Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR ARTS, COMMERCE & SCIENCE COLLEGE, NEW PANVEL

(AUTONOMOUS COLLEGE)

Re-accredited 'A+' Grade by NAAC

'College with Potential for Excellence' Status Awarded by UGC

'Best College Award' by University of Mumbai

NEP 2020

Syllabus for M.Sc.-I in Organic Chemistry

Programme: M.Sc.

Course: M.Sc.-I Analytical Chemistry

Programme Code: MSCAC1019

Choice Based Credit, Grading and Semester System (60:40)

w.e.f. Academic Year 2023-2024

Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR
ARTS, COMMERCE & SCIENCE COLLEGE, NEW PANVEL
(AUTONOMOUS COLLEGE)

Approved Syllabus of M.Sc-I Analytical Chemistry

Sr. No.	Heading	Particulars
1	**Title of Course**	M.Sc.-I Organic Chemistry
2	**Eligibility for Admission**	The B.Sc. degree examination of the University of Mumbai with chemistry 6 units or 3 units or degree of any other university recognized as equivalent thereto.
3	**Passing marks**	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	**Ordinances/Regulations (if any)**	------
5	**No. of Semesters**	One year/Two semester
6	**Level**	P.G. part-I
7	**Pattern**	Semester (60:40)
8	**Status**	Revised
9	**To be implemented from the Academic year**	2023-2024

BOS Chairman **Principal**

After completion of M.Sc. programme students will acquire

S. N.	After completion of M.Sc. program students will acquire	Graduate Attribute
PO1	An ability to identify and describe broadly accepted methodologies of science, and different modes of reasoning.	Disciplinary knowledge
PO2	An ability to demonstrate proficiency in various instrumentation, modern tools, advanced techniques and ICT to meet industrial expectations and research outputs.	Disciplinary knowledge/Digital literacy
PO3	An ability to identify problems, formulates, and proves hypotheses by applying theoretical knowledge and skills relevant to the discipline.	Problem-solving
PO4	An ability to be articulate thoughts, research ideas, information, scientific outcomes in oral and in written presentation to range of audience.	Communication skills
PO5	A capacity for independent, conceptual and creative thinking, analysis and problem solving through the existing methods of enquiry.	Problem solving
PO6	Skills required for cutting edge research, investigations, field study, documentation, networking, and ability to build logical arguments using scholarly evidence.	Research skills
PO7	An ability to portray good interpersonal skills with ability to work collaboratively as part of a team undertaking a range of different team roles	Teamwork
PO8	The ability to understand ethical responsibilities and impact of scientific solutions in global, societal and environmental context and contribute to the sustainable development	Moral and ethical awareness/ multicultural competence
PO9	An ability to demonstrate leadership, to take action and to get others involved.	Leadership
PO10	An openness to and interest in, life-long learning through directed and self-directed study	Self-directed learning
PO11	An ability to translate the knowledge and demonstrate the skills required to be employed and successful professional development.	Life-long learning

After completion of the M.Sc. programme students will acquire

Programme: M.Sc. Analytical Chemistry

PSOs No	After completing the programme in M.Sc. Analytical Chemistry, Students will able to:	Graduate Attribute
PSO1	Understand the principles, and methodologies of analytical techniques and their applications in industrial, social, and environmental contexts.	Disciplinary knowledge/ Multicultural competence
PSO2	Integrate and apply the knowledge of the analytical methods, tools, and ICT facilities to the range of scientific problems using critical thinking and communicate results effectively.	Problem-solving
PSO3	Demonstrate research skills in the core and allied areas of chemical sciences, professionalism and ethical conduct.	Research skills/ lifelong learning

Masters in Science (Analytical Chemistry)
Syllabus for Semester I and II

Preamble:

Master of Science (M.Sc.) in Analytical Chemistry is a post-graduate course of the department of Chemistry, Changu Kana Thakur Arts, Commerce & Science College, New Panvel (Autonomous).

There are two P.G. programmes in Chemistry, namely the M.Sc. programme in Organic Chemistry and the M.Sc. programme in Analytical Chemistry. Both P.G. programmes are equivalent in all respects for employment and higher studies. Each of these two P.G. programmes shall extend over a period of two academic years comprising of four semesters. The syllabi and scheme of examinations of these two programmes are detailed below. The theory and practicals of courses for two semesters of the two programmes are the same. Chemistry is a fundamental science and has contributed immensely to the improvement of the life of human beings by providing many human requirements and essentialities. Chemistry is important to the world economy as well. The developments in Chemistry during the last few decades are phenomenal. It is also seen that these developments are crossing the traditional vertical boundaries of scientific disciplines; more inclination is seen towards biological sciences. New branches of chemistry are emerging and gaining importance, such as bioorganic chemistry, materials chemistry, computational chemistry, etc.

The practice of Chemistry at an industrial scale is also undergoing radical changes and is more or more based on a deep understanding the chemical phenomena. The emerging Chemical Technologies are highly science-based. The aid of computers has not only accelerated growth in the practice of Chemistry but revolutionized the entire field. A chemist cannot isolate himself from other disciplines. Thus, after a long span of more and more specialization in graduate and post-graduate syllabi, a symbiotic interdisciplinary approach now seems to be more relevant.

M. Sc-I Analytical Chemistry

For the subject of chemistry, there shall be four papers for 60 lectures each comprising of four units of 15 L each.

Semester-I

1. Paper-I / Physical Chemistry,
2. Paper- II / Organic Chemistry
3. Paper- III /Analytical Chemistry
4. Paper- IV/Inorganic Chemistry-I, II (Electives)
5. Paper- V/Research Methodology

Semester-II

1. Paper-I / Physical Chemistry,
2. Paper- II / Organic Chemistry
3. Paper- III /Analytical Chemistry
4. Paper- IV/Inorganic Chemistry-I, II (Electives)
5. Paper/On Job Training

Scheme of Examination

The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part and by conducting the Semester End Examinations with 60% marks in the second part. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below-

A) Internal Assessment: 40 % 40 Marks

Sr. No.	Particular	Marks
01	One periodical class test / online examination to be conducted in the given semester	20 Marks
02	Any One tools out of these (15 Marks each) 1. Group/ Individual Project 2. Presentation and write up on the selected topics of the subjects / Case studies. 3. Test on Practical Skills 4. Open Book Test 5. Quiz	15 Marks
03	Active participation	05

Question Paper Pattern

(Periodical Class Test for the Courses at Under Graduate Programmes)

Maximum Marks: 20 Duration: 40 Minutes
Questions to be set: 02
All Questions are Compulsory

Question No.	Particular	Marks
Q-1	Match the Column / Fill in the Blanks / Multiple Choice Questions/ Answer in One or Two Lines (Concept based Questions) (1 Marks / 2 Marks each)	10 Marks
Q-2	Answer in Brief (Attempt any Two of the Three) (5 Marks each)	10 Marks

B) Semester End Examination: 60 % 60 Marks

- Duration: The examination shall be of $2\frac{1}{2}$ hours duration.

Question Paper Pattern

Theory question paper pattern
1. There shall be five questions each of 12 marks. 2. All questions shall be compulsory with internal options. 3. Questions may be subdivided into sub-questions a, b, c… and the allocation ofmarks depends on the weightage of the unit.

Passing Standard

The learners shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment and Semester End Examination. The learners shall obtain a minimum of 40% marks (i.e. 16 out of 40) in the Internal Assessment and 40% marks in Semester End Examination (i.e. 24 Out of 60) separately, to pass the course and a minimum of grade D in each project wherever applicable to pass a particular semester.

❖ Guidelines and Evaluation pattern for project work (100 Marks)

Introduction

Inclusion of project work in the course curriculum of the M.Sc. programme is one of the ambitious aspects in the programme structure. The main objective of inclusion of project work is to inculcate the element of research work challenging the potential of learner as regards to his/ her eager to enquire and ability to interpret particular aspect of the study in his/ her own words. It is expected that the guiding teacher should undertake the counselling sessions and make the awareness among the learners about the methodology of formulation, preparation and evaluation pattern of the project work.

- There are two modes of preparation for project work

1. Project work based on research methodology in the study area
2. Project work based on an internship in the study area

I	**Theory:** The semester-end examination for theory coursework will be conducted as per the following scheme.		
	Each theory paper shall be of two- and two-and-a-half-hour duration.		
	All questions are compulsory and will have internal options.		
	Q-1	From Unit – I (having internal options.) 12 M	
	Q-2	From Unit – II (having internal options.) 12M	
	Q-3	From Unit – III (having internal options.) 12M	
	Q-4	From Unit – IV (having internal options.) 12M	
	Q-5	Questions from all the FOUR Units with equal weightage of marks allotted to each Unit. 12 M	
II	**Practical**	The Semester End Examination for Practical course work will be conducted as per the following scheme.	
Sr. No.	Particulars of External Practical Examination		**Marks%**
1	Laboratory Work		80
2	Journal		10
3	Viva		10
	TOTAL		**100**

Choice Based Credit, Grading and Semester System (CBCGS)
To be implemented from the Academic year 2023-24

M.Sc.-I Analytical Chemistry
Semester- I

Course Code	Unit	Topics	Credits	L / Week
PSC1PC1	I	Thermodynamics-I	4	1
	II	Quantum Chemistry		1
	III	Chemical Dynamics-I		1
	IV	Electrochemistry		1
PSC1OC1	I	Addition reactions	4	1
	II	Nucleophilic substitution reactionsand Aromaticity		1
	III	Stereochemistry		1
	IV	Oxidation and Reduction		1
PSC1AC1	I	Language of Analytical Chemistry	4	1
	II	Quality in Analytical Chemistry		1
	III	Optical Methods		1
	IV	Thermal Methods		1
PSC1PR1	-	Practical Course Practical (Physical Chemistry + Analytical Chemistry)	8	16
PSC1IC2 Elective-I	I	Chemical Bonding	2	1
	II	Molecular Symmetry and GroupTheory		1
Elective-2 PSC1IC2	III	Materials Chemistry and Nanomaterials	2	1
	IV	Characterization of Coordination Compounds		
PSC1PR2		Practicals of Practicals (Inorganic Chemistry + Organic Chemistry)	2	8

PSC1RM1	**I**	**Research and Literature Survey**	**4**	**1**
	II	**Data Analysis**		**1**
	III	**Methods of Scientific Research and Writing**		**1**
	IV	**Chemical Safety and Ethical handling of Chemicals**		**1**

Choice Based Credit, Grading and Semester System (CBCGS)To be implemented from the Academic year 2023-2024

M.Sc.-I Analytical Chemistry Semester- II

Course Code	Unit	Topics	Credits	L / Week
PSC2PC2	I	Chemical Thermodynamics II	4	1
	II	Quantum Chemistry II		1
	III	Chemical Kinetics and Molecular Reaction Dynamics		1
	IV	Solid State Chemistry and Phase Equilibria		1
PSC2OC2	I	Alkylation of NucleophilicCarbon Intermediates Reaction of carbon nucleophiles with carbonyl groups	4	1
	II	Reactions and Rearrangements		1
	III	Eliminations Reactions and Organometallic Chemistry		1
	IV	NMR spectroscopy and Mass spectrometry		1
PSC2AC2	I	Chromatography	4	1
	II	X-ray spectroscopy, Mass spectrometry, Radioanalytical Methods		1
	III	• SurfaceAnalytical Techniques • Atomic Spectroscopy		1
	IV	Electroanalytical Methods		1
PSC2PR1	-	Practical Course Practical (Physical Chemistry + Analytical Chemistry)	8	16
Elective-I PSC2IC2	I	Inorganic Reaction Mechanism	4	1
	II	Organometallic Chemistry of Transitionmetals		1
Elective-II PSC2IC2	III	Environmental Chemistry		1
	IV	Bioinorganic Chemistry		1

PSC2PR2		**Practicals Course Practical's (Inorganic Chemistry + Organic Chemistry)**	**2**	**8**
PSC2OJT	**OJT**	**On Job Training**	**4**	**60**

SEMESTER-I

Course Description	
Semester	**I**
Course Name	**Physical Chemistry**
Course Code	**PSC1PC1**
Eligibility for Course	**T.Y.B.Sc. (Chemistry)**
Credit	**4**
Hours	**60**

Course Objectives

1. To develop laboratory competence in relating physical aspects in chemistry
2. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.
3. To provide the students with sound preparation for requirement of modern industry and provide competency in basic academic research as well as a cohesive, clearly structured overview of Chemistry

Course Outcomes

After successful completion of this course students will be able to

Sr. No	Course Outcomes	Bloom Taxonomy Level (BLT)
CO1	Prove Maxwell relations and its significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient and inversion temperature. Apply Third law of Thermodynamics to find out absolute entropy	Understand
CO2	Make use of quantum mechanics for Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions. Particle in a one, two- and three-dimensional box	Apply
CO3	Define, understand basic terms of Chemical Dynamics i.e. rate constant, order of reaction, molecularity of reaction also compare Composite Reactions and Polymerization reactions	Evaluate

CO4	Make use of of Colloids and Surface Phenomena in daily applications	Apply

Unit	Course Description	Hrs
1.	**Thermodynamics-I**	
	1.1. State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; its significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants. [8L] 1.2. Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity, standard molar entropies and their dependence on molecular mass and molecular structure, residual entropy. [7L]	15
2.	**Quantum Chemistry**	
	2.1. Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics. 2.2. Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions. 2.3. Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system such as, position, linear momentum, angular momentum, total energy, eigen functions, eigen values and eigen value equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system, Postulates of Quantum Mechanics, Schrodinger‟s Time independent wave equation from Schrodinger‟s time dependent wave equation. **2.4.** Application of quantum mechanics to the following systems: **a)** Free particle, wave function and energy of a free particle. **b)** Particle in a one, two and three dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. **c)** Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula.	15
3.	**Chemical Dynamics-I**	
	3.1. Composite Reactions: Recapitulation: Rate laws, Differential rate equations Consecutive reactions,	15

	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. 3.2. Polymerization reactions: Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization, Kinetic chain length and estimation of average no of monomer units in the polymer produced by chain polymerization. 3.3. Reaction in Gas Phase Unimolecular Reactions: Lindeman-Hinshelwood theory, Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory.	
4.	**Colloids and Surface Phenomena**	
	Colloidal Systems-Sols, Lyophilic and lyophobic sols, properties of sols, coagulation. Sols of surface-active reagents, surface tension and surfactants, electrical phenomena at interfaces including electrokinetic effects, micelles, reverse micelles, solubilization. Thermodynamics of micellization, critical micelle concentration, factors affecting critical micelle concentration (cmc), experimental methods of cmc determination, Micellar catalysis. Adsorption, adsorption isotherms, methods for determining surface structure and composition, BET equation, surface area determination, Gibbs adsorption equation and its verification. Application of photoelectron spectroscopy, ESCA and Auger spectroscopy to the study of surfaces. Numerical Problems	**15**

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1. Peter Atkins and Julio de Paula, Atkin‟s Physical Chemistry, 7th Edn., Oxford University Press, 2002.

2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.

3. Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rd Edn., John Wiley and Sons (Asia) Pte.Ltd., 2002.

4. Ira R. Levine, Physical Chemistry, 5th Edn., Tata McGraw-Hill New Delhi, 2002.

5. G.W. Castellan, Physical Chemistry, 3rd Edn., Narosa Publishing House, New Delhi, 1983.

6. S. Glasstone, Text Book of Physical Chemistry, 2nd Edn., McMillan and Co. Ltd., London, 1962

7. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.

8. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.

9. R.K. Prasad, Quantum Chemistry, 2nd Edn., New Age International Publishers, 2000.

10. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.

11. W.G. Davis, Introduction to Chemical Thermodynamics – A Non – Calculus Approach, Saunders, Philadelphia, 19772.

12. Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.

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14. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.

15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992. 16. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.

17. Physical Chemistry by Gurtu and Gurtu

18. A Text book of Physical Chemistry by K L kapoorVol5 , 2nd Edn

Physical Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Physical Chemistry**
Course Code	**PSC1PR1**
Eligibility for Course	**T.Y. B.Sc. (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No.	COs	Bloom Taxonomy Level (BLT)
CO1	Know the principles of different instruments like Potentiometry, Conductometry, pH Metry.	Understand
CO2	Determine the heat of solution of sparingly soluble acid and identify the reaction between acetone and iodine.	Apply

Sr. No.	Course Description	Hrs
1.	To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperature.	4
2.	To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature.	4
3.	To investigate the reaction between acetone and iodine. Or Kinetics of reaction between bromate and iodide. (New expt.)	4
4.	To study the variation in the solubility of $Ca(OH)_2$ in presence of NaOH and hence to determine the solubility product of $Ca(OH)_2$ at room temperature.	4
5.	Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?	4
6.	To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.	4
7.	To study the effect of substituent on the dissociation constant of acetic acid conductometrically.	4
8.	To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.	4
9.	To verify Ostwald‟s dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.	4
10.	Determination of dissociation constant of dibasic acid.	

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.

Course Description	
Semester	**I**
Course Name	**Organic Chemistry**
Course Code	**PSC1OC1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**4**
Hours	**60**

Course Objectives

4. To study the basics of addition reactions and their applications.
5. To study stereochemistry in man detail
6. To study the different reagents in the organic transformation.
7. To understand the role of carbon nucleophiles in organic synthesis

Course Outcomes

After successful completion of this course, students will be able to

Sr. No.	CO	Bloom Taxonomy Level (BLT)
CO1	Understand the types of addition reaction and their applications	Remember
CO2	Summarize the various aspects of aromaticity, aliphatic and aromatic nucleophilic substitution reactions with their mechanism and examples.	Understand
CO3	Apply the concept of Configurational descriptors (R,S nomenclature) to chiral centers in Organic compounds	Apply
CO4	Predict the mechanism, selectivity, importance and applications of oxidizing and reducing agent	Apply

Unit	Course Description	Hrs
1.	**Addition Reactions:** 1.1 Addition reactions to carbon carbon multiple bonds -Mechanism and Stereochemical aspects of addition reaction Involving electrophile 1.2 Structural Effect and reactivity: Halogenation, Hydrohalogenation, Hydration, Hydroxylation, Hydroboration, Epoxidation, Carbene addition and Ozonolysis. 1.3. Acids and Bases: Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity and solvation.	15

	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.	
2.	**Nucleophilic substitution reactions and Aromaticity:** 2.1. Nucleophilic substitution reactions: (9 L) 2.1.1. Aliphatic nucleophilic substitution: SN1, SN2, SNi reactions, mixed SN1 and SN2 and SET mechanisms. SN 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.SNcA, SN1‟ and SN2‟ reactions.SN at sp2 (vinylic) carbon. 2.1.2. Aromatic nucleophilic substitution: SNAr, SN1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. 2.1.3. Ester hydrolysis: Classification, nomenclature and study of mechanisms of acid and base catalyzed hydrolysis with suitable examples (Any two). Orientation and Reactivity-Effect of Substrate, Leaving group and attacking nucleophile 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 (C60)	15
3.	**Stereochemistry:** 3.1. Concept of Chirality: Recognition of symmetry elements. 3.2. 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. Stereo-descriptors: R, S, for chiral centres in acyclic and cyclic compounds. 3.3. 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. 3.4. 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) propseudoasymmetric centre. Symbols for enantiotopic and diastereotopic faces. E, Z nomenclature Resolution of Racemic mixtures	15

4.	**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 K2Cr2O7/H2SO4 (Jones reagent), CrO3-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 HIO4; cycloalkanones using CrO3; aromatic rings using RuO4 and NaIO4. 4.1.4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH2 to CO by SeO2, oxidation of arylmethanes by CrO2Cl2 (Etard oxidation). 4.1.5. Oxidation of aldehydes and ketones: with H2O2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) 4.2. Reduction: General mechanism, selectivity, and important applications of the following reducing reagents: 4.2.1. Reduction of CO to CH2 in aldehydes and ketones-Clemmensen reduction, WolffKishner reduction and Huang-Minlon modification. 4.2.2. Metal hydride reduction: Boron reagents (NaBH4, NaCNBH3, diborane, 9-BBN, Na(OAc)3BH, aluminium reagents (LiAlH4, DIBAL-H, Red Al, L and K- selectrides). 4.2.3. NH2NH2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzschdihydropyridine). 4.2.4. Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.	**15**

Organic Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Organic Chemistry**
Course Code	**PSC1PR2**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	COs	Bloom Taxonomy Level (BLT)
CO1	Plan preparation of organic compounds	Apply
CO2	Demonstrate the skill of purification of organic compounds by recrystallization and sublimation methods.	Understand
CO3	Apply the thin layer chromatography technique to check the purity of the synthesized product.	Apply
CO4	Can Sketch the structure of organic compounds using software Chem Biodraw.	Apply

Sr. No.	Course Description	Hrs
1.	One step preparations	40
2.	(1.0 g scale) 1. Bromobenzene to p-nitrobromobenzene	
3.	2. Anthracene to anthraquinone	
4.	3. Benzoin to benzil	
5.	4. Anthracene to Anthracene maleic anhydride adduct	
6.	5. 2-Naphthol to BINOL	
7.	6. p-Benzoquinone to 1,2,4-triacetoxybenzene	
8.	7. Ethyl acetoacetate to 3-methyl-1-phenylpyrazol-5-one	
9.	8. Preparation of benzilic acid from benzil	
10	9. Preparation of p-iodonitrobenzene from p-nitroaniline	
11.	11. Use of Computer - Chem Draw-Sketch, ISI – Draw: Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name, Get ^{1}HNMR and ^{13}C. Students can able to draw the one name reaction and its reaction mechanism.	

