15
Q.2. Perform the given experiment and interpret the results.	15
Q.3. Perform the given experiment and interpret the results/Field Visit Report.	10
Q.4. Viva-Voce	05
Q.5. Certified Journal	05

(This is sample paper pattern for practical. It can be changed by the department/college as per the prescribed practical given in syllabus)

Marks Distribution and Passing Criterion for Each Semester

Theory						Practical		
Course Code SEM I / SEM II	**Internal**	**Min marks for passing**	**Theory Examination**	**Min marks for passing**	**Total**	**Course Code**	**Practical Examination**	**Min marks for passing**
23BPCH1T01/ 2T01	40	16	60	24	100	-	-	-
23BPCH1T02/ 2T02	40	16	60	24	100	-	-	-
23BPCH1T03/ 2T03	40	16	60	24	100	-	-	-
Laboratory 1	-	-	-	-	-	23BPCH1P01/ 2P01	50	20
23BPCH1T04 or 1T05/ 2T04 or 2T05	20	08	30	12	50	-	-	-
Laboratory 2	-	-	-	-	-	23BPCH1P02 or 1P03/ 2P02 or 2P03	50	20
23BPRM1T01 (SEM I)	40	16	60	24	100	-	-	-
OJT/FP (SEM II)	-	-	-	-	-	23BPCH2P04	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

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