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4. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.

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10. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, AcademicPress.

11. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.

12. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya ShankarSingh, Pearson Education.

13. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.

14. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, CambridgeUniversity Press.

15. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati

Prakashan.Organic Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Analytical Chemistry**
Course Code	**PSC1AC1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**4**
Hours	**60**

Course Objectives

1. To develop laboratory competence in relating chemical structure to spectroscopic phenomena.
2. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.
3. To provide the students with a sound preparation for the requirement of modern industry and provide competency in basic academic research as well as a cohesive, clearly structured overview of Chemistry

Course Outcomes

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Explain the concept of data domain, performance characteristics of an instrument/method, total quality management, quality standards for laboratories, quality audits and quality reviews.	Understand
CO2	Discover the applications of UV-Visible spectroscopy, IR spectroscopy, Differential scanning calorimetry.	Apply
CO3	Identify the need of automation in chemical analysis, safety measures in laboratory, need of accreditation of laboratories and GLP.	Evaluate
CO4	Interpret the data based on calculations and statistical tests.	Evaluate

Unit	Course Description	Hrs
1.	**1.1 Concepts of Analytical Chemistry: [5L]** 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, **1.2 Calculations based on Chemical Principles: [5L]** 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. 1.3 Basic Statistical Tools: [5L] Types of errors – determinate and indeterminate errors, Significant figures and propagation of errors. Confidence limit, Test of significance – the F-test and t-test - One sample t-test. Independent, Paired sample t-test. The statistical Q-test for rejection of a result, statistics for small data sets, Errors in instrumental analysis: Calibration curves, line of regression, errors in slope and intercept.	15
2.	**Quality in Analytical Chemistry:** **2.1 Quality Management System (QMS): [5L]** Quality Management System: Quality management concepts and principles - Traceability, quality control, quality assurance, quality management and quality manual, calibration and test methods TQM in Chemical Industry: Applying Kaizen, Six Sigma approach and 5S to quality in industries. Quality audits and quality reviews, responsibility of laboratory staff for quality and problems. 2.2 Good Laboratory Practices: [4L] GLP Principles, Documentation of laboratory work, Preparation of Standard Operating Procedures (SOPs), Validation of methods, reporting and documentation of results. 2.3. Accreditation of laboratories: [3L] International organization for standardization, National accreditation board for testing and calibration laboratories. Scope of accreditation. 2.4 Safety in Laboratories: [3L] Importance of Safety in Laboratories, classification of Personal Protection Equipment (PPE), Safety and health Standards: Indian Standards & codes for safety & health, OSHA standards, Types of Toxic Hazard (TH), Classification of Chemical Hazards and their control.	15
3.	**Optical Methods:** 3.1 Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers, Laser as a source of radiation, Fibre optics [3L] 3.2 Molecular Ultraviolet and Visible Spectroscopy [6L] 3.2.1 Derivation of Beer- Lambert's Law and its limitations, factors affecting molecular absorption, types of transitions [emphasis on charge transfer	15

	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 [6L] 3.3.1 IR Spectrosopy: Principle, Instrumentation: Sources, Sample handling, Transducers, 3.3.2 FTIR Spectroscopy: Principle, instrumentation & its advantages. 3.3.3 Applications of IR spectroscopy: structure analysis of organic compounds, inorganic Molecules e.g. Sulphato, Carbonato, Nitrato & metal chelates - Acetylacetanato Complexes. Analysis of petroleum hydrocarbons, oil and grease contents by EPA method, Quantitative analysis of multi-component mixtures. 3.3.4 Introduction and basic principles of diffuse reflectance spectroscopy and its applications.	
4.	**4.1 Thermal Methods:** [5 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 crystallinity, oxidative stability, Drug analysis, Magnetic transition. e. g. Analysis of Polyethylene for its crystallinity. 4.2 Automation in chemical analysis: [5 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 multi-layered films, gas monitoring equipments, Automatic titrators. 4.3 Environmental Toxicology: [5] Introduction to Environmental Toxicology, Concepts of Toxicology, Toxic substances in the environment, their sources and entry roots, Transport of toxicants by air and water; Transport through food chain-bio-transformation and bio-magnification. Analysis Methods	**15**

References

Unit I

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) (Free download).

5. 3000 solved problems in chemistry, Schaums Solved problem series, David E. Goldbers, McGraw Hill international Editions, Chapter 11,15,16,21,22

Unit II

1. Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, Ch: 5, Ch: 6 &Ch: 7.

2. Quality Management, Donna C S Summers, Prentice-Hall of India, Ch:3.

3. Quality in Totality: A Manager‟s Guide To TQM and ISO 9000, ParagDiwan, Deep & Deep Publications, 1st Edition, 2000.

4. Quality Control and Total Quality Management - P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5.

5. Industrial Hygiene and Chemical Safety, M H Fulekar, Ch:9, Ch:11 & Ch:15.

6. Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher, Ch:4, Ch:5 & Ch:19.

7. 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.

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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) 106-124.

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. TheophanidesTheophile (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

10. Environmental toxicology Kees van Gestel, Vrije Universiteit, Amsterdam

11. Environmental Toxicology III , by V. Popov, Wessex Institute of Technology, UK; C.A. Brebbia, Wessex Institute of Technology, UK

Analytical Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Analytical Chemistry**
Course Code	**PSC1PR1**
Eligibility for Course	**T. Y BSc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	COs	Bloom Taxonomy Level (BLT)
CO1	Demonstrate the titration skills for the analysis of samples of a diverse variety	Apply
CO2	Apply the statistical methods for data analysis	Apply
CO3	Analyze the measured data based on Chemical principles	Analyse
CO4	Measure the characteristics of ion exchange resins	Evaluate

Unit	Course Description	Hrs
1.	To carry out assay of the sodium chloride injection by Volhard's method.	4
2.	a) Statistical method: Application of Q test, t test to the data obtained for calibration of 5 mL pipette. b) Determine mean, deviation, Q value and t value using MS-EXCEL software	4
3.	To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.	4
4.	To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.	4
5.	To determine the breakthrough capacity of a cation exchange resin.	4
6.	To determine the Mg (titrimetrically) and Al (gravimetrically) content of a Magnelium alloy by titration with EDTA.	4
7.	To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).	4
8.	To determine number of nitro groups in the given compound using $TiCl_3$.	4
9.	Separation of amino acids in a mixture by TLC using Ninhydrin (Demonstration)	4

References:

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 Nostr and Company,Inc.,1939.

6. E.B.Sandell and H.Onishi,"Spectrophotometric Determination of Traces of Metals",Part-II,4th Ed.,A Wiley InterscicencePublication,New York,1978.

Course Description (Elective-I)	
Semester	**I**
Course Name	**Inorganic Chemistry-I**
Course Code	**PSC1IC1**
Eligibility for Course	**T.Y.B. Sc.in Chemistry**
Credit	**2**
Hours	**30**

Course Objectives:

1. To apply theories of bonding, hybridization, MOT for Polyatomic species.
2. To understand preparation, proporties and structures of higher boranes, carboranes, metalloboranes and metallocarboranes, metal carbonyls and halide clusters.
3. To understand all elements of symmetry, point group, symmetry classification, symmetry criterion of optical activity, symmetry restrictions on dipole moment.
4. To understand concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups, Mulliken's notations for irreducible representations. Reduction of reducible representations using reduction formula.
5. To understand concept of band theory, Fermi level, K-Space and Brillouin Zones, Defects in solids.
6.To explain Preparative methods of inorganic solids & nano materials.
7.To explain Electron Paramagnetic Resonance Spectroscopy and its applications, spectral calculations using Orgel and Tanabe-Sugano diagram.
8. To determine of formation constants of metal complexes.

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Explain theories of bonding, hybridization, resonance concept, MOT for diatomic species of first transition Series, Polyatomic species and Higher boranes, carboranes, metalloboranes and metallocarboranes, metal carbonyls and halide clusters.	Understand
CO2	Explain The concept of band theory, Fermi level, K-Space and Brillouin Zones. Structures of Compounds of the type: AB, AB2 etc. and Preparative methods of inorganic solids & nano materials.	Understand

Unit	Course Description	Hrs
1.	**Chemical Bonding:**	15h
1.1	Recapitulation of hybridization Derivation of wave functions for sp, sp2, sp3 orbitalhybridization types considering only sigma bonding.	
1.2	Discussion of involvement of d orbitals in various types of hybridizations. Concept ofresonance, resonance energy derivation expected. Formal charge with examples.	
1.3	Molecular Orbital Theory for Polyatomic species considering σ bonding for SF6, CO2,B2H6, I3- molecular species.	
1.4	Higher boranes, carboranes, metalloboranes and metallocarboranes, metal carbonyls and halide clusters, compounds with metal-metal multiple bonds.	
2.	**Molecular Symmetry and Group Theory:**	15h
2.1	Symmetry criterion of optical activity, symmetry restrictions on dipole moment. Asystematic procedure for symmetry classification of molecules.	
2.2	Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group MultiplicationTables. 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 C2v, C3v and D2h, structure of character tables.	
2.4	**Applications of Group Theory** (a) Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in ABn (Ammonia, CH4) 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.	

Course Description (Elective-II)	
Semester	**I**
Course Name	**Inorganic Chemistry-II**
Course Code	**PSC1IC1**
Eligibility for Course	**T.Y.B. Sc.in Chemistry**
Credit	**2**
Hours	**30**

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Construct Group Multiplication Tables, Character tables using concept of Molecular Symmetry and Group Theory.	Apply
CO1	Determine electronic parameters such as Δ, B, C, Nephelauxetic ratio, formation constants of metal complexes and Characterize coordination compounds using techniques like thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic	Evaluate

Unit	Course Description	Hrs
3.	**Materials Chemistry and Nanomaterials:**	15h
3.1	**Solid State Chemistry**	
3.1.1	Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones.	
3.1.2	**Crystal Defects and non-stoichiometry:** Classification of Defects: subatomic,atomic and lattice defects in solids; Thermodynamics of vacancy in metals; Thermodynamics of Schottky defects in ionic solids ; Thermodynamics of Frenkel defects in silver halides; Calculation of number of defects and average energy required for defect.	
3.1.3	Methods of preparation for inorganic solids: sol- gel method (applications in Biosensors), microwave synthesis (discussion on principles, examples, merits and demerits are expected)	
3.2	**Nanomaterials**	
3.2.1	Preparative methods: Chemical methods, Microwave, Langmuir Blodgett(L-B) method, Biological methods: Synthesis using microorganisms	
3.2.2	Applications in the field of semiconductors, solar cells	
4.	**Characterisation of Coordination compounds**	15h
4.1	Electron Paramagnetic Resonance Spectroscopy (EPR):	

	i) Theory and Instrumentation of EPR in brief. ii) Spin Hamiltonian, Isotropic and anisotropic EPR spectra, Magic Pentagon rule. iii) Applications of EPR spectroscopy: Structural determination of Inorganic complexes	
4.2	Spectral calculations using Orgel and Tanabe-Sugano diagram, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio.	
4.3	Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectral methods.	

References

Unit I

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

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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.
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International Publishers, New Delhi, 2009.
5. A. SalahuddinKunju and G. Krishnan, Group Theory and its Applications in Chemistry,PHI Learning, 2012.
6. P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya PublishingHouse. 2014.
7. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory inChemistry, 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, A. 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 Structureand 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).
7. Physical Methods in Chemistry, R. S. Drago (2nd Edition) (1977).

Course Description	
Semester	**I**
Course Name	**Inorganic Chemistry Practical**
Course Code	**PSC1PR2**
Eligibility for Course	**T.Y.B.Sc. in Chemistry**

Credit	**2**
Hours	**30**

Sr. No.	After completing the course, Students will be able to:	Bloom Taxonomy Level (BTL)
CO1	Prepare various inorganic complexes such as Bis-(tetramethylammonium) tetrachloroCuprate (II) (Me4 N) 2[CuCl4],Tetramminemonocarbanato Cobalt (III) Nitrate, Bis (ethylenediammine) Copper (II) Sulphate, Hydroniumdichlorobis(dimethylglyoximato) etc.	Understand
CO2	Determine the electrolytic nature of inorganic compounds	Apply
CO3	Apply Slope intercept method for determination of equilibrium constants forFe^{+3}/ SCN- system.	Apply
CO4	Analyze the inorganic complex for percentage of metal and ligand.	Analyse

Inorganic Preparations (Synthesis and Characterization)

1) Bis-(tetramethylammonium) tetrachloroCuprate (II) (Me4 N) 2[CuCl4]

2) Tetramminemonocarbanato Cobalt (III) Nitrate [Co(NH3)4CO3]NO3

3) Bis (ethylenediammine) Copper (II) Sulphate [Cu(en)2]SO4

4) Hydronium dichlorobis(dimethylglyoximato) Cobaltate(III) H[Co(dmgH)2Cl2]

Instrumentation

1) Determination of equilibrium constant by Slope intercept method for Fe+3/ SCN- system

2) Determination of Electrolytic nature of inorganic compounds by Conductancemeasurement.

Reference:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd

The Synthesis and Characterization of Inorganic Compounds by William L. Jolly 3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

Research Methodology

Course Description	**----**
Semester	**I**
Course Name	**Research Methodology**
Course Code	**PSC1RM1**
Eligibility for the Course	**B.Sc. Chemistry**
Credit	**4**
Hours	**60**

Course Outcomes

After successful completion of this course students will be able to

Sr. No.	Course Outcomes	Bloom Taxonomy Level (BTL)
CO1	Explain the importance of different types of print and digital resources for gap analysis and data collection.	Understand
CO2	Design/propose methodologies preferably with green and safe approach to conduct research	Create
CO3	Anayze scientific data by statistical and graphical methods.	Analyse
CO4	Apply skills of chemical safety & ethical handling of chemicals	Apply

Unit	Course Description	Hrs
1	**Research and Literature Survey**	
	Scientific Research: (5L) Research: Definition, types, Need of research. Identification of the problem, formulating the objectives, Hypotheses, Research Methods and Methodology Selecting & defining Research problem, Research Process, Research Design: preparing Research design (experimental or otherwise), Actual investigation, Data analysis and interpretation. **Literature survey: (5L)** Need for Literature Survey, References, Sources of literature: Primary, Secondary and Tertiary sources, Journals: Peer-reviewed, indexed, UGC-care listed, predatory, fake journals Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples **Digital Web sources: [5L]** E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Shodhganga, Researchgate, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.	**15**

2	**Data Analysis**	
	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), SPSS, 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. (15L)	**15**
3	**Methods of Scientific Research and Writing**	
	Scientific papers: 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 (15L)	**15**
4	**Chemical Safety & Ethical Handling of Chemicals**	
	Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals. (15L)	**15**

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1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in Chemistry,* 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data Analysis for Chemistry* OxfordUniversity Press.
3. Topping, J., (1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill London.
4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters 3-5
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6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.

SEMESTER-II

Course Description	
Semester	**II**
Course Name	**Physical Chemistry**
Course Code	**PSC2PC2**
Eligibility for Course	**T. Y BSc (Chemistry)**
Credit	**4**
Hours	**60**

Course Outcomes

After successful completion of this course students will be able to

Sr. No	COs	Bloom Taxonomy Level (BLT)
CO1	Explain Bioenergetics, Real solutions and Fugacity of real gases also show graphical representations of BET isotherms	Apply
CO2	Prove expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen and aapplication of the Schrödinger equation to two electron system	Evaluate
CO3	Explain terms involved in Chemical Kinetics and Molecular Reaction Dynamics. Elementary Reactions in Solution, Kinetics of reactions catalysed by enzymes -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses, Inhibition of Enzyme action.	Apply, Evaluate
CO4	Apply Photochemistry to solve NET, SET GATE Problems.	Apply

Unit	Course Description	Hrs
1.	**Chemical Thermodynamics II**	
	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	15

	surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected). 1.4. Bioenergetics: standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.	
2.	**Quantum Chemistry**	
	2.1. Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates, separation of the variables, the phi equation, wavefunction, quantum number, the theta equation, wave function, quantization of rotational energy, spherical harmonics. 2.2. Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, the R the q * and the f equations, solution of the equation, introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots., points of maximum probability, expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen. expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots., points of maximum probability, expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen. 2.3. Application of the Schrödinger equation to two electron system, limitations of the equation, need for the approximate solutions, methods of obtaining the approximate solution of the Schrödinger wave equation. 2.4. Hückel Molecular Orbitals theory for ethylene, 1,3-butadiene and benzene. (Derivation expected)	15
3.	**Chemical Kinetics and Molecular Reaction Dynamics**	
	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 catalysed by enzymes -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses. **3.3.** Inhibition of Enzyme action: Competitive, Non competitive 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 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.	15
4.	**Photochemistry**	
	4.1: Absorption of light, laws of photochemistry, electronic structure of molecules, molecular orbital, electronically excited singlet states, designation based on multiplicity rule, construction of Jablonski diagram, electronic transition, Frank Condon principle, selection rules, intensity of absorption bands, nature of electronic spectra and primary process, photo-	15

	dissociation, pre-dissociation, **4.2** Photo physical phenomena: physical pathways of excited molecular system (radiative and non-radiative), prompt fluorescence, delayed fluorescence, and phosphorescence, fluorescence quenching: concentration quenching, collisional quenching, quenching by excimer and exciplex emission, fluorescence resonance energy transfer between photo-excited donor and acceptor systems. **4.3**. Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, examples and applications in chemical analysis. Photochemical reactions, photo-oxidation, photoreduction, photo-dimerization, photoisomerization and photosensitized reactions. Photochemistry of environment: Greenhouse effect.	

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. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.

9. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.

10. R.K. Prasad, Quantum Chemistry, 2nd Edn., New Age International Publishers, 2000.

11. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.

12. W.G. Davis, Introduction to Chemical Thermodynamics – A Non – Calculus Approach, Saunders, Philadelphia, 19772.

13. Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.

14. Ira N. Levine, Quantum Chemistry, 5th Edn., Pearson Education (Singapore) Pte.Ltd., Indian Branch, New Delhi, 2000.

15. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.

16. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.

17. Solid State Chemistry [An Introduction], 3rd Ed., Lesley E. Smart & Elaine A. Moore, Taylor & Francis, 2010.

18. The Physics and „Chemistry of Solids, Stephen Elliott, Willey India, 2010

19. Principles of the Solid State, H.V. Keer, New Age International Publishers, 2011.

20. Solid State Chemistry, D.K. Chakrabarty, New Age International Publishers, 1996.

21. Principles of physical Chemistry ,Marrown and Prutton 5th edition

22. Essentials of Physical Chemistry ,ArunBahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.

23. Introduction of Solids L.V Azaroff , Tata McGraw Hill .

24. A Text book of physical Chemistry ; Applications of thermodynamics vol III, Mac Millan Publishers India Ltd ,2011

25. New directions in solid state Chemistry, C.N.R. Rao and J Gopalkrishnan , Cambridge University Press.

Physical Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Physical Chemistry Practical**
Course Code	**PSC2PR1**
Eligibility for Course	**T.Y. B. Sc. (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	COs	**Bloom Taxonomy Level (BLT)**
CO1	Know principles of different instruments like Potentiometry, Conductometry, pH Metry and colorimeter	Understand
CO2	Make use of graphical representation to identify Shape of Orbitals.	Apply

Sr. No.	**Course Description**	**Hrs**
1	Polar plots of atomic orbitals such as 1s, $2p_x$ & $3d_z^2$ orbitals by using angular part of hydrogen atom wave functions.	4
2	To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.	4
3	To study phase diagram of three component system water – chloroform /toluene - acetic acid.	4
4	To determine the rate constant of decomposition reaction of diacetone alcohol by dilatometric method.	4
5	Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?	4
6	To determine the formula of silver ammonia complex by potentiometric method. Determination of binary mixture of halides. (New expt.)	4
7	To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.	4
8	To determine Hammette constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.	4
9	To determine the Michaelis – Menten's constant value (Km) of the enzyme Beta Amylase spectrophotometrically.	

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.

Course Description	
Semester	**II**
Course Name	**Organic Chemistry**
Course Code	**PSC2OC2**
Eligibility for Course	**T. Y BSc (Chemistry)**
Credit	**2**
Hours	**60**

Course Outcomes

After successful completion of this course students will be able to

Sr No.	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Explain the Generation of carbanion, enolate, and enamine with their alkylation & acylation reaction and name reactions with their mechanism.	Understand
CO2	Illustrate mechanism, stereochemistry, applications and importance of name reactions and rearrangements.	Understand
CO3	Explain the role of reagents in organic synthesis and elimination reactions.	Analyse
CO4	Interpret the structure of organic compounds using combined of spectral techniques.	create

Unit	**Course Description**	Hrs
1	**1.1. Alkylation of Nucleophilic Carbon Intermediates:** 1.1.1. Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. 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. 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: 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 and Robinson annulation. 1.2.2. Addition reactions with amines and iminium ions; Mannich reaction. 1.2.3. Amine catalyzed condensation reaction: Knoevenagel reaction.	15

	1.2.4. Acylation of carbanions. Asymmetric methodology with enolates and Enamines	
2	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, Bamberger Rearrangements. 2.3. Cationic rearrangements: Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein. 2.4. Anionic rearrangements: Brook, Neber, Von Richter, Wittig, Benzylic acid Rearrangements, Payne.	15
3	**3.1 Elimination Reactions:** E1, E2 E1CB, Stereochemistry of elimination, elimination vs. substitution, Anti and Syn Elimination. Dehydrohalogenation, Dehalogenation, Dehydration, Hoffmann and Saytzeff elimination, Pyrolytic elimination. **3.2 Organometallic Chemistry** Organolithium, Organomagnesium, Organozinc, Organocupper, **3.3 Introduction to Molecular Orbital Theory for Organic Chemistry:**. Molecular orbitals: Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allylcation, anion and radical. Concept of nodal planes and energies of π-MOs	15
4	**Spectroscopy:** **4.1. Proton magnetic resonance spectroscopy:** 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. **4.2. 13C 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:** Determination of molecular formula of organic compounds based on isotopic abundance and HRMS. Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels Alder reaction. 4.4. Structure determination involving individual or combined use of the above spectral techniques. 4.5. 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). 4.6. 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,	15

	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.	

Organic Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Organic Chemistry**
Course Code	**PSC2PR2**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Identify the chemical type of components present in a binary mixture of an organic compound.	Apply
CO2	Apply skills in the separation and qualitative analysis of organic compounds of binary mixtures by microscale technique.	Apply
CO3	Make use of crystallization, sublimation and distillation for purification of the organic compounds.	Apply
CO4	Demonstrate the practical aspects in the preparation of the organic compounds derivatives.	Understand

Sr. No.	**Course Description**	**Hrs**
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.	30

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford UniversityPress.

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 (7th Edition)

5. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, PearsonEducation.

6. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.

7. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.

8. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.

9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.

10. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.

11. Mechanism in Organic Chemistry, Peter Sykes, 6th

12. Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley

13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz,Thomson Brooks.

14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C.Morrill, John Wiley and Sons.

15. Organic Spectroscopy, William Kemp, W.H. Freeman & Company.

16. Organic Spectroscopy-Principles and Applications, Jagmohan, Narosa Publication.

17. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co.

18. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.

19. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parasher, Alpha ScienceInternational, 2011.

20. Reactions, Rearrangements and Reagents by S. N. Sanyal

21. Name Reactions, Jie Jack Li, Springer

22. Name Reactions and Reagents in Organic Synthesis, Bradford P. Mundy, M.G. Ellerd,and F.G. Favaloro, John Wiley & Sons.

Course Description	
Semester	**II**
Course Name	**Analytical Chemistry**
Course Code	**PSC2AC1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**4**
Hours	**60**

Course Outcomes

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Translate the theoretical principles of advanced separation techniques, spectroscopic techniques, radioanalytical techniques, electroanalytical techniques into applications.	Understand
CO2	Explain the working principles of surface analytical techniques such as SEM, STM, TEM, ESCA, Auger spectroscopy and ICP-AES	Understand
CO3	Compare the different ion sources and mass analyzers in mass spectroscopy	Analyze
CO4	Determine the electrical quantities such as charge, current, potential using Electroanalytical methods	Evaluate

Unit	**Course Description**	Hrs
1.	**Chromatography**	
	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	15

	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] 1.4 High-Performance Liquid Chromatography (HPLC): Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. Chiral and ion chromatography. [5 L]	
2.	**X-ray spectroscopy**:	
	principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. [4 L] 2.2 Mass spectrometry: recapitulation, instrumentation, ion sources for molecular studies, electron impact, field ionization, field absorption, chemical ionization and fast atom bombardment sources. Mass analyzers: Quadrupole, time of flight and ion trap. Applications. [6 L] 2.3 Radioanalytical Methods – recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. [5 L]	15
3.	**Surface Analytical Techniques**	
	Introduction, Types of surface measurements: Photon probe technique, electron probe technique, Ion probe technique, Scanning probe microscopy 3.2 Electron probe techniques: 3.1.1 Scanning Electron Microscopy (SEM): Principle, Instrumentation and Application 3.1.2 Electron Spectroscopy (ESCA and Auger): Principle, instrumentation and Application 3.2 Atomic Spectroscopy [6 L] 3.2.1 Recapitulation: Flame AAS and furnace AAS Interferences - chemical and spectral, evaluation methods in AAS, qualitative and quantitative applications 3.2.2 AES: Principle of AES, Interferences Inductively Coupled Plasma- Atomic Emission Spectroscopy (ICP-AES) – Introduction, Principle, Instrumentation, applications 3.2.3 Applications of AAS and AES in environmental analysis	15
4.	**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]	15

	4.3 Coulometry: Introduction, principle, instrumentation, coulometry at controlled potential and controlled current [2 L]	

References:

Unit I

1. Instrumental Analysis, Skoog, Holler & Crouch

2 HPLC Practical and Industrial Applications, 2 nd Ed., Joel K. Swadesh, CRC Press

Unit II 1.Essentials of Nuclear Chemistry, H J Arnikar, New Age Publishers (2005) 2. Fundamentals of Radiochemistry D. D. Sood , A. V. R. Reddy and N. Ramamoorthy 3. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 12 4. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 20

Unit III

1. Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition, (2003), ISBN-10: 8131505421, ISBN-13: 978-8131505427

2. Physical Principles of Electron Microscopy, An Introduction to TEM, SEM, and AEM

3. Authors: Ray F. Egerton, ISBN: 978-0- 387-25800- 3 (Print) 978-0- 387-26016- 7 (Online)

4. Modern techniques of surface science by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994.

5. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, NewYork, 1993.

6. 5. Transmission Electron Microscopy: A text book for Material Science, David B Williams and C., Barry Carter, Springer

7. Modern Spectroscopy, by J.M. Hollas, 3rd Edition (1996), John Wiley, New York

8. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.

9. Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition (2003), ISBN10: 8131505421, ISBN-13: 978-8131505427

Unit IV

1. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th Edition, Harcourt College Publishers, 1998. Chapters - 23, 24, 25.

2. Analytical Chemistry Principles – John H Kennnedy, 2nd edition, Saunders College Publishing (1990).

3. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000).

4. Vogel's Text book of quantitative chemical analysis, 6th edition, Pearson Education Limited, (2007).

5. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980).

6. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7th edition, CBS publishers.

Analytical Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Analytical Chemistry**
Course Code	**PSC2PR1**
Eligibility for Course	**T. Y. B.Sc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No.	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Demonstrate the operational skills on the selected instruments and retrieve information	Understand
CO2	Develop a sense of time management, safe use of chemicals and environmental safety	Apply
CO3	Measure the physical property of the samples and relate it with quantity	Evaluate
CO4	Construct the graphs based on the measurements and calculations	Evaluate

Sr. No.	**Course Description**	**Hrs**
1	To determine percent purity of washing soda in terms of sodium carbonate pH metrically.	4
2	To determine amount of Ti (III) and Fe (II) in a mixture by titration with Ce (IV) potentiometrically.	4
3	To determine the amount of nitrite present in the given water sample colorimetrically.	4
4	To determine the amount of Fe (II) and Fe (III) in a mixture using 1,10-phenanthroline spectrophotometrically.	4
5	Simultaneous determination of Cr (VI) and Mn (VII) in a mixture spectrophotometrically.	4
6	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 $BaCl_2$.	4

7	To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.	4
8	Separation of benzene and toluene using gas chromatography and determination of column resolution (Rs). (demonstration)	4

References

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.

Course Description (Elective-I)	
Semester	**II**
Course Name	**Inorganic Chemistry-I**
Course Code	**PSC2IC2**
Eligibility for Course	**T.Y.B.Sc.in Chemistry**
Credit	**2**
Hours	**30**

Course Objectives:

1. To study and understand Photochemical Reactions, Ligand substitution reactions of octahedral and tetrahedral complexes, Redox reactions: inner and outer sphere mechanisms, stereochemistry of substitution reactions of octahedral complexes

2. To study and understand Organometallic Chemistry of Transition metals, Eighteen and sixteen electron rule, Structure and bonding on the basis of VBT and MOT in organometallic compounds.

3. To study and understand Toxicity of metallic species including case studies. Interaction of radiation in context with the environment: Sources and biological implication of radioactive materials.

4. To study concept of green chemistry, Biomass and biofuels.

5. To study and understand Bioinorganic Chemistry related to Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- structure of metal active center and differences in mechanism of oxygen binding, Copper containing enzymes, Nitrogen fixation Metal ion transport and storage Medicinal applications of cis-platin and related compounds.

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Recall Organometallic Chemistry of Transition metals, Eighteen and sixteen electron rules, Preparation and property's structure and bonding of the Organometallic compounds	Remember
CO2	Explain Photochemical Reactions, Ligand substitution reactions of: Octahedral complexes, Square planar complexes, trans-effect, its theories and applications. Redox reactions: inner and outer sphere mechanisms, stereochemistry of substitution reactions of octahedral complexes	Understand

Unit	**Course Description**	Hrs
1.	**Inorganic Reaction Mechanism:**	15h
1.1	Photochemical Reactions: Prompt and delayed reactions, Quantum yield, Recapitulation of fluorescence and phosphorescence. Photochemical reactions by irradiating at d-d and charge transfer bands.	
1.2	Ligand substitution reactions of: a) Octahedral complexes without breaking of metal-ligand bond (Use of isotopiclabelling method) b) Square planar complexes, trans-effect, its theories and applications. Mechanismand factors affecting these substitution reactions.	
1.3	Redox reactions: inner and outer sphere mechanisms, complimentary and non-complimentary reactions.	
1.4	Stereochemistry of substitution reactions of octahedral complexes. (Isomerization andracemization reactions and applications.)	
2.	**Organometallic Chemistry of Transition metals:**	15h
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 transition metal 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	Basic organometallic reactions introduction: Ligand substitution, oxidative reactions, migratory reactions, migratory insertion, extrusion, oxidative addition, reductive elimination mechanism and stereochemistry	

Course Description (Elective-II)	
Semester	**II**
Course Name	**Inorganic Chemistry-II**
Course Code	**PSC2IC2**
Eligibility for Course	**T.Y.B.Sc.in Chemistry**
Credit	**2**
Hours	**30**

Sr. No.	COs	Bloom Taxonomy Level (BLT)
CO1	Measure the physical property of the samples and relate it with quantity	Evaluate
CO2	Construct the graphs based on the measurements and calculations	Evaluate

Unit	Course Description	Hrs
3.	**Environmental Chemistry:**	15h
3.1	Toxicity of metallic species: Mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, biochemical effects and toxicology, control and treatment.	
3.2	Case Studies: (a) Itai-itai disease for Cadmium toxicity, **(b)** Arsenic Poisoning in the Indo-Bangladesh region.	
3.3	Interaction of radiation in context with the environment:Sources and biological implication of radioactive materials. Effect of low level radiation on cells- Its applications in diagnosis and treatment, Effect of radiation on cell proliferation and cancer.	
3.4	**Green Chemistry:** Biomass and Biofuels: Issues of Ethanol,Biodiesel from Plant Oils and from AlgaeActivity. Bio-based Liquid Fuels and Chemicals, Recycling Carbon Dioxide—A Feedstock for the Production of Chemicals and Liquid Fuels, Thermochemical Production of Fuels: Including Methanol and Hydrogen—Fuel of the Future.	
4.	**Bioinorganic Chemistry:**	15h
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	Medicinal applications of cis-platin and related compounds	

References

UNIT-I

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5thEd., 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, 8thEd., S. Chand & Company ltd.
4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.

5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002
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5. Fundamentals of Environmental and Toxicological Chemistry 4th edition, Stanley E. Manahan, ISBN: 978-1-4665-5317-0, CRC Press Taylor & Francis Group, 2013.
6. Living in the Environment 17th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10: 0-538-49414-X, Brooks/Cole, Cengage Learning, 2011
7. Poisoning and Toxicology Handbook, Jerrold B. Leikin, Frank P. Paloucek, ISBN: 1-4200-4479-6, Informa Healthcare USA, Inc.
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Unit IV

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Course Description	
Semester	**II**
Course Name	**Inorganic Chemistry Practical**
Course Code	**PSC2PR1**
Eligibility for Course	**T.Y.B.Sc. in Chemistry**
Credit	**2**
Hours	**30**

Course Outcomes

COs. No.	After completing the course, Students will be able to:	Bloom Taxonomy Level (BTL)
CO1	Analyse ores and alloys using volumetric and gravimetric analysis.	Analyse
CO2	Estimate percentage of metals in the ore and alloy	Evaluate
CO3	Apply the potentiometric method for redox titrations of Fe, Cu etc.	Apply

Ores and Alloys

1) Analysis of Devarda‟s alloy
2) Analysis of Cu – Ni alloy
3) Analysis of Tin Solder alloy
4) Analysis of Brass alloy

Instrumentation

1) Estimation of Copper using Iodometric method Potentiometrically.
2) Estimation of Fe+3 solution using Ce(IV) ions Potentiometrically

Reference:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd

2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly 3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: DrDeepak Pant

OJT

Course Description	
Semester	**II**
Course Name	**On Job Training**
Course Code	**PSC2OJT**
Eligibility for Course	**T.Y. B. Sc. (Chemistry)**
Credit	**4**
Hours	**60**

After completing the course, Students will be able to:		BTL Level
CO1	Practical Skill Development: Trainees will acquire hands-on experience and proficiency in relevant industry tools, techniques, and processes, effectively applying theoretical knowledge to real-world tasks.	Analyse
CO2	Problem-Solving Abilities: Trainees will develop critical thinking and problem-solving skills by addressing practical challenges and troubleshooting issues encountered in the work environment.	Apply
CO3	Professional Competency: Trainees will demonstrate enhanced job readiness and professional competency, including adherence to industry standards, effective communication, and teamwork	Understand
CO4	Industry Knowledge:Trainees will gain a deeper understanding of industry practices, workflows, and organizational culture, improving their ability to navigate and contribute effectively within their field.	Understand
CO5	Performance Improvement:Trainees will improve their performance and productivity by integrating feedback and learning from experienced professionals, leading to better job performance and career growth.	Apply

Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR

Arts, Commerce and Science College, New Panvel (Autonomous)

Re-accredited A+ Grade by NAAC (Third Cycle-CGPA-3.61)
'College with Potential for Excellence' Status Awarded by UGC
'Best College Award' by University of Mumbai

As per National Education Policy - 2020

Title of the Programme

M. Sc. in Chemistry

(Faculty of Science)

Syllabus for M. Sc. Part II (Analytical Chemistry)

Semester III and IV

(Approved in Academic Council meeting held on 15 th January 2024)

(With effect from the academic year 2024-25)

Sr. No.	Heading	Particulars
1	Title of Course	M.Sc.-II Analytical Chemistry
2	Eligibility for Admission	Passed from M.Sc. I
3	Passing marks	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	Ordinances/Regulations (if any)	-
5	No. of Semesters	One year/Two semester
6	Level	P.G. part-II
7	Pattern	Semester (60:40)
8	Status	Revised
9	To be implemented from Academic year	2024-2025

Name of BOS Chairman: Prof.(Dr.) B.V Jadhav **Signature of BOS Chairman:**

Masters in Science (Analytical Chemistry)
Syllabus for Semester III and IV

Preamble:

Master of Science (M.Sc.) in Analytical chemistry is a post-graduate course of department of chemistry, Changu Kana Thakur Arts, Commerce & Science College, New Panvel (Autonomous).

Master of Science (M.Sc.) in Analytical chemistry is a post-graduate course of Department of chemistry, Changu Kana Thakur Arts, Commerce & Science College, New Panvel (Autonomous).

The programme is envisioned to provide a focused, outcome-based syllabus at the postgraduate level with student-centric structure of the teaching-learning experiences. It engages students in the curriculum of their choice and prepare students for both academia and employability.

The new curriculum of M.Sc. II (Analytical Chemistry) offer courses in the various areas of analytical chemistry. All the courses are having defined objectives and Learning Outcomes, which will help prospective students in choosing the elective courses to broaden their skills in the field of chemistry and interdisciplinary areas.

The courses will train students with sound theoretical and experimental knowledge that suits the need of academics and industry. The courses also offers ample skills to pursue research as career in the field of chemistry and allied areas.

Department of Chemistry of Changu Kana Thakur Arts, Commerce and Science College hope the programme will create best analytical minds to meet the needs of society.

Objectives of the Course:

1. To develop laboratory competence related instrumental and non-instrumental analysis
2. To demonstrate the ability of critical thinking and data analysis.
3. To provide the students with sound preparation for requirement of modern industry and provide competency in basic academic research as well as a cohesive, clearly structured overview of Chemistry

Scheme of Examination

The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part and by conducting the Semester End Examinations with 60% marks in the second part. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below-

A) Internal Assessment: 40 % 40 Marks

Sr. No.	Particular	Marks
01	One periodical class test / online examination to be conducted in the given semester	20 Marks
02	Any One tools out of these (15 Marks each) 1. Group/ Individual Project 2. Presentation and write up on the selected topics of the subjects / Case studies. 3. Test on Practical Skills 4. Open Book Test	15 Marks
03	Active participation	05 Marks

Question Paper Pattern

(Periodical Class Test for the Courses at Under Graduate Programmes)

Maximum Marks: 20 Duration: 40 Minutes

Questions to be set: 02

All Questions are Compulsory

Question No.	Particular	Marks
Q-1	Match the Column / Fill in the Blanks / Multiple Choice Questions/ Answer in One or Two Lines (Concept based Questions) (1 Marks /2 Marks each)	10 Marks
Q-2	Answer in Brief (Attempt any Two of the Three) (5 Marks each)	10 Marks

B) Semester End Examination: 60 % 60 Marks

- Duration: The examination shall be of 2 $\frac{1}{2}$ hours duration.

Question Paper Pattern

Theory question paper pattern
1. There shall be five questions each of 12 marks. 2. All questions shall be compulsory with internal options. 3. Question may be subdivided into sub-questions a, b, c… and the allocation of marks depends on the weightage of the unit.

Passing Standard

The learners shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment and Semester End Examination. The learners shall obtain minimum of 40% marks (i.e. 16 out of 40) in the Internal Assessment and 40% marks in Semester End Examination (i.e. 24 Out of 60) separately, to pass thecourse and minimum of grade D in each project wherever applicable to pass a particular semester.

❖ Guidelines and Evaluation pattern for project work (100 Marks)

Introduction

Inclusion of project work in the course curriculum of the M.Sc. programme is one of the ambitious aspects in the programme structure. The main objective of inclusion of project work is to inculcate the element of research work challenging the potential of learner as regards to his/ her eager to enquire and ability to interpret particular aspect of the study in his/her own words. It is expected that the guiding teacher should undertake the counselling sessions and make the awareness among the learners about the methodology of formulation, preparation and evaluation pattern of the project work.

- There are two modes of preparation of project work

1. Project work based on research methodology in the study area
2. Project work based on internship in the study area

I	**Theory:** The Semester End Examination for theory course work will be conducted as per the following scheme.		
	Each theory paper shall be of two- and half-hour duration.		
	All questions are compulsory and will have internal options.		
	Q-1	From Unit – I (having internal options.) 12 M	
	Q-2	From Unit – II (having internal options.) 12M	
	Q-3	From Unit – III (having internal options.) 12M	
	Q-4	From Unit – IV (having internal options.) 12M	
	Q-5	Questions from all the FOUR Units with equal weightage of marks allotted to each Unit. 12 M	
II	**Practical**	The Semester End Examination for Practical course work will be conducted as per the following scheme.	
Sr. No.	Particulars of External Practical Examination		**Marks%**
1	Laboratory Work		80
2	Journal		10
3	Viva		10
	TOTAL		**100**

Choice Based Credit, Grading and Semester System (CBCGS) to be implemented from the Academic year 2024-2025

M.Sc.-II Analytical Chemistry Semester- III

Course Name and Code	Unit	Topics	Credits	L / Week
Quality in Analytical Chemistry (PSC3QAC)	I	Quality in Analytical Chemistry	4	1
	II	Sample Management system		1
	III	Laboratory Accreditation-I		1
	IV	Uncertainty in Measurement and Calibration of Instrument-II		1
Advanced Instrumental Techniques (PSC3AIT)	I	Spectral Methods –I	4	1
	II	Spectral Methods –II		1
	III	Electroanalytical Methods		1
	IV	Miscellaneous Techniques		1
Bio Analytical and Food Analysis (PSC3BCFA)	I	Bio-analytical Chemistry-I	4	1
	II	Bio-analytical Chemistry-II		1
	III	Food analysis-I		1
	IV	Food analysis-II		1
Practical in Analytical chemistry-I(PSC3PAC1)	-	Practical in Analytical chemistry-I	2	4
Pharmaceutical Analysis Elective I (PSC3PA1)	I	Introduction to Pharmaceutical Analysis	2	1
	II	Pharmaceutical testing		1
Forensic & Cosmetics Analysis Elective II (PSC3FCA)	I	Forensic Analysis	2	1
	II	Cosmetics Analysis		1
Practical in Analytical chemistry-I(PSC3PAC2)	-	Practical in Analytical chemistry-II	2	8

Research Project (PSC3RP)	**-**	**Research Project**	**4**	**60**

Choice Based Credit, Grading and Semester System (CBCGS)
to be implemented from the Academic year
2024-2025
M.Sc.-II Analytical Chemistry
Semester- IV

Course Name and Code	Unit	Topics	Credits	L / Week
Separation Techniques (PSC4QAC)	I	Separation Techniques-I	4	1
	II	Separation Techniques-II		1
	III	Separation ,Analysis and Standardization of Herbal based products		1
	IV	Advanced Separation Techniques		1
Advanced Instrumental Techniques (PSC4AIT)	I	Spectral Methods –III	4	1
	II	Spectral Methods –IV		1
	III	Radio Chemical and Thermal Methods		1
	IV	Hyphenated Techniques		1
Environmental Analysis and Its Management (PSC4EAM)	I	Effluent Treatment	4	1
	II	Solid Waste Management		1
	III	Water quality Monitoring		1
	IV	Monitoring of air pollution and Environmental legislation		1
Intellectual Property Rights (PSC4IPR)	I	Introduction to Intellectual Property Rights-I	**2**	1
	II	Introduction to Intellectual Property Rights-II		1
Analysis of selected materials (PSC4ASM)	I	Plastics and Polymers	2	1
	II	Metallurgical Analysis		1
Practical in Analytical chemistry-I(PSC4PAC1)	-	Practical in Analytical chemistry-I	2	8
Research Project (PSC4RP)	**RP**	**Research Project**	**6**	**60**

SEMESTER-III

Course Description	**Major I**
Semester	**III**
Course Name	**Quality in Analytical Chemistry**
Course Code	**PSC3QAC**
Eligibility for Course	**M.Sc. Part I (Chemistry)**
Credit	**4**
Hours	**60**

Course Outcomes

After successful completion of this course students will be able to

Sr. No	Course Outcomes	Bloom Taxonomy Level (BLT)
CO1	The importance of GLP and their regulations	Understand
CO2	The theoretical aspects of sampling, pre-treatment and method validation.	Understand
CO3	The laboratory accreditation, its benefits and importance of ICH guidelines.	Understand
CO4	Measure the uncertainty in measurements, dealing with signal to noise ratio and legislator aspects of pharmaceutical industries.	Apply

UNIT	Course Description	Hrs
I	**Quality Management system**	
	1.1 Good Laboratory Practices and their regulations: For analytical labs, roles and responsibilities of quality personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration. **[6L]** **1.2 Concepts and significance of Quality control charts:** The X-quality control chart, the R-quality control chart and its interpretation, spiked sample control charts, use of blind samples in quality control, use of proficiency evaluations in quality control. **[6L]** **1.3 Documentation: Raw Data:** Type of notebooks, control of notebook distribution and data entry. General Reagents and volumetric reagents. **[3L]**	15
II	**Sample Management system**	
	2.1 Sampling: Definition, types of sample, sampling plan, quality of sample, sub-sampling, Sampling of raw materials, intermediates and finished products. Sample, sample labelling, sample log-in/register preparations – dissolution technology and decomposition, storage of samples. Importance and need of preservation of sample and records, Pre-treatment of samples: soil, food and cosmetics. **[8L]** **2.2 Selection of the Method:** Sources of methods, factors to consider when selecting a method, performance criteria for methods used, reasons for incorrect analytical results. Method validation – ICH guidelines Q2A, and quality by design (PAT). **[7L]**	15
III	**Laboratory Accreditation- I**	

	3.1 Laboratory accreditation: Criteria for laboratory accreditation, Benefits of laboratory accreditation, evolution and significance of quality management, ISO series of standards on quality management system. Registration/ certification – benefits of QMS certification, Advantages and requirements of ISO 9000-2000; ISO 9001-2000. Significance of ISO 9001, 9002, 9003 and 9004. Quality management principles in QMS. **[8L]** **3.2 ICH guidelines:** Q1A to Q1F (stability guidelines), Q3A to Q3D (Impurities) Q6A to Q6B (Specifications) Q10 (Pharmaceutical Quality System) ICH guidelines – Quality Risk assessment Q 9. **[7L]**	15
IV	**Uncertainty in Measurement and Calibration of Instrument**	
	4.1 Measurement of uncertainty: Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results. **[5L]** **4.2 Signal to noise:** Signal to noise ratio, importance and reasons to improve S/N ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction, software, methods for noise reduction. Numerical problems are expected on 4.1 and 4.2). **[5L]** **4.3 Calibration and maintenance of Instruments / Equipment:** Instrument calibration – linear calibration curves, equipment calibration, frequency of calibration, calibration of common laboratory instrument and equipment (Analytical balances, volumetric glassware, ovens, furnaces, UV / Visible spectrophotometer, pH meter, conductivity meter, IR spectrophotometers, AAS, GC, HPLC etc.). Maintenance of instruments and equipment. **[5L]**	**15**

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2. Quality assurance in analytical Chemistry, W Funk, V Dammann, G. Donnevert VCH Weinheim1995.
3. Amit S. Patil *et. al.*, Quality by Design (QbD): A new concept for development of Quality pharmaceuticals, International Journal of Pharmaceutical Quality Assurance; 4(2); 13-19.
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7. Analytical Chemistry, G. D. Christain, Wiley
8. Quantitative Chemical Analysis, 6 th Edition, Vogel: Chapter 12.
9. Instrumental Analysis, 5th Edition, Skoog, Holler and Nieman: Chapter 33.
10. Quality Management, Donna C S Summers, Prentice-Hall of India, Ch.: 3

Course Description	**Major II**
Semester	**III**
Course Name	**Advanced Instrumental Techniques**
Course Code	**PSC3AIT**
Eligibility for Course	**M.Sc. Part I Chemistry**
Credit	**4**
Hours	**60**

After successful completion of this course students will be able to

Sr. No.	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Study the of principle, instrumentation and applications of NMR spectroscopy.	Understand
CO2	Study the detail concept of mass spectroscopy and Raman spectroscopy.	Understand
CO3	Get detailed insights of advanced electroanalytical techniques.	Apply
CO4	Find the applications of chemiluminescence, ORD-CD, Photoacoustic spectroscopy in analytical chemistry.	Apply

UNIT	Course Description	Hrs
I	**Spectral Methods I**	**15**
	1.1 NMR Spectroscopy: Theory and Instrumentation- recapitulation, FTNMR, 2D NMR, FID signal generation mechanism, Techniques in 2D NMR- homo nuclear correlation spectroscopy (COSY), total correlation spectroscopy (TOCSY), heteronuclear correlation (HETCOR) **[9L]** **1.2 Radio waves in imaging**: Principal instrumentation and applications of MRI **[3L]** , a ^{19}spectroscopy **[3L]**	
II	**Spectral Methods II**	**15**
	2.1 Mass spectrometry: recapitulation, correlation of mass spectra with molecular structure- interpretation of mass spectra, analytical information derived from mass spectra- molecular identification, metastable peaks, Fragmentation Reactions **[5L]** **2.2 Raman spectroscopy:** Principle, Theory, Instrumentation, techniques (Surface-enhanced Raman Spectroscopy and Resonance Raman Spectroscopy) and Applications of Raman spectroscopy **[6L]** **2.3** Spectrofluorimetry and Phosphorimetry **[4L]**	
III	**Electroanalytical Methods**.	**15**
	Advanced Electroanalytical Techniques: **3.1** Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography **[3L]** **3.2** Potential Sweep methods- Linear Sweep Voltammetry and Cyclic Voltammetry **[3L]** **3.3** Potential Step method- Chronoamperomertry **[2L]** **3.4** Controlled potential technique- Chronopotentiometry **3.5** Stripping Voltammetry- anodic, cathodic, and adsorption **[2L**] **3. 6** Chemically and electrolytically modified electrodes and ultra-microelectrodes in voltammetry **[3L**]	
IV	**Miscellaneous Techniques**	**15**
	4.1 Principle, Instrumentation and Applications of following Techniques: Chemiluminesescence techniques **[3L**] Chirooptical Methods: ORD, CD **[5L]** Photoacoustic spectroscopy **[3L**] Spectroelectrochemistry **[4L]**	

References:

1. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
2. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 5th Edition (1998)Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A. Dean and F. Settle Jr 6th Ed CBS (1986)
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5. Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987)
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9. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (A series of volumes)
10. Techniques and mechanism of electrochemistry, P. A. Christian and A. Hamnett, Blachie Academic and Professional (1994)
11. Wilson and Wilson's Comprehensive Analytical Chemistry, Ed. G. Svehla. (A series of Volumes)
12. Treatise on Analytical Chemistry, Eds. I. M. Kolthoff and Others, Interscience Pub. (A series of volumes).
13. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, (A series of volumes)
14. Polarographic Methods in Analytical Chemistry, M. G. Arora, Anmol Publications Pvt Ltd
15. Surface Analysis –The Principal Techniques, 2nd Edition Edited by John C. Vickerman and Ian S. Gilmore 2009 John Wiley & Sons, Ltd. ISBN: 978-0-470-01763-0
16. NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry *R. V. Parish*. Ellis Horwood, Chichester.
17. A Complete Introduction to Modern NMR Spectroscopy 1st Edition by Roger S. Macomber

Course Description	**Major III**
Semester Major 3	**III**
CoursName	**Bioanalytical Chemistry and Food Analysis**
Course Code	**PSC3BCFA**
Eligibility for Course	**M.Sc. Part I (Chemistry)**
Credit	**4**
Hours	**60**

Course Outcomes

After successful completion of this course students will be able to

Sr. No.	COS	Bloom Taxonomy Level (BLT)
CO1	Study bioanalytical techniques of analysis.	Understand
CO2	The importance of Immunoassays and its applications.	Understand
CO3	General idea about food processing, food preservation and determination of food contaminant etc.	Apply
CO4	The technique used in food packaging and food analysis.	Apply

UNIT	Course Description	Hrs
I	**Bioanalytical chemistry –I**	15
	1.1 Body Fluids: Introduction Composition of body fluids and detection of abnormal levels of glucose, creatinine, uric acid in blood, protein, ketone bodies and bilirubin in urine leading to diagnosis of diseases **[5L]** **1.2** Physiological and nutritional significance of vitamins (water Soluble and fat soluble) and minerals. **[5L]** **1.3** Analytical techniques (including microbiological techniques) for Estimation of Vitamins. **[5L]**	
II	**Bioanalytical Chemistry-II**	**15**
	2.1 Introduction of Antigen and Antibody. General Features of the Antigen and Antibody Interactions**. [3L]** **2.2 Immunoassays:** Theory, Principle, Applications and Limitations of RIA, ELISA and Fluoro-immuno assays**. [3L]** **2.3 Introduction to Biomolecules:** lipids, proteins, amino acids, Nucleic acids, enzymes, carbohydrates- specific examples; sampling in biosystems. **[3L]** **2.4** Isolation of biomolecules, basic principles of centrifugation, types of centrifugation methods for biomolecules, Flow cytometry. **[3L]** **2.5** Biosensors for glucose, RTPCR and significance in diagnostics, DNA and other biologically important molecules. **[3L]**	
III	**Food Analysis – I**	**15**
	3.1 Fuel value of food and its determination, Importance of food nutrients **[2L]** **3.2** Food Additives: Legislation**,** chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. **[5L]** **3.3** Analysis of food for additives: Determination of nitrate and nitrites, determination of ascorbic acid, and identification of colors in food, natural colours **[3L]** **3.4** Food Contaminants: Trace metals and pesticide residues, Contaminants from industrial wastes (polychlorinated biphenyls, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants. **[5L]**	

IV	**Food Analysis - II**	**15**
	4.1 Aspects of food safety: HACCP, FSSAI, GMP, role of FDA, Agmark, ISI concept of sanitation and hygienic production of food **[3L]** **4.2 Food packaging**: Introduction, types of packing materials and industrial requirements. **[3L]**	
	4.3 Analysis of Milk and Milk Products: Fat content, proteins, acidity, bacteriological quality **[3L]** **4.4 Analysis of oils and fats**: acid value, sap value, iodine value. Determination of rancidity and antioxidants**. [3L]** **4.5 Analysis of spices:** cloves, cinnamon, pepper, mustard. Determination of volatile oils and fixed oils. **[3L]**	

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1. General, Organic and biological chemistry, H. Stephen Stoker, Cengage Learning.
2. Advance dairy chemistry, vol 3, P. F. Fox, P. L. H. McSweeney Springer.
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4. Molecular Biological and Immunological Techniques and Applications for food, edited by Bert Popping, Carmen Diaz-Amigo, Katrin Hoenicke, John Wiley & sons.
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7. Modern packaging Encyclopedia and planning guide, Macgra Wreyco.
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9. Analytical Biochemistry, D, J. Homes and H. Peck, Longman (1983)
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12. The Immunoassay Handbook Theory and Applications of Ligand Binding, ELISA and Related Techniques, David Wild, Fourth Edition, 2013

Course Description	**Major IV**
Semester	**III**
Course Name	**Practical in Analytical Chemistry -I**
Course Code	**PS3PAC1**
CEligibility for Course	**M.Sc. (Chemistry)**
Credit	**2**
Hours	**60**

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	The use of various instrumental methods for the analysis of different samples.	Apply
CO2	Study graphical representation of the data.	Apply
CO3	Knowledge of quality control methods and understand the importance of accuracy.	Understand

Sr. No.	**Course Description**	Hrs
1.	Determination of the pK value of bromo thymol blue indicator.	4
2.	Determination of moisture content in given sample by Karl Fischer titration method.	4
3.	Estimation of strong acid, weak acid and salt in the given mixture Conductometrically.	4
4.	Determination of percentage purity of methylene blue indicator.	4
5.	Estimation of fluoride in a tooth paste spectrophotometrically.	4
6.	Determine the composition of Ferric-Salicylate complex by Jobs method.	4
7.	Estimation of Vitamin C in lemon Juice/squash by colorimetric method.	4
8.	Analysis of mixture of carbonate and bicarbonate (present in ppm range) using pH metry.	4
9.	Estimation of Na^+ in dairy whitener by flame photometry.	4

10.	Spectrophotometric determination of pH of buffer solution.	4
11.	Estimation of micronutrient from food by AAS (any two elements such as Fe, Cu, Zn, Mo, B, Mn) [Demonstration]	4
12.	Determination of copper by extractive spectrophotometry using diethyldithiocarbamate.	4
13.	Linearity study of the Benzene and Toluene mixture using by GC.	4
14.	Determination of pk value of H_3PO_4 by potentiometrically.	4
15.	Analyze the concentration of various components of food sample such as sugars, proteins using colorimetric method.	4

Course Description	**Elective I**
Semester	**III**
Course Name	**Pharmaceutical Analysis**
Course Code	**PSC3PA1**
Eligibility for Course	**M.Sc. Part I (Chemistry)**
Credit	**2**
Hours	**30**

Course Outcomes

After successful completion of this course students will be able to

Sr. No	COs	Bloom Taxonomy Level (BLT)
CO1	The pharmaceutical analysis and quality control methods of pharmaceutical industry.	Understand
CO2	The details of drug analysis on the basis of functional groups and other factors.	Know

UNIT	Course Description	Hrs
I.	**Introduction to Pharmaceutical Analysis**	15
	1.1 General idea regarding the Pharmaceutical Industry **[1L]** 1.2 Pharmaceutical formulations, novel drug delivery system, Classification of dosage forms. Water for pharmaceutical use **[5L]** 1.3 Use of Pharmacopeia in IP and BP. **[2L]** 1.4 Standardization and quality control of raw material and finished product: In Process quality control; Identification; Purity; Ash values, Uniformity test, Friability; Stability studies and Shelf life etc**. [5L]** 1.5 Assay as per IP i) Adrenaline, ii) Cephalexin, iii) ferrous fumarate, iv) paracetamol**. [2L]**	
II.	**Pharmaceutical Testing**	15

	2.1 Analysis of compounds based on functional groups **[2L]** 2.2 Instrumental methods for analysis of drugs **[3L]** 2.3 Pharmaceutical Assay: Proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests**. [5L]** 2.4 Sources of impurities and impurity profiling **[2L]** 2.5 Limit tests, dissolution tests, disintegration tests, bioequivalence and bioavailability studies. **[3L]**	

References

1. The Handbook of Drug Laws, M L Mehra, University Book Agency, Ahmedabad, 1997.
2. Chemical Analysis of Drugs, Takeru Higuchi, Interscience Publishers, 1995.
3. Text book of Pharmaceutical Analysis, Kenneth Antonio Connors, Wiley, 2001.
4. Indian Pharmacopeia, Volume I and II.
5. Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, 1995.
6. AOAC volume I and II.

Course Description	**Elective II**
Semester	**III**
Course Name	**Forensic and Cosmetics Analysis**
Course Code	**PSC3FCA**
Eligibility for Course	**M.Sc. Part I (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	The applications of analytical chemistry in forensic science.	Understand
CO2	The various aspects of cosmetic industry and analysis of different type cosmetics.	Understand

UNIT	Course Description	Hrs
I	**Forensic Analysis**	15
	1.1 Analytical Chemistry in Forensic Science: General idea. **[1L]** **1.2** Forensic Serology & DNA Analysis **[3L]** Blood: Blood preservation, bloods stain analysis. DNA Analysis: RELP & PCR **1.3** Hair analysis: Structure and composition of hair, morphological examination, Chemical analysis of hair components and components remaining on or in hair. **[2L]** **1.4 Alcohol in body fluids:** Sampling and sample preservation, analysis - GC, IR, enzymatic and other methods **[2L]** **1.5 Analytical Toxicology:** Isolation, identification and determination of: **[7L]** Narcotics: Heroin, morphine and cocaine. Stimulants: Amphetamines and caffeine. Depressants: Benzodiazepines, Barbiturates. Hallucinogens: LSD and Cannabis. Metabolites of drugs in blood and urine of addicts. Viscera, stomach wash, vomit and postmortem blood for poisons like– cyanide, arsenic, mercury, insecticides and pesticides.	
II	**Cosmetic Analysis**	**15**
	2.1 Cosmetics: Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis. **[2L]** **2.2 Deodorants and antiperspirants:** Al, Boric acid, chlorides, sulphates, and methanamine. **[3L]** **2.3 Face powder:** Ti, Fe, oxides of Ti, Fe and Al (total). **[2L]** **2.4 Hair tonic:** 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers) **[5L]** **2.5 Creams and Lotions:** Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) **[3L]**	

References

1. Lab Manual on Blood analysis and Medical Diagnostics, Dr Gayatri Prakash, S Chand and Company Ltd, New Delhi.
2. Manual of Medical Laboratory Techniques, S Ramakrishnan and K N Sulochana, Jaypee BrothersMedical Publishers (P) Ltd, 2012.
3. Indian Pharmacopeia, Volume I and II.
4. Forensic Chemistry, Suzanne Bell, Pearson Prentice Hall Publication, 2006.
5. Forensic Chemistry, David E Newton, Infobase Publishing, 2007.
6. Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, 1995.
7. AOAC volume I and II.
8. Harry's Cosmetology, 7th Ed, Longman Scientific Co.
9. Formulation and Function of Cosmetics, Joseph Stefan Jellinek, Wiley Interscience, 1971.
10. Cosmetic Technology, Edward Sagarin, Interscience Publishers, 1957.
11. Modern Cosmetics, Edgar George Thommsen, Francis Chilson, Drug and Cosmetic Industry, 1947.
12. Encyclopedia of Industrial Chemical Analysis, Foster Dee Snell et al, Interscience Publishers, 1967.
13. Fundamentals of Urine and Body Fluid Analysis, Nancy A Brunzel, Elsevier health Sciences, 2013.

Course Description	**Elective Practical's**
Semester	**III**
Course Name	**Practical in Analytical Chemistry -II**
Course Code	**PS3PAC2**
CEligibility for Course	**M.Sc. (Chemistry)**
Credit	**2**
Hours	**60**

Sr.No.	**Course Description**	Hrs
1.	Estimation of lactose in milk by Cole ferricyanide method.	4
2.	Estimation of Caffeine in tea	4
3.	Determination of Iodine value of oil / fat	4
4.	Estimation of cholesterol and uric acid in given blood sample.	4
5.	Estimation of Protein by Biuret Method.(Colorimeter)	4
6.	Estimation of drugs by non-aqueous titration: Pyridoxine hydrochloride, Sulphamethoxazole.	4
7.	Analysis of detergents: Active detergent matter and alkalinity	4
8.	Analysis of smear of lipstick on the napkin and its identification by comparing with lipstick samples.	4
9.	Determination of nicotine content in cigarette tobacco.	4

10.	Estimation of Ca in Ca-pentathonate/calcium lactate tablets	4
11.	Analysis of Aspirin/paracetamol as per IP with respect to identification and assay.	4
12.	Estimation of Glucose by Folin-Wu method.	4
13.	Analysis of milk for its calcium, phosphorous and iron.	4
14.	Estimation of Aldehyde in lemon grass oil / Cinnamon oil	4
15.	Estimation of Fe in iron tablet by titrimetrically.	4

References:

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 Nostr and Company,Inc.,1939.
6. E.B.Sandell and H.Onishi,"Spectrophotometric Determination of Traces of Metals",Part-II,4th Ed.,A Wiley InterscicencePublication,New York,1978.

SEMESTER-IV

Course Description	**Major I**
Semester	**IV**
Course Name	**Separation Techniques**
Course Code	**PSC4QAC**
Eligibility for Course	**M. Sc. Part I Chemistry**
Credit	**4**
Hours	**60**

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Insights of modern chromatographic techniques for separation on the basis of charge, size, and affinity of composition.	Understand
CO2	Details of various separation processes.	Apply
CO3	The separation, analysis and standardization of herbal based products.	Understand
CO4	The concept of electrophoresis in analysis and Supercritical fluid Chromatography.	Understand

UNIT	Course Description	Hrs
I	**Separation Techniques - I**	**15**
	1.1 Ion exchange chromatography: Ion exchange equilibria, breakthrough capacity, inorganic ion exchangers, synthetic ion exchangers, chelating resins and their applications for separation of inorganic and organic compounds**. [5L]** **1.2 Ion chromatography:** Principle, instrumentation with special reference to Separation and suppressor columns, applications. **[2L]** **1.3 Exclusion chromatography:** Theory, instrumentation and applications of gel permeation chromatography, retention behaviour, inorganic molecular sieves, determination of molecular weight of polymers. **[5L]** **1.4 Affinity Chromatography:** principle, instrumentation and applications Optimum pressure liquid chromatography (OPLC) **[3L]**	
II	**Separation Techniques – II**	**15**
	2.1 Membrane Separation Processes: operating principles and applications of microfiltration, ultra-filtration, reverse osmosis, dialysis and electro-dialysis. **[7L]** **2.2 Solvent Extraction:** Extraction equilibria of Liquid cation exchangers, liquid anion exchangers and crown ethers. Nature of extracted species. Parameters Influencing extraction including e.g. role of diluents, aggregation, third phase formation and counter ion. Applications of liquid-liquid extraction in metallurgy and biotechnology. **[8L]**	
III	**Separation, Analysis and Standardization of Herbal based products**	
	3.1: Herbs as a raw material: Definition of herb, herbal medicine, herbal Medicinal products, herbal drug preparation. Sources of herbs. Selection, identification and authentication of herbal materials, drying and processing of herbal raw materials, drying and processing of herbal raw material. **[6L]** **3.2 : Extraction of herbal materials:** Choice of solvent for extraction, methods used for extraction and principals involved in extraction**. [3L]** **3.3 : Standardization of herbal formulation and herbal extracts:** Standardization of herbal extract as per WHO, GMP guidelines, Physical, Chemical, Spectral and toxicological standardization, qualitative and	

	quantitative estimations**. [6L]**	
IV	**Advanced Separation Techniques**	**15**
	4.1 Electrophoresis: introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephadex and thin layers) **[2L]** **4.2 Techniques of Electrophoresis:** low and high voltage, sds-page, continuous electrophoresis, capillary electrophoresis, zone, gel, isoelectric focusing, isotaechophoresis and miceller electro kinetic capillary chromatography, instrumentation, detection and applications. **[8L]** **4.3 Supercritical fluid Chromatography:** Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis. **[5L]**	

References

1. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
2. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
3. Extraction Chromatography, T. Braun, G. Ghersene, Elsevier Publications 1978.
4. Super critical fluid extraction, Larry Taylor Wiley publishers N.Y. 1996
5. Ion exchange separation in analytical chemistry, O Samuelson John Wiley 2nd ed 1963
6. Ion exchange chromatography, Ed H.F Walton Howden, Hutchenson and Rossing 1976
7. Chromatographic and electrophoresis techniques, I Smith Menemann Interscience 1960
8. Analytical Chemistry, G. D. Christain, Wiley
9. Instrumental Analysis, 5th Edition, Skoog, Holler and Nieman: Chapter 33
10. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. GrawHill (1987)

Course Description	**Major II**
Semester	**IV**
Course Name	**Advanced Instrumental Technique**
Course Code	**PSC4AIT**
Eligibility for Course	**M. Sc. Part I Chemistry**
Credit	**4**
Hours	**60**

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	The theoretical concepts of surface analytical techniques.	Understand
CO2	Advanced spectroscopic techniques used for characterization of matter.	Evaluate
CO3	Principle and interfacing of radio analytical techniques and hyphenated thermal methods.	Understand
CO4	The detail concept of hyphenated techniques including GC-MS, GC-IR, LC-MS, and HPLC-MS etc.	Undestand

UNIT	Course Description	Hrs
I	**Spectral Methods III**	**15**
	1.1 Principle, Instrumentation and Applications of Scanning Probe Microscopy, Atomic Force Microscopy **[3L]** Scanning Tunneling Microscopy **[3L]** **1.2** Ion Probe Spectroscopy, Secondary Ion mass spectroscopy. **[3L]** **1.3** Low-Energy Ion Scattering and Rutherford Backscattering **[4L]** **1.4** Atomic Emission Spectroscopy**,** electrical discharge sources **[2L]**	
II	**Spectral Methods IV**	**15**
	2.1 Principle, Instrumentation, and Applications of a. Electron Spin Resonance Spectroscopy (ESR) **[4L]** b. Mossbauer's Spectroscopy **[4L]** c. Particle-Induced X-Ray Emission **[4L]** d. Transmission electron Microscopy**[3L]**	

III	**Radiochemical and Thermal Methods**	**15**
	3.1 Activation analysis- NAA, radiometric titrations and radio-release methods, Advantages of NAA**[7L]** **3.2 Thermal analysis:** Principle, Interfacing, instrumentation and applications of the following. (a) Simultaneous Thermal Analysis- TG-DTA and TG-DSC (b) Evolved gas analysis- TG-MS and TG-FTIR **[8L]**	
IV	**Hyphenated Techniques**	
	4.1 Concept of hyphenation, need for hyphenation, possible hyphenations. **[2L]** **4.2** Principle, Interfacing , instrumentation and Applications of i) GC – MS, ICP –MS, GC – IR, Tandem Mass Spectrometry, LC – MS, CE-MS. **[13L]**	

References :

1. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West and F. J Holler Holt- Saunders 6th Edition (1998)
2. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5 Ed.
3. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A.
4. Thermal methods of Analysis, P. J. Haines, Blackie Academic & Professional, London (1995)
5. Thermal Analysis, 3rd Edition W. W. Wendlandt, John Wiley, N.Y. (1986)
6. Principles and Practices of X-ray spectrometric Analysis, 2 NY, (1975)
7. Ed E. P. Bertain, Plenum Press,Nuclear Analytical Chemistry, D. Bane, B. Forkman, B. Persson, Chartwell - Bratt Ltd (1984)
8. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, A series of volumes
9. Spectrometric Identification of Organic Compounds Hardcover – by Robert M. Silverstein Wiley
10. Encyclopedia of Analytical Science, Editors-in-Chief: Paul Worsfold, Alan Townshend, and Colin Poole ISBN: 978-0-12-369397-6
11. Encyclopedia of Analytical Chemistry: Applications, Theory, and Instrumentation. Meyers Robert A Meyers
12. Introduction to Thermal Analysis Techniques and Applications Edited by Michael E. Brown Principles and Applications of Thermal Analysis Edited by Paul Gabbott

Course Description	**Major III**
Semester	**IV**
Course Name	**Environmental Analysis and its Management**
Course Code	**PSC4EAM**
Eligibility for Course	**M. Sc.Part I Chemistry**
Credit	**4**
Hours	**60**

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Various methods for solid waste management.	Understand
CO2	The quality and requirement of potable water and bore well water.	Understand
CO3	The importance of water quality and its monitoring.	Understand
CO4	Different aspects of Chemistry of atmosphere and Environmental legislation.	Apply

UNIT	Course Description	Hrs
I	**Effluent Treatment**	**15**
	1.1 Effluent treatment plant: general construction and process flow charts **[3L]** **1.2** Treatment and disposal of Sewage. **[3L]** **1.3** Domestic waste water treatment, aerobic, treatment process, anaerobic treatment process, industrial waste water treatment, Effluent parameters **[2L]** **1.4** Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent**. [2L]** **1.5** Recovery of metals from effluent, modern methods – Electrodialysis, Electrodeposition and Ion Exchange etc**.[3L]** **1.6** Importance of recovery of metals from effluent, Recycle and reuse of process and treated (effluent) water **[2L]**	
II	**Solid Waste Management**	**15**
	2.1 Solid waste management: objectives, concept of recycle, reuse and recovery [**3L]** **2.2** Methods of solid waste disposal: Landfilling, Incineration, Recycling, Composting. **[2L]** **2.3** Treatment and disposal of sludge / dry cake **[2L**] **2.4** Onsite sanitation system and disposal of sludge **[2L]** **2.5** Managing non-decomposable solid wastes**[2L]** **2.6** Bio- medical waste**:** Introduction, Classification and methods of disposal **[4L]**	
III	**Water quality Monitoring**	**15**
	3.1 Sources of Water – Potable water, Waste water **[1L]** **3.2** Potable water: Quality and requirements of potable water, direct and indirect pollutants for potable water reservoirs **[2L]** **3.3** Regulatory requirements for packaged drinking water **[2L]** **3.4** Waste water: Water pollutants, Microorganisms, Inorganic pollutants, Organic pollutants **[2L**]	

	3.5 The purpose of chemical analysis, sampling of water **[2L]** **3.6** Pollution indicators – pH of water, specific conductance, determination of acidity and alkalinity, Chemical oxygen demand, biological oxygen demand, dissolved oxygen, turbidity, determination of aluminum, arsenic, boron, cadmium, calcium, carbon dioxide, chloride, residual chlorine, Suspended solids **[3L]** **3.7** The purpose of chemical analysis, sampling of water, pH of water, specific conductance, determination of acidity and alkalinity, Chemical oxygen demand, biological oxygen demand, dissolved oxygen, turbidity, determination of aluminum, arsenic, boron, cadmium, calcium, carbon dioxide, chloride, residual chlorine, anionic detergents, tannin and lignin **[3L]**	
IV	**Monitoring of Air Pollution and Environmental legislation**	**15**
	4.1 Monitoring of Air pollution Sampling methods for air, flew gas, industrial exhaust, stag samples etc. **[2L]** **4.2** Importance of automobile exhaust control and its limits**[2L]** **4.3** Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors. **[2L]** **4.4** Monitoring of air pollutants by Instrumental Methods-Control of air pollution by raw material change, process modification, adsorption, absorption and combustion methods. **[2L]** **4.5** Pollutants in the environment and their sources; general classifications of pollutants and their chemical structures, properties, toxicity. **[2L]** **4.6** Environmental Impact Assessment: Environmental Impact Assessment process in India **[2L]** **4.7** Environmental Legislation: Role and responsibilities of pollution control boards, Motor Vehicle Act and method of analysis with respect to PUC. **[3L]**	

References:

1. Environmental Pollution Analysis, S. M. khopkar, New Age International publication (2011).
2. Water and water pollution (hand book) Ed., Seonard'l Ciacere, Vol I to IV, Marcel Dekker inc. N.Y.(1972)
3. Water pollution, Arvind kumar, APH publishing (2004)
4. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paperback publication.
5. Solid waste management, K Sasikumar and Sanoop Gopi Krishna PHI publication (2009)
6. Solid waste management, Surendrakumar Northen Book Center (2009)
7. Handbook of chemical technology and pollution control 3 Edn Martin Hocking AP Publication (2005).
8. 8 Fundamental Concepts of Environmental Chemistry, Second Edition G. S. Sodhi , Alpha Science, 2005
9. Chemical analysis of metals ; Sampling and analysis of metal bearing ores: American Society for Testing and Materials 1980 - Technology & Engineering
10. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau of Mines, 1979.

Course Description	**Elective I**
Semester	**IV**
Course Name	**Intellectual Property Rights**
Course Code	**PSC4IPR**
Eligibility for Course	**M. Sc.Part I Chemistry**
Credit	**2**
Hours	**30**

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Study about details of intellectual property.	Apply
CO2	Study the intellectual property rights (IPR)	Evaluate
CO3	Industrial designing and traits in it.	Understand

UNIT	Course Description	Hrs
I	**Introduction to Intellectual Property Rights-I**	**15**
	1.1 Historical Perspective, Different types of IP, Importance of protecting IP**. [2L]** **1.2 Patents:** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting novation with public health, Software patents and their importance for India [**5L**] **1.3: Industrial Designs:** Definition, How to obtain- features, International design registration**. [2L]** **1.4: Industrial Designs:** Definition, How to obtain, features, International design registration**. [2L]** **1.5: Trade Marks:** Introduction, How to obtain different types of marks – Collective marks, certification marks, service marks, trade names etc. **[2L]** **1.6: Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India. **[2L]**	
II	**Introduction to Intellectual Property Rights-II**	**15**

	2.1 Trade Secrets: Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection. **[2L]** **2.2 IP Infringement issue and enforcement:** Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. **[2L]** **2.3 Economic Value of Intellectual Property:** Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. **[3L]** **2.4 Different International agreements:** (a) World Trade Organization (WTO): (i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade Related Services (GATS); Madrid Protocol. (iii) Berne Convention (iv) Budapest Treaty (b) Paris Convention WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity **[8L]**	

Course Description	**Elective II**
Semester	**IV**
Course Name	**Analysis of selected materials**
Course Code	**PSC4ASM**
Eligibility for Course	**M. Sc.Part I Chemistry**
Credit	**2**
Hours	**30**

Course Outcomes

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Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Get idea about classifications and applications of plastics, polymers, paints and pigments and their environmental impact.	Apply
CO2	The impact of plastic on environment as pollutant.	Evaluate
CO3	The various metals, ferrous and non-ferrous alloys used in various industries.	Understand
CO4	Study metallurgical analysis.	Understand

UNIT	Course Description	Hrs
I	**Plastics and Polymers**	15
	1.1 Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride, ethylene, acrylic and cellulosic plastics. **[5L]** **1.2** Metallic impurities in plastic and their determination. **[2L]** **1.3** Impact of plastic on environment as pollutant. **[2L]** **1.4** Paints and pigments: Types of paints pigments, determination of volatile and non – volatile components, Flash point (significance and method of determination), separation and analysis of pigments, binders and thinners. **[3L]**	

	1.5 Role of Organo silicones in paints and their impact on environment. **[3L]**	
II	**Metallurgical Analysis**	**15**
	2.1 Metallurgy: Concentration of ores, methods of metal dressing (hand picking, magnetic separation, centrifuge, froth flotation etc.), pollution due to metallurgical process (Metal dressing, calcinations, smelting). Principles of pyrometallurgy-roasting, agglomeration, smelting, refining & secondary refining, extraction of Fe from Hematite ore. Principles of hydrometallurgy, extraction of Al from bauxite. Principles of Electrometallurgy, extraction of Cu from Copper pyrites**. [8L]** **2.2 Analysis of Ferroalloys:** Analysis of steel - Molybdenum, Phosphorous. **[2L]** **2.3 Analysis of non- Ferrous alloys:** i) Analysis of Tin, Zinc and Copper in Brass, Bronze. ii) Analysis of Tin and lead in Solder. iii) Analysis of Cement: Composition of Portland cement, estimation of Aluminium oxide and Ferrous oxide. Determination of Alumina in Cement by Polarography **[5L]**	

Refrences:

1. Chemical analysis of metals ; Sampling and analysis of metal bearing ores: American Society for Testing and Materials 1980 - Technology & Engineering

2. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau ofMines, 1979.

3. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).

4. Zone refining and allied techniques, Norman L. Parr, G. Newnes Technology & Engineering (1960).

5. Handbook of chemical technology and pollution control 3 Edn Martin Hocking AP Publication (2005).

6 Fundamental Concepts of Environmental Chemistry, Second Edition G. S. Sodhi , Alpha Science, 2005

Course Description	**Elective Practical**
Semester	**IV**
Course Name	**Practical in Analytical Chemistry -I**
Course Code	**PSC4PAC1**
Eligibility for Course	**M.Sc.Part I (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	**Cos**	**Bloom Taxonomy Level (BLT)**
CO1	Students will learn the analysis of quality of various types of samples using instrumental methods of analysis.	Apply
CO2	Students will learn graphical representation of the data.	Understand
CO3	Students will learn the various advanced analytical techniques for analysis of different samples.	Apply
CO4	Students will get knowledge of quality control methods and understand the importance of accuracy.	Apply

Sr. No.	**Course Description**	Hrs
1.	Determination of nickel by extractive photometry using dimethyl glyoxime.	4
2.	Simultaneous determination of Ti^{3+} and V^{5+} spectrophotometrically by H_2O_2 method.	4
3.	Determination of percent purity of methyl alcohol by Gas chromatography	4
4.	To analyze Bronze for Zn by complexometric method.	4
5.	Interpretation of spectra of HPLC (at least 4 sample spectra of each)	4
6.	Interpretation of spectra of GC (at least 4 sample spectra of each)	4
7.	Analysis of water sample: Mn^{2+} by colorimetric method	4
8.	Analysis of Bauxite for Ti by colorimetry / Al by gravimetry / Fe (volumetry)	4
9.	Interpretation of thermograms TGA (4 sample thermograms)	4
10.	Interpretation of thermograms DTA (4 sample thermograms)	

11.	Interpretation of thermograms DSC (4 sample thermograms)	4
12.	Interpretation of spectra NMR (at least 4 sample spectra of each	4
13.	Interpretation of spectra Mass, (at least 4 sample spectra of each	4
14.	Interpretation of spectra IR, UV visible (at least 4 sample spectra of each)	4
15.	Interpretation of XRD pattern of Cubic system.	4

Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR ARTS, COMMERCE & SCIENCE COLLEGE, NEW PANVEL

(AUTONOMOUS COLLEGE)

Re-accredited 'A+' Grade by NAAC
'College with Potential for Excellence' Status Awarded by UGC'Best College Award' by University of Mumbai

NEP 2020

Syllabus for M.Sc.-I Organic Chemistry

Programme: M.Sc.

Course: M.Sc.-I Organic Chemistry

Programme Code: MSCOC1018

Choice-Based Credit, Grading and Semester System (60:40)

w.e.f. Academic Year 2023-2024

Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR
ARTS, COMMERCE & SCIENCE COLLEGE, NEW PANVEL
(AUTONOMOUS COLLEGE)

Approved Syllabus of M.Sc.-I Organic Chemistry

Sr. No.	Heading	Particulars
1	**Title of Course**	M.Sc.-I Organic Chemistry
2	**Eligibility for Admission**	The B.Sc. degree examination of the University of Mumbai with chemistry 6 units or 3 units or degree of any other university recognized as equivalent thereto.
3	**Passing marks**	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	**Ordinances/Regulations (if any)**	------
5	**No. of Semesters**	One year/Two semester
6	**Level**	P.G. part-I
7	**Pattern**	Semester (60:40)
8	**Status**	Revised
9	**To be implemented from the Academic year**	2023-2024

BOS Chairman **Principal**

After completion of the M.Sc. programme students will acquire

S. N.	After completion of the M.Sc. program students will acquire	Graduate Attribute
PO1	An ability to identify and describe broadly accepted methodologies of science, and different modes of reasoning.	Disciplinary knowledge
PO2	An ability to demonstrate proficiency in various instrumentation, modern tools, advanced techniques and ICT to meet industrial expectations and research outputs.	Disciplinary knowledge/Digital literacy
PO3	An ability to identify problems, formulate, and prove hypotheses by applying theoretical knowledge and skills relevant to the discipline.	Problem-solving
PO4	An ability to be articulate thoughts, research ideas, information, scientific outcomes in oral and in written presentation to range of audience.	Communication skills
PO5	A capacity for independent, conceptual and creative thinking, analysis and problem solving through the existing methods of enquiry.	Problem solving
PO6	Skills required for cutting edge research, investigations, field study, documentation, networking, and ability to build logical arguments using scholarly evidence.	Research skills
PO7	An ability to portray good interpersonal skills with ability to work collaboratively as part of a team undertaking a range of different team roles	Teamwork
PO8	The ability to understand ethical responsibilities and impact of scientific solutions in global, societal and environmental context and contribute to the sustainable development	Moral and ethical awareness/ multicultural competence
PO9	An ability to demonstrate leadership, to take action and to get others involved.	Leadership
PO10	An openness to and interest in, life-long learning through directed and self-directed study	Self-directed learning
PO11	An ability to translate the knowledge and demonstrate the skills required to be employed and successful professional development.	Life-long learning

Programme: M.Sc. Organic Chemistry

PSOs No.	After completing the programme in M.Sc. Organic Chemistry, Students will able to:	Graduate Attribute
PSO1	Develop analytical thinking and apply the same for understanding principles, proposing mechanisms and logical conclusions, and understanding the interdisciplinary nature of Chemistry and emerging trends in Chemistry.	Disciplinary knowledge Problem-solving
PSO2	Get research opportunities in academics as well as employment at R & D in the synthetic division of chemical, pharmaceutical, dyestuff and food industries	Research skills
PSO3	Competency in design and planning of synthesis and carrying out with Good Laboratory Practices, handling instruments and interpretation of spectral data for structure determination of organic compounds	Research skills

Masters of Science (Organic Chemistry)
Syllabus for Semester I and II

Preamble of the Syllabus:

Master of Science (M.Sc.) in Organic Chemistry is a post-graduate course of department of Chemistry, Changu Kana Thakur Arts, Commerce & Science College, New Panvel (Autonomous).

There are two P.G. programmes in Chemistry, namely M.Sc. programme in Organic Chemistry and M.Sc. programme in Analytical Chemistry. Both P.G. programmes are equivalent in all respect for employment and higher studies. Each of these two P.G. programmes shall extend over two academic years comprising four semesters. The syllabi and scheme of examinations of these two programmes are detailed below. The theory and practicals of courses for two semesters of the two programmes are the same. Chemistry is a fundamental science and has contributed immensely to the improvement of the life of human beings by providing many of human requirements and essentialities. Chemistry is important to the world economy as well. The developments in Chemistry during the last few decades are phenomenal. It is also seen that these developments are crossing the traditional vertical boundaries of scientific disciplines; moreinclination is seen towards biological sciences. New branches of chemistry are emerging and gaining importance, such as bioorganic chemistry, materials chemistry, computational chemistry, etc.

The practice of Chemistry at an industrial scale is also undergoing radical changes and is more or more based on deep understanding the chemical phenomena. The emerging Chemical Technologies are highly science based. The aid of computers has not only accelerated growth in the practice of Chemistry, but revolutionized the entire field. A chemist cannot isolate himself from other disciplines. Thus, after a long span of more and more specialization in graduate and post-graduate syllabi, a symbiotic interdisciplinary approach now seems to be more relevant.

Objectives of the Course:

1. To develop laboratory competence in relating chemical structure to spectroscopic phenomena.
2. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.
3. To provide the students with sound preparation for requirement of modern industry and provide competency in basic academic research as well as a cohesive, clearly structured overview of Chemistry

Course Outcome:

1. Think critically and analyse chemical problems.
2. Present scientific and technical information resulting from laboratory experimentation in both written and oral formats.
3. Work effectively and safely in a laboratory environment.
4. Use technologies/instrumentation to gather and analyse data.
5. Work in teams as well as independently.
6. Apply modern methods of analysis to chemical systems in a laboratory setting.

M. Sc. Organic Chemistry

For the subject of chemistry, there shall be four papers for 60 lectures each comprising of four units of 15 L each.

Semester-I

1. Paper-I / Inorganic Chemistry,
2. Paper- I / Organic Chemistry
3. Paper- III /Analytical Chemistry
4. Paper- IV/Physical Chemistry-I, II (Electives)
5. Paper- V/Research Methodology

Semester-II

1. Paper-I / Inorganic Chemistry,
2. Paper- I / Organic Chemistry
3. Paper- III /Analytical Chemistry
4. Paper- IV/Physical Chemistry-I, II (Electives)
5. On Job Training (OJT)

Scheme of Examination

The performance of the learners shall be evaluated in two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part and by conducting the Semester End Examinations with 60% marks in the second part. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below-

A) Internal Assessment: 40 % 40 Marks

Sr. No.	Particular	Marks
01	One periodical class test / online examination is to be conducted in the given semester	20 Marks
02	Any One tool out of these (15 Marks each) 1. Group/ Individual Project 2. Presentation and write-up on the selected topics of the subjects / Case studies. 3. Test on Practical Skills 4. Open Book Test 5. Quiz	15 Marks
03	Active participation	05

Question Paper Pattern

(Periodical Class Test for the Courses at Under Graduate Programmes)

Maximum Marks: 20 Duration: 40 Minutes
Questions to be set: 02
All Questions are Compulsory

Question No.	Particular	Marks
Q-1	Match the Column / Fill in the Blanks / Multiple Choice Questions/ Answer in One or Two Lines (Concept-based Questions) (1 Mark/ 2 Marks each)	10 Marks
Q-2	Answer in Brief (Attempt any Two of the Three) (5 Marks each)	10 Marks

B) Semester End Examination: 60 % 60 Marks

- Duration: The examination shall be of $2\frac{1}{2}$ hours duration.

Question Paper Pattern

Theory question paper pattern
1. There shall be five questions each of 12 marks. 2. All questions shall be compulsory with internal options. 3. Questions may be subdivided into sub-questions a, b, and c… and the allocation ofmarks depends on the weightage of the unit.

Passing Standard

The learners shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment and Semester End Examination. The learners shall obtain minimum of 40% marks (i.e. 16 out of 40) in the Internal Assessment and 40% marks in Semester End Examination (i.e. 24 Out of 60) separately, to pass the course and minimum of grade D in each project wherever applicable to pass a particular semester.

❖ Guidelines and Evaluation pattern for project work (100 Marks)

Introduction

The inclusion of project work in the course curriculum of the M.Sc. programme is one of the ambitious aspects in the programme structure. The main objective of inclusion of project work is to inculcate the element of research work challenging the potential of learner as regards to his/ her eager to enquire and ability to interpret particular aspect of the study in his/ her own words. It is expected that the guiding teacher should undertake the counselling sessions and make the awareness among the learners about the methodology of formulation, preparation and evaluation pattern of the project work.

- There are two modes of preparation for project work
  1. Project work based on research methodology in the study area
  2. Project work based on an internship in the study area

I	**Theory:** The Semester End Examination for theory course work will be conducted as per the following scheme.		
	Each theory paper shall be of two- and half-hour duration.		
	All questions are compulsory and will have internal options.		
	Q-1	From Unit – I (having internal options.) 12 M	
	Q-2	From Unit – II (having internal options.) 12M	
	Q-3	From Unit – III (having internal options.) 12M	
	Q-4	From Unit – IV (having internal options.) 12M	
	Q-5	Questions from all the FOUR Units with equal weightage of marks allotted to each Unit. 12 M	
II	**Practical**	The Semester End Examination for Practical course work will be conducted as per the following scheme.	
Sr. No.	Particulars of External Practical Examination		**Marks%**
1	Laboratory Work		80
2	Journal		10
3	Viva		10
	TOTAL		**100**

Choice Based Credit, Grading and Semester System (CBCGS)
To be implemented from the Academic year 2023-24

M.Sc.-I Organic Chemistry
Semester- I

Course Code	Unit	Topics	Credits	L / Week
PSC1IC1	I	Chemical Bonding	4	1
	II	Molecular Symmetry and Group Theory		1
	III	Materials Chemistry and Nanomaterials		1
	IV	Characterization of Coordination Compounds		1
PSC1OC1	I	Addition reactions	4	1
	II	Nucleophilic substitution reactionsand Aromaticity		1
	III	Stereochemistry		1
	IV	Oxidation and Reduction		1
PSC1AC1	I	Language of Analytical Chemistry	4	1
	II	Quality in Analytical Chemistry		1
	III	Optical Methods		1
	IV	Thermal Methods		1
PSC1RM	I	Print: Primary, Secondary and Tertiary sources	4	1
	II	DATA ANALYSIS		1
	III	Methods Of Scientific Research and Writing		1
	IV	Chemical Safety & Ethical Handling of Chemicals		1
PSC1PR1	-	Practical Course Organic Chemistry Practicals + Analytical Chemistry Practical's	2	8
Elective-I	I	Thermodynamics-I	2	2

PSC1PC1	**II**	**Quantum Chemistry**		
Elective-II PSC1PC2	**III**	**Chemical Dynamics-I**	**2**	**2**
	IV	**Electrochemistry**		
PSC1PR2	**-**	**Practical Course Physical chemistry Practical's + Inorganic Chemistry Practical's**	**2**	**8**
PSC1RM1	**I**	**Research and Literature Survey**	**4**	**1**
	II	**Data Analysis**		**1**
	III	**Methods of Scientific Research and Writing**		**1**
	IV	**Chemical Safety and Ethical handling of Chemicals**		**1**

Choice Based Credit, Grading and Semester System (CBCGS)
To be implemented from the Academic year 2023-2024

M.Sc.-I Organic Chemistry
Semester- II

Course Code	Unit	Topics	Credits	L / Week
PSC2IC2	I	Inorganic Reaction Mechanism	4	1
	II	Organometallic Chemistry of Transition metals		1
	III	Environmental Chemistry		1
	IV	Bioinorganic Chemistry		1
PSC2OC2	I	Alkylation of Nucleophilic Carbon Intermediates Reaction of carbon nucleophiles with carbonyl groups	4	1
	II	Reactions and Rearrangements		1
	III	Elimination Reactions and Organometallic Chemistry		1
	IV	NMR spectroscopy and Mass spectrometry		1
PSC2AC2	I	Chromatography	4	1
	II	X-ray spectroscopy, Mass spectrometry, Radioanalytical Methods		1
	III	• Surface Analytical Techniques • Atomic Spectroscopy		1
	IV	Electroanalytical Methods		1
PSC2PR1	-	Practical Course Organic Chemistry Practicals + Analytical Chemistry Practical's	2	8
Elective-I PSC2PC1		Chemical Thermodynamics II	2	1
		Quantum Chemistry II		
Elective-II PSC2PC2		Chemical Kinetics and Molecular Reaction Dynamics	2	1
		Solid State Chemistry and Phase Equilibria		
PSC2PR2	-	Practical Course Physical chemistry Practical + Inorganic Chemistry Practicals	2	8
PSC2OJT --	OJT	On Job training	4	

SEMESTER-I

Course Description (Major)	
Semester	**I**
Course Name	**Inorganic Chemistry**
Course Code	**PSC1IC1**
Eligibility for Course	**T.Y.B. Sc.in Chemistry**
Credit	**4**
Hours	**60**

Course Objectives:

1. To apply theories of bonding, hybridization, MOT for Polyatomic species.
2. To understand preparation, proporties and structures of higher boranes, carboranes, metalloboranes and metallocarboranes, metal carbonyls and halide clusters.
3. To understand all elements of symmetry, point group, symmetry classification, symmetry criterion of optical activity, symmetry restrictions on dipole moment.
4. To understand concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups, Mulliken's notations for irreducible representations. Reduction of reducible representations using reduction formula.
5. To understand concept of band theory, Fermi level, K-Space and Brillouin Zones, Defects in solids.
6.To explain Preparative methods of inorganic solids & nano materials.
7.To explain Electron Paramagnetic Resonance Spectroscopy and its applications, spectral calculations using Orgel and Tanabe-Sugano diagram.
8. To determine of formation constants of metal complexes.

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Explain theories of bonding, hybridization, resonance concept, MOT for diatomic species of first transition Series, Polyatomic species and Higher boranes, carboranes, metalloboranes and metallocarboranes, metal carbonyls and halide clusters.	Understand
CO2	Explain The concept of band theory, Fermi level, K-Space and Brillouin Zones. Structures of Compounds of the type: AB, AB2 etc. and Preparative methods of inorganic solids & nano materials.	Understand
CO3	Construct Group Multiplication Tables, Character tables using concept of Molecular Symmetry and Group Theory.	Apply
CO4	Determine electronic parameters such as Δ, B, C, Nephelauxetic ratio, formation constants of metal complexes and Characterize coordination compounds using techniques like thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic	Evaluate

Unit	Course Description	Hrs
1.	**Chemical Bonding:**	15h
1.1	Recapitulation of hybridization Derivation of wave functions for sp, sp2, sp3 orbitalhybridization 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	Molecular Orbital Theory for Polyatomic species considering σ bonding for SF6, CO2,B2H6, I3- molecular species.	
1.4	Higher boranes, carboranes, metalloboranes and metallocarboranes, metal carbonyls and halide clusters, compounds with metal-metal multiple bonds.	
2.	**Molecular Symmetry and Group Theory:**	15h
2.1	Symmetry criterion of optical activity, symmetry restrictions on dipole moment. Asystematic procedure for symmetry classification of molecules.	
2.2	Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group MultiplicationTables. 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 C2v, C3v and D2h, the structure of character tables.	
2.4	**Applications of Group Theory** (a) Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in ABn (Ammonia, CH4) 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.	
3.	**Materials Chemistry and Nanomaterials:**	15h
3.1	**Solid State Chemistry**	
3.1.1	Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones.	
3.1.2	**Crystal Defects and non-stoichiometry:** Classification of Defects: subatomic,atomic and lattice defects in solids; Thermodynamics of vacancy in metals; Thermodynamics of Schottky defects in ionic solids ; Thermodynamics of Frenkel defects in silver halides; Calculation of number of defects and average energy required for defect.	
3.1.3	Methods of preparation for inorganic solids: sol- gel method (applications in Biosensors), microwave synthesis (discussion on principles, examples, merits and demerits are expected)	
3.2	**Nanomaterials**	
3.2.1	Preparative methods: Chemical methods, Microwave, Langmuir Blodgett(L-B) method, Biological methods: Synthesis using microorganisms	
3.2.2	Applications in the field of semiconductors, solar cells	
4.	**Characterisation of Coordination compounds**	15h

4.1	Electron Paramagnetic Resonance Spectroscopy (EPR): i) Theory and Instrumentation of EPR in brief. ii) Spin Hamiltonian, Isotropic and anisotropic EPR spectra, Magic Pentagon rule. iii) Applications of EPR spectroscopy: Structural determination of Inorganic complexes	
4.2	Spectral calculations using Orgel and Tanabe-Sugano diagram, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio.	
4.3	Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectral methods.	

References

Unit I

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.

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6. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, OxfordUniversity Press, 1967.

7. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin CummingsPublishing Company, 1989.

8. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.

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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.
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Chemistry,PHI Learning, 2012.
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7. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory inChemistry, 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, A. 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 Structureand 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).
7. Physical Methods in Chemistry, R. S. Drago (2nd Edition) (1977).

Course Description	
Semester	**I**
Course Name	**Inorganic Chemistry Practical**
Course Code	**PSC1PR2**
Eligibility for Course	**T.Y.B. Sc.in Chemistry**
Credit	**2**
Hours	**30**

Sr. No.	After completing the course, Students will be able to:	Bloom Taxonomy Level (BTL)
CO1	Prepare various inorganic complexes such as Bis-(tetramethylammonium) tetrachloroCuprate (II) (Me4 N) 2[CuCl4],Tetramminemonocarbanato Cobalt (III) Nitrate, Bis (ethylenediammine) Copper (II) Sulphate, Hydroniumdichlorobis(dimethylglyoximato) etc.	Understand
CO2	Determine the electrolytic nature of inorganic compounds	Apply
CO3	Apply Slope intercept method for determination of equilibrium constants forFe^{+3}/ SCN- system.	Apply
CO4	Analyze the inorganic complex for percentage of metal and ligand.	Analyse

Inorganic Preparations (Synthesis and Characterization)

1) Bis-(tetramethylammonium) tetrachloroCuprate (II) (Me4 N) 2[CuCl4]

2) Tetramminemonocarbanato Cobalt (III) Nitrate [Co(NH3)4CO3]NO3

3) Bis (ethylenediammine) Copper (II) Sulphate [Cu(en)2]SO4

4) Hydronium dichlorobis(dimethylglyoximato) Cobaltate(III) H[Co(dmgH)2Cl2]

Instrumentation

1) Determination of equilibrium constant by Slope intercept method for Fe+3/ SCN- system

2) Determination of Electrolytic nature of inorganic compounds by Conductancemeasurement.

Reference:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd

The Synthesis and Characterization of Inorganic Compounds by William L. Jolly 3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

Course Description	
Semester	**I**
Course Name	**Organic Chemistry**
Course Code	**PSC1OC1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**4**
Hours	**60**

Course Objectives

1. To study the basics of addition reactions and their applications.
2. To study stereochemistry in man detail
3. To study the different reagents in the organic transformation.
4. To understand the role of carbon nucleophiles in organic synthesis

Course Outcomes

After successful completion of this course, students will be able to

Sr. No.	CO	Bloom Taxonomy Level (BLT)
CO1	Understand the types of addition reaction and their applications	Remember
CO2	Summarize the various aspects of aromaticity, aliphatic, and aromatic nucleophilic substitution reactions with their mechanism and examples.	Understand
CO3	Apply the concept of Configurational descriptors (R, S nomenclature) to chiral centers in Organic compounds	Apply
CO4	Predict the mechanism, selectivity, importance, and applications of oxidizing and reducing agent	Apply

Unit	Course Description	Hrs
1.	**Addition Reactions:** 1.1 Addition reactions to carbon-carbon multiple bonds -Mechanism and Stereochemical aspects of addition reaction Involving electrophile 1.2 Structural Effect and reactivity: Halogenation, Hydrohalogenation, Hydration, Hydroxylation, Hydroboration, Epoxidation, Carbene addition and Ozonolysis. 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
2.	**Nucleophilic substitution reactions and Aromaticity:** 2.1. Nucleophilic substitution reactions: (9 L) 2.1.1. Aliphatic nucleophilic substitution: SN1, SN2, SNi reactions, mixed SN1 and SN2 and SET mechanisms. SN 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.SNcA, SN1‟ and SN2‟ reactions.SN at sp2 (vinylic) carbon. 2.1.2. Aromatic nucleophilic substitution: SNAr, SN1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. 2.1.3. Ester hydrolysis: Classification, nomenclature and study of mechanisms of acid and base catalyzed hydrolysis with suitable examples (Any two). Orientation and Reactivity-Effect of Substrate, Leaving group and attacking nucleophile 2.2. Aromaticity: (6 L) 2.2.1. Structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of	15

	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 (C60)	
3.	**Stereochemistry:** 3.1. Concept of Chirality: Recognition of symmetry elements. 3.2. 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. Stereo-descriptors: R, S, for chiral centres in acyclic and cyclic compounds. 3.3. 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. 3.4. 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) propseudoasymmetric centre. Symbols for enantiotopic and diastereotopic faces. E, Z nomenclature Resolution of Racemic mixtures	15

4.	**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 K2Cr2O7/H2SO4 (Jones reagent), CrO3-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 HIO4; cycloalkanones using CrO3; aromatic rings using RuO4 and NaIO4. 4.1.4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH2 to CO by SeO2, oxidation of arylmethanes by CrO2Cl2 (Etard oxidation). 4.1.5. Oxidation of aldehydes and ketones: with H2O2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) 4.2. Reduction: General mechanism, selectivity, and important applications of the following reducing reagents: 4.2.1. Reduction of CO to CH2 in aldehydes and ketones- Clemmensen reduction, WolffKishner reduction and Huang-Minlon modification. 4.2.2. Metal hydride reduction: Boron reagents (NaBH4, NaCNBH3, diborane, 9-BBN, Na(OAc)3BH, aluminium reagents (LiAlH4, DIBAL-H, Red Al, L and K- selectrides). 4.2.3. NH2NH2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzschdihydropyridine). 4.2.4. Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.	**15**

Organic Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Organic Chemistry**
Course Code	**PSC1PR1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Plan preparation of organic compounds	Apply
CO2	Demonstrate the skill of purification of organic compounds by recrystallization and sublimation methods.	Understand
CO3	Apply the thin layer chromatography technique to check the purity of the synthesized product.	Apply
CO4	Can Sketch the structure of organic compounds using software Chem Biodraw.	Apply

Sr. No.	**Course Description**	Hrs
1.	One step preparation	40
2.	(1.0 g scale) 1. Bromobenzene to p-nitrobromobenzene	
3.	2. Anthracene to anthraquinone	
4.	3. Benzoin to benzil	
5.	4. Anthracene to Anthracene maleic anhydride adduct	
6.	5. 2-Naphthol to BINOL	
7.	6. p-Benzoquinone to 1,2,4-triacetoxybenzene	
8.	7. Ethyl acetoacetate to 3-methyl-1-phenyl pyrazole-5-one	
9.	8. Preparation of benzilic acid from benzil	
10	9. Preparation of p-iodonitrobenzene from p-nitroaniline	
11.	11. Use of Computer-Chem Draw-Sketch, ISI – Draw: Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name, Get ^{1}HNMR and ^{13}C. Students can able to draw the one-name reaction and its reaction mechanism.	

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford UniversityPress.

2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.

3. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, NewDelhi.

4. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.

5. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. NewInternational Publishers Ltd.

6. March‟s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B.Smith, Jerry March, Wiley.

7. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad,Pearson Education.

8. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.

9. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge UniversityPress.

10. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, AcademicPress.

11. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.

12. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya ShankarSingh, Pearson Education.

13. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.

14. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, CambridgeUniversity Press.

15. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan.Organic Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Analytical Chemistry**
Course Code	**PSC1AC1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**4**
Hours	**60**

Course Objectives

1. To develop laboratory competence in relating chemical structure to spectroscopic phenomena.
2. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.
3. To provide the students with a sound preparation for the requirements of modern industry and provide competency in basic academic research as well as a cohesive, clearly structured overview of Chemistry

Course Outcomes

After successful completion of this course, students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Explain the concept of data domain, performance characteristics of an instrument/method, total quality management, quality standards for laboratories, quality audits and quality reviews.	Understand
CO2	Discover the applications of UV-visible spectroscopy, IR spectroscopy, and Differential scanning calorimetry.	Apply
CO3	Identify the need of automation in chemical analysis, safety measures in laboratory, need of accreditation of laboratories and GLP.	Evaluate
CO4	Interpret the data based on calculations and statistical tests.	Evaluate

Unit	**Course Description**	Hrs
1.	**1.1 Concepts of Analytical Chemistry: [5L]** 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, **1.2 Calculations based on Chemical Principles: [5L]** 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. 1.3 Basic Statistical Tools: [5L] Types of errors – determinate and indeterminate errors, Significant figures and propagation of errors. Confidence limit, Test of significance – the F-test and t-test - One sample t-test. Independent, Paired sample t-test. The statistical Q-test for rejection of a result, statistics for small data sets, Errors in instrumental analysis: Calibration curves, line of regression, errors in slope and intercept.	15
2.	**Quality in Analytical Chemistry:** **2.1 Quality Management System (QMS): [5L]**	15

	Quality Management System: Quality management concepts and principles - Traceability, quality control, quality assurance, quality management and quality manual, calibration and test methods TQM in Chemical Industry: Applying Kaizen, Six Sigma approach and 5S to quality in industries. Quality audits and quality reviews, responsibility of laboratory staff for quality and problems. 2.2 Good Laboratory Practices: [4L] GLP Principles, Documentation of laboratory work, Preparation of Standard Operating Procedures (SOPs), Validation of methods, reporting and documentation of results. 2.3. Accreditation of laboratories: [3L] International organization for standardization, National accreditation board for testing and calibration laboratories. Scope of accreditation. 2.4 Safety in Laboratories: [3L] Importance of Safety in Laboratories, classification of Personal Protection Equipment (PPE), Safety and health Standards: Indian Standards & codes for safety & health, OSHA standards, Types of Toxic Hazard (TH), Classification of Chemical Hazards and their control.	
3.	**Optical Methods:** 3.1 Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers, Laser as a source of radiation, Fibre optics [3L] 3.2 Molecular Ultraviolet and Visible Spectroscopy [6L] 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 [6L] 3.3.1 IR Spectrosopy: Principle, Instrumentation: Sources, Sample handling, Transducers, 3.3.2 FTIR Spectroscopy: Principle, instrumentation & its advantages. 3.3.3 Applications of IR spectroscopy: structure analysis of organic compounds, inorganic Molecules e.g. Sulphato, Carbonato, Nitrato & metal chelates - Acetylacetanato Complexes. Analysis of petroleum hydrocarbons, oil and grease contents by EPA method, Quantitative analysis of multi-component mixtures. 3.3.4 Introduction and basic principles of diffuse reflectance spectroscopy and its applications.	15
4.	**4.1 Thermal Methods:** [5 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,	**15**

	liquid crystals, Percentage crystallinity, oxidative stability, Drug analysis, Magnetic transition. e. g. Analysis of Polyethylene for its crystallinity. 4.2 Automation in chemical analysis: [5 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 multi-layered films, gas monitoring equipments, Automatic titrators. 4.3 Environmental Toxicology: [5] Introduction to Environmental Toxicology, Concepts of Toxicology, Toxic substances in the environment, their sources and entry roots, Transport of toxicants by air and water; Transport through food chain-bio-transformation and bio-magnification. Analysis Methods	

References

Unit I

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) (Free download).
5. 3000 solved problems in chemistry, Schaums Solved problem series, David E. Goldbers, McGraw Hill international Editions, Chapter 11,15,16,21,22

Unit II

1. Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, Ch: 5, Ch: 6 &Ch: 7.
2. Quality Management, Donna C S Summers, Prentice-Hall of India, Ch:3.
3. Quality in Totality: A Manager‟s Guide To TQM and ISO 9000, ParagDiwan, Deep & Deep Publications, 1st Edition, 2000.
4. Quality Control and Total Quality Management - P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5.
5. Industrial Hygiene and Chemical Safety, M H Fulekar, Ch:9, Ch:11 & Ch:15.
6. Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher, Ch:4, Ch:5 & Ch:19.
7. 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.
8. 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 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) 106-124.
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. TheophanidesTheophile (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, 6th Edition, Vogel: Chapter 12
6. Analytical Chemistry by Open Learning: Thermal Methods by James W. Dodd & Kenneth H. Tonge
7. Instrumental methods of analysis, 7th 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
10. Environmental toxicology Kees van Gestel, Vrije Universiteit, Amsterdam
11. Environmental Toxicology III, by V. Popov, Wessex Institute of Technology, UK; C.A. Brebbia, Wessex Institute of Technology, UK

Analytical Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Analytical Chemistry**
Course Code	**PSC1PR1**
Eligibility for Course	**T. Y BSc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course, students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Demonstrate titration skills for the analysis of samples of a diverse variety	Apply
CO2	Apply the statistical methods for data analysis	Apply
CO3	Analyze the measured data based on Chemical principles	Analyse
CO4	Measure the characteristics of ion exchange resins	Evaluate

Unit	**Course Description**	Hrs

1.	To carry out assay of the sodium chloride injection by Volhard's method.	4
2.	a) Statistical method: Application of Q test, t test to the data obtained for calibration of 5 mL pipette. b) Determine mean, deviation, Q value and t value using MS-EXCEL software	4
3.	To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.	4
4.	To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.	4
5.	To determine the breakthrough capacity of a cation exchange resin.	4
6.	To determine the Mg (titrimetrically) and Al (gravimetrically) content of a Magnelium alloy by titration with EDTA.	4
7.	To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).	4
8.	To determine number of nitro groups in the given compound using $TiCl_3$.	4
9.	Separation of amino acids in a mixture by TLC using Ninhydrin (Demonstration)	4

References:

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 Nostr and Company,Inc.,1939.
6. E.B.Sandell and H.Onishi,"Spectrophotometric Determination of Traces of Metals",Part-II,4th Ed.,A Wiley InterscicencePublication,New York,1978.

Course Description (Elective-I)	
Semester	**I**
Course Name	**Physical Chemistry-I**
Course Code	**PSC1PC1**
Eligibility for Course	**T.Y.B.Sc. (Chemistry)**
Credit	**2**
Hours	**30**

Course Objectives

4. To develop laboratory competence in relating physical aspects in chemistry
5. To demonstrate the ability to synthesize, separate and characterize compounds using published reactions, protocols, standard laboratory equipment, and modern instrumentation.
6. To provide the students with sound preparation for requirement of modern industry and provide competency in basic academic research as well as a cohesive, clearly structured overview of Chemistry

Course Outcomes

After successful completion of this course students will be able to

Sr. No	Course Outcomes	Bloom Taxonomy Level (BLT)
CO1	Prove Maxwell relations and its significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient and inversion temperature. Apply Third law of Thermodynamics to find out absolute entropy	Understand
CO2	Make use of quantum mechanics for Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions. Particle in a one, two- and three-dimensional box	Apply

Unit	Course Description	Hrs
1.	**Thermodynamics-I**	
	1.1. State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; its significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants. [8L] 1.2. Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity, standard molar entropies and their dependence on molecular mass and molecular structure, residual entropy. [7L]	15
2.	**Quantum Chemistry**	
	2.1. Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics. 2.2. Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions. 2.3. Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system such as, position, linear momentum, angular momentum, total energy, eigen functions, eigen values and eigen value equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system, Postulates of Quantum Mechanics, Schrodinger‟s Time independent wave equation from Schrodinger‟s time dependent wave equation. **2.4.** Application of quantum mechanics to the following systems: **a)** Free particle, wave function and energy of a free particle. **b)** Particle in a one, two and three dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. **c)** Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the	15

	recursion formula.	

Course Description (Elective-II)	
Semester	**I**
Course Name	**Physical Chemistry-II**
Course Code	**PSC1PC2**
Eligibility for Course	**T.Y.B.Sc. (Chemistry)**
Credit	**2**
Hours	**30**

Course Outcomes

After successful completion of this course, students will be able to

Sr. No	Course Outcomes	Bloom Taxonomy Level (BLT)
CO1	Define, and understand basic terms of Chemical Dynamics i.e. rate constant, order of reaction, molecularity of reaction also compare Composite Reactions and Polymerization reactions	Evaluate
CO2	Make use of Colloids and Surface Phenomena in daily applications	Apply

1.	**Chemical Dynamics-I**	Hours
	3.1. 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. 3.2. Polymerization reactions: Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization, Kinetic chain length and estimation of average no of monomer units in the polymer produced by chain polymerization. 3.3. Reaction in Gas Phase Unimolecular Reactions: Lindeman-Hinshelwood theory, Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory.	15
2.	**Colloids and Surface Phenomena**	
	Colloidal Systems-Sols, Lyophilic and lyophobic sols, properties of sols, coagulation. Sols of surface-active reagents, surface tension and surfactants, electrical phenomena at interfaces including electrokinetic effects, micelles, reverse micelles, solubilization. Thermodynamics of micellization, critical micelle concentration, factors affecting critical micelle concentration (cmc), experimental methods of cmc determination, Micellar catalysis. Adsorption, adsorption	**15**

	isotherms, methods for determining surface structure and composition, BET equation, surface area determination, Gibbs adsorption equation and its verification. Application of photoelectron spectroscopy, ESCA and Auger spectroscopy to the study of surfaces. Numerical Problems	

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. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.

8. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.

9. R.K. Prasad, Quantum Chemistry, 2nd Edn., New Age International Publishers, 2000.

10. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.

11. W.G. Davis, Introduction to Chemical Thermodynamics – A Non – Calculus Approach, Saunders, Philadelphia, 19772.

12. Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.

13. Ira N. Levine, Quantum Chemistry, 5th Edn., Pearson Education (Singapore) Pte.Ltd., Indian Branch, New Delhi, 2000.

14. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.

15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992. 16. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.

17. Physical Chemistry by Gurtu and Gurtu

18. A Text book of Physical Chemistry by K L kapoorVol5 , 2nd Edn

Physical Chemistry Practical

Course Description	
Semester	**I**
Course Name	**Physical Chemistry**
Course Code	**PSC1PR2**
Eligibility for Course	**T.Y. B.Sc. (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No.	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Know the principles of different instruments like Potentiometry, Conductometry, pH Metry.	Understand
CO2	Determine the heat of solution of sparingly soluble acid and identify the reaction between acetone and iodine.	Apply
CO3		
CO4		

Sr. No.	**Course Description**	Hrs
1.	To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperatures.	4
2.	To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature.	4
3.	To investigate the reaction between acetone and iodine. Or Kinetics of reaction between bromate and iodide. (New expt.)	4
4.	To study the variation in the solubility of $Ca(OH)_2$ in presence of NaOH and hence to determine the solubility product of $Ca(OH)_2$ at room temperature.	4
5.	Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?	4
6.	To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.	4
7.	To study the effect of substituent on the dissociation constant of acetic acid conductometrically.	4
8.	To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.	4
9.	To verify Ostwald‟s dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.	4
10.	Determination of dissociation constant of dibasic acid.	

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.

Research Methodology

Course Description	**Minor**
Semester	**I**
Course Name	**Research Methodology**
Course Code	**PSC1RM1**
Eligibility for the Course	**B.Sc. Chemistry**
Credit	**4**
Hours	**60**

Course Outcomes

After successful completion of this course, students will be able to

Sr. No.	Course Outcomes	Bloom Taxonomy Level (BTL)
CO1	Explain the importance of different types of print and digital resources for gap analysis and data collection.	Understand
CO2	Design/propose methodologies preferably with a green and safe approach to conduct research	Create
CO3	Analyze scientific data by statistical and graphical methods.	Analyse
CO4	Apply skills in chemical safety & ethical handling of chemicals	Apply

Unit	Course Description	Hrs
1	**Research and Literature Survey**	
	Scientific Research: (5L) Research: Definition, Types, Need of research. Identification of the problem, formulating the objectives, Hypotheses, Research Methods and Methodology Selecting & defining the Research problem, Research Process, and Research Design: preparing Research design (experimental or otherwise), Actual investigation, Data analysis and interpretation. **Literature survey: (5L)** Need for Literature Survey, References, Sources of literature: Primary, Secondary and Tertiary sources, Journals: Peer-reviewed, indexed, UGC-care listed, predatory, fake journals Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples **Digital Web sources: [5L]** E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact	**15**

	factor, H-index, E-consortium, UGC infonet, E-books, Shodhganga, Researchgate, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.	
2	**Data Analysis**	
	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), SPSS, 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. (15L)	**15**
3	**Methods of Scientific Research and Writing**	
	Scientific papers: 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 (15L)	**15**
4	**Chemical Safety & Ethical Handling of Chemicals**	
	Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals. (15L)	**15**

REFERENCES:

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

SEMESTER-II

Course Description	
Semester	**II**
Course Name	**Inorganic Chemistry**
Course Code	**PSC2IC2**
Eligibility for Course	**T.Y.B. Sc.in Chemistry**
Credit	**4**
Hours	**60**

Course Objectives:

1. To study and understand Photochemical Reactions, Ligand substitution reactions of octahedral and tetrahedral complexes, Redox reactions: inner and outer sphere mechanisms, stereochemistry of substitution reactions of octahedral complexes
2. To study and understand Organometallic Chemistry of Transition metals, Eighteen and sixteen electron rule, Structure and bonding on the basis of VBT and MOT in organometallic compounds.
3. To study and understand Toxicity of metallic species including case studies. Interaction of radiation in context with the environment: Sources and biological implication of radioactive materials.
4. To study concept of green chemistry, Biomass and biofuels.
5. To study and understand Bioinorganic Chemistry related to Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- structure of metal active center and differences in mechanism of oxygen binding, Copper containing enzymes, Nitrogen fixation Metal ion transport and storage Medicinal applications of cis-platin and related compounds.

Course Outcomes

Sr.No.	After completing the course, Student will able to:	Bloom Taxonomy Level (BTL)
CO1	Recall Organometallic Chemistry of Transition metals, Eighteen and sixteen electron rules, Preparation and property's structure and bonding of the Organometallic compounds	Remember
CO2	Explain Photochemical Reactions, Ligand substitution reactions of: Octahedral complexes, Square planar complexes, trans-effect, its theories and applications. Redox reactions: inner and outer sphere mechanisms, stereochemistry of substitution reactions of octahedral complexes	Understand
CO3	Explain Bioinorganic Chemistry related to biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- structure of metal active center and differences in mechanism of oxygen binding, Copper containing enzymes, Nitrogen fixation Metal ion transport and storage, Medicinal applications of cis-platin and related compounds.	Understand
CO4	Discuss the implication of toxic metallic species radioactive materials on environment and biological system using case studies.	Create

Unit	Course Description	Hrs
1.	**Inorganic Reaction Mechanism:**	15h
1.1	Photochemical Reactions: Prompt and delayed reactions, Quantum yield, Recapitulation of fluorescence and phosphorescence. Photochemical reactions by irradiating at d-d and charge transfer bands.	
1.2	Ligand substitution reactions of: a) Octahedral complexes without breaking of metal-ligand bond (Use of isotopiclabelling method) b) Square planar complexes, trans-effect, its theories and applications. Mechanismand factors affecting these substitution reactions.	
1.3	Redox reactions: inner and outer sphere mechanisms, complimentary and non-complimentary reactions.	
1.4	Stereochemistry of substitution reactions of octahedral complexes. (Isomerization andracemization reactions and applications.)	
2.	**Organometallic Chemistry of Transition metals:**	15h
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 transition metal 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	Basic organometallic reactions introduction: Ligand substitution, oxidative reactions, migratory reactions, migratory insertion, extrusion, oxidative addition, reductive elimination mechanism and stereochemistry	
3.	**Environmental Chemistry:**	15h
3.1	Toxicity of metallic species: Mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, biochemical effects and toxicology, control and treatment.	
3.2	Case Studies: (a) Itai-itai disease for Cadmium toxicity, **(b)** Arsenic Poisoning in the Indo-Bangladesh region.	
3.3	Interaction of radiation in context with the environment:Sources and biological implication of radioactive materials. Effect of low level radiation on cells- Its applications in diagnosis and treatment, Effect of radiation on cell proliferation and cancer.	
3.4	**Green Chemistry:** Biomass and Biofuels: Issues of Ethanol,Biodiesel from Plant Oils and from AlgaeActivity. Bio-based Liquid Fuels and Chemicals, Recycling Carbon Dioxide—A Feedstock for the Production of Chemicals and Liquid Fuels, Thermochemical Production of Fuels: Including Methanol and	

	Hydrogen—Fuel of the Future.	
4.	**Bioinorganic Chemistry:**	15h
4.1	Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- the structure of the 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 metallothioneins	
4.6	Medicinal applications of cis-platin and related compounds	

References

UNIT-I

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5thEd., 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, 8thEd., S. Chand & Company ltd.
4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.

5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002
6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house,2012.
7. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, MilestonePublishers, 2013-2014.
8. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.

9. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing housePvt Ltd., 2001.

10. Inorganic reaction mechanism by Jorden & inorganic reaction mechanism by Basolo Pearson
11. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rdEd., Oxford University Press 2008.

Unit II

1. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.

2. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded,

NewAge International Pvt Ltd, 2000.
3. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, WileyInternational Pvt, Ltd 2000.
4. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.
5. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd.
6. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004
7. Organometallic chemistry by B.D.Gupta.
8. Organometallic chemistry by " Crabtree

Unit III

1. Environmental Chemistry 5th edition, Colin Baird Michael Cann, W. H. Freeman andCompany, New York, 2012.
2. Environmental Chemistry 7th edition, Stanley E. Manahan, CRC Press Publishers,

3. Environmental Contaminants, Daniel A. Vallero, ISBN: 0-12-710057-1, Elsevier Inc.,2004.
4. Environmental Science 13th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10:0-495-56016-2, Brooks/Cole, Cengage Learning, 2010.
5. Fundamentals of Environmental and Toxicological Chemistry 4th edition, Stanley E. Manahan, ISBN: 978-1-4665-5317-0, CRC Press Taylor & Francis Group, 2013.
6. Living in the Environment 17th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10: 0-538-49414-X, Brooks/Cole, Cengage Learning, 2011
7. Poisoning and Toxicology Handbook, Jerrold B. Leikin, Frank P. Paloucek, ISBN: 1-4200-4479-6, Informa Healthcare USA, Inc.
8. Casarett and Doull‟s Toxicology- The Basic Science of Poisons 6th edition, McGraw-Hill,2001.

Unit IV

1. R. W. Hay, Bioinorganic Chemistry, Ellis Harwood, England, 1984.

2. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First SouthIndian Edition, Viva Books, New Delhi, 1998.
3. J. A. Cowan, Inorganic Biochemistry-An introduction, VCH Publication, 1993.

4. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University SciencePublications, Mill Valley, Caligronic, 1994.
5. G.N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri& Sons, Calcutta,1988.
6. J.Chem. Educ. (Special issue), Nov, 1985.

7. E.Frienden, J.Chem. Educ., 1985, 62.
8. Robert R.Crechton, Biological Inorganic Chemistry – An Introduction, Elsevier

9. J. R. Frausto da Silva and R. J. P. Williams The Biological Chemistry of the Elements,Clarendon Press, Oxford, 1991.
10. JM. D. Yudkin and R. E. Offord A Guidebook to Biochemistry, Cambridge UniversityPress, 1980.

Course Description	
Semester	**II**
Course Name	**Inorganic Chemistry Practical**
Course Code	**PSC2PR2**
Eligibility for Course	**T.Y.B. Sc.in Chemistry**
Credit	**2**
Hours	**30**

Course Outcomes

COs. No.	After completing the course, Students will be able to:	Bloom Taxonomy Level (BTL)
CO1	Analyse ores and alloys using volumetric and gravimetric analysis.	Analyse
CO2	Estimate the percentage of metals in the ore and alloy	Evaluate
CO3	Apply the potentiometric method for redox titrations of Fe, Cu etc.	Apply

Ores and Alloys

1) Analysis of Devarda‟s alloy
2) Analysis of Cu – Ni alloy
3) Analysis of Tin Solder alloy
4) Analysis of Brass alloy

Instrumentation

1) Estimation of Copper using Iodometric method Potentiometrically.
2) Estimation of Fe+3 solution using Ce(IV) ions Potentiometrically

Reference:

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

Course Description	
Semester	**II**
Course Name	**Organic Chemistry**
Course Code	**PSC2OC2**
Eligibility for Course	**T. Y BSc (Chemistry)**
Credit	**2**
Hours	**60**

Course Outcomes

After successful completion of this course students will be able to

Sr No.	COs	Bloom Taxonomy Level (BLT)
CO1	Explain the Generation of carbanion, enolate, and enamine with their alkylation & acylation reaction and name reactions with their mechanism.	Understand
CO2	Illustrate mechanism, stereochemistry, applications and importance of name reactions and rearrangements.	Understand
CO3	Explain the role of reagents in organic synthesis and elimination reactions.	Analyse
CO4	Interpret the structure of organic compounds using combined of spectral techniques.	create

Unit	Course Description	Hrs
1	**1.1. Alkylation of Nucleophilic Carbon Intermediates:** 1.1.1. Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. 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. 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: 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 and Robinson annulation. 1.2.2. Addition reactions with amines and iminium ions; Mannich reaction. 1.2.3. Amine catalyzed condensation reaction: Knoevenagel reaction. 1.2.4. Acylation of carbanions. Asymmetric methodology with enolates and Enamines	15
2	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, Bamberger Rearrangements. 2.3. Cationic rearrangements: Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein. 2.4. Anionic rearrangements: Brook, Neber, Von Richter, Wittig, Benzylic acid Rearrangements, Payne.	15
3	**3.1 Elimination Reactions:** E1, E2 E1CB, Stereochemistry of elimination, elimination vs. substitution, Anti and Syn Elimination. Dehydrohalogenation, Dehalogenation, Dehydration, Hoffmann and Saytzeff elimination, Pyrolytic elimination. **3.2 Organometallic Chemistry** Organolithium, Organomagnesium, Organozinc, Organocupper, **3.3 Introduction to Molecular Orbital Theory for Organic Chemistry:** Molecular orbitals: Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allylcation,	15

	anion and radical. Concept of nodal planes and energies of π-MOs	
4	**Spectroscopy:** **4.1. Proton magnetic resonance spectroscopy:** 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. **4.2. 13C 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:** Determination of molecular formula of organic compounds based on isotopic abundance and HRMS. Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels Alder reaction. 4.4. Structure determination involving individual or combined use of the above spectral techniques. 4.5. 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). 4.6. 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.	15

Organic Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Organic Chemistry**
Course Code	**PSC2PR1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course, students will be able to

Sr. No	COs	Bloom Taxonomy Level (BLT)
CO1	Identify the chemical type of components present in a binary mixture of an organic compound.	Apply
CO2	Apply skills in the separation and qualitative analysis of organic compounds of binary mixtures by microscale technique.	Apply
CO3	Make use of crystallization, sublimation and distillation for purification of the organic compounds.	Apply
CO4	Demonstrate the practical aspects in the preparation of the organic compound derivatives.	Understand

Sr. No.	Course Description	Hrs
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.	30

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford UniversityPress.

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 (7th Edition)

5. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, PearsonEducation.

6. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.

7. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.

8. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.

9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.

10. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr.,

Maya Shankar Singh, Pearson Education.

11. Mechanism in Organic Chemistry, Peter Sykes, 6th

12. Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley

13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz,Thomson Brooks.

14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C.Morrill, John Wiley and Sons.

15. Organic Spectroscopy, William Kemp, W.H. Freeman & Company.

16. Organic Spectroscopy-Principles and Applications, Jagmohan, Narosa Publication.

17. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co.

18. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.

19. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parasher, Alpha ScienceInternational, 2011.

20. Reactions, Rearrangements and Reagents by S. N. Sanyal

21. Name Reactions, Jie Jack Li, Springer

22. Name Reactions and Reagents in Organic Synthesis, Bradford P. Mundy, M.G. Ellerd,and F.G. Favaloro, John Wiley & Sons.

Course Description	
Semester	**II**
Course Name	**Analytical Chemistry**
Course Code	**PSC2AC1**
Eligibility for Course	**T.Y.B.Sc (Chemistry)**
Credit	**4**
Hours	**60**

Course Outcomes
After successful completion of this course, students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Translate the theoretical principles of advanced separation techniques, spectroscopic techniques, radioanalytical techniques, electroanalytical techniques into applications.	Understand
CO2	Explain the working principles of surface analytical techniques such as SEM, STM, TEM, ESCA, Auger spectroscopy and ICP-AES	Understand

CO3	Compare the different ion sources and mass analyzers in mass spectroscopy	Analyze
CO4	Determine the electrical quantities such as charge, current, and potential using Electroanalytical methods	Evaluate

Unit	Course Description	Hrs
1.	**Chromatography**	
	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] 1.4 High Performance Liquid Chromatography (HPLC): Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. Chiral and ion chromatography. [5 L]	15
2.	**X-ray spectroscopy**:	
	principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. [4 L] 2.2 Mass spectrometry: recapitulation, instrumentation, ion sources for molecular studies, electron impact, field ionization, field absorption, chemical ionization and fast atom bombardment sources. Mass analyzers: Quadrupole, time of flight and ion trap. Applications. [6 L] 2.3 Radioanalytical Methods – recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. [5 L]	15
3.	**Surface Analytical Techniques**	
	Introduction, Types of surface measurements: Photon probe technique, electron probe technique, Ion probe technique, Scanning probe microscopy 3.2 Electron probe techniques: 3.1.1 Scanning Electron Microscopy (SEM): Principle, Instrumentation and Application 3.1.2 Electron Spectroscopy (ESCA and Auger): Principle, instrumentation and Application 3.2 Atomic Spectroscopy [6 L] 3.2.1 Recapitulation: Flame AAS and furnace AAS	15

	Interferences - chemical and spectral, evaluation methods in AAS, qualitative and quantitative applications 3.2.2 AES: Principle of AES, Interferences Inductively Coupled Plasma- Atomic Emission Spectroscopy (ICP-AES) – Introduction, Principle, Instrumentation, applications 3.2.3 Applications of AAS and AES in environmental analysis	
4.	**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 4. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 20

Unit III

1. Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition, (2003), ISBN-10: 8131505421, ISBN-13: 978-8131505427
2. Physical Principles of Electron Microscopy, An Introduction to TEM, SEM, and AEM
3. Authors: Ray F. Egerton, ISBN: 978-0- 387-25800- 3 (Print) 978-0- 387-26016- 7 (Online)
4. Modern techniques of surface science by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994.
5. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, NewYork, 1993.
6. 5. Transmission Electron Microscopy: A text book for Material Science, David B Williams and C., Barry Carter, Springer
7. Modern Spectroscopy, by J.M. Hollas, 3rd Edition (1996), John Wiley, New York
8. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.
9. Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition (2003), ISBN10: 8131505421, ISBN-13: 978-8131505427

Unit IV

1. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th Edition, Harcourt College Publishers, 1998. Chapters - 23, 24, 25.
2. Analytical Chemistry Principles – John H Kennnedy, 2nd edition, Saunders College Publishing (1990).

3. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000).
4. Vogel's Text book of quantitative chemical analysis, 6th edition, Pearson Education Limited, (2007).
5. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980).
6. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7th edition, CBS publishers.

Analytical Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Analytical Chemistry**
Course Code	**PSC2PR1**
Eligibility for Course	**T. Y. B.Sc (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No.	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Demonstrate the operational skills on the selected instruments and retrieve information	Understand
CO2	Develop a sense of time management, safe use of chemicals and environmental safety	Apply

Sr. No.	**Course Description**	**Hrs**
1	To determine percent purity of washing soda in terms of sodium carbonate pH metrically.	4
2	To determine amount of Ti (III) and Fe (II) in a mixture by titration with Ce (IV) potentiometrically.	4
3	To determine the amount of nitrite present in the given water sample colorimetrically.	4
4	To determine the amount of Fe (II) and Fe (III) in a mixture using 1,10-phenanthroline spectrophotometrically.	4
5	Simultaneous determination of Cr (VI) and Mn (VII) in a mixture spectrophotometrically.	4
6	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 $BaCl_2$.	4
7	To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.	4
8	Separation of benzene and toluene using gas chromatography and determination of column resolution (Rs). (demonstration)	4

References

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

Course Description (Elective-I)	
Semester	**II**
Course Name	**Physical Chemistry-I**
Course Code	**PSC2PC2**
Eligibility for Course	**T. Y BSc (Chemistry)**
Credit	**2**
Hours	**30**

Course Outcomes

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Explain Bioenergetics, Real solutions and Fugacity of real gases also show graphical representations of BET isotherms	Apply
CO2	Prove expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen and aapplication of the Schrödinger equation to two electron system	Evaluate

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

	2.1. Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates, separation of the variables, the phi equation, wavefunction, quantum number, the theta equation, wave function, quantization of rotational energy, spherical harmonics. 2.2. Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, the R the q * and the f equations, solution of the equation, introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots., points of maximum probability, expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen. expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots., points of maximum probability, expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen. 2.3. Application of the Schrödinger equation to two electron system, limitations of the equation, need for the approximate solutions, methods of obtaining the approximate solution of the Schrödinger wave equation. 2.4. Hückel Molecular Orbitals theory for ethylene, 1,3-butadiene and benzene. (Derivation expected)	15

Course Description (Elective-II)	
Semester	**II**
Course Name	**Physical Chemistry-II**
Course Code	**PSC2PR2**
Eligibility for Course	**T. Y BSc (Chemistry)**
Credit	**2**
Hours	**30**

Course Outcomes

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Explain terms involved in Chemical Kinetics and Molecular Reaction Dynamics. Elementary Reactions in Solution, Kinetics of reactions catalyzed by enzymes -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses, Inhibition of Enzyme action.	Apply, Evaluate
CO2	Apply Photochemistry to solve NET, SET GATE Problems.	Apply

1.	**Chemical Kinetics and Molecular Reaction Dynamics**	
	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 catalysed 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 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.	15
2.	**Photochemistry**	
	4.1: Absorption of light, laws of photochemistry, electronic structure of molecules, molecular orbital, electronically excited singlet states, designation based on multiplicity rule, construction of Jablonski diagram, electronic transition, Frank Condon principle, selection rules, intensity of absorption bands, nature of electronic spectra and primary process, photo-dissociation, pre-dissociation, **4.2** Photo physical phenomena: physical pathways of excited molecular system (radiative and non-radiative), prompt fluorescence, delayed fluorescence, and phosphorescence, fluorescence quenching: concentration quenching, collisional quenching, quenching by excimer and exciplex emission, fluorescence resonance energy transfer between photo-excited donor and acceptor systems.	15

	4.3. Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, examples and applications in chemical analysis. Photochemical reactions, photo-oxidation, photoreduction, photo-dimerization, photoisomerization and photosensitized reactions. Photochemistry of environment: Greenhouse effect.	

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.

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Physical Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Physical Chemistry Practical**
Course Code	**PSC2PR2**
Eligibility for Course	**T.Y. B. Sc. (Chemistry)**
Credit	**2**
Hours	**30**

After successful completion of this course students will be able to

Sr. No	**COs**	**Bloom Taxonomy Level (BLT)**
CO1	Know principles of different instruments like Potentiometry, Conductometry, pH Metry and colorimeter	Understand
CO2	Make use of graphical representation to identify Shape of Orbitals.	Apply

Sr. No.	**Course Description**	**Hrs**
1	Polar plots of atomic orbitals such as 1s, $2p_x$ & $3d_z^2$ orbitals by using angular part of hydrogen atom wave functions.	4
2	To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.	4
3	To study phase diagram of three component system water – chloroform /toluene - acetic acid.	4

4	To determine the rate constant of decomposition reaction of diacetone alcohol by dilatometric method.	4
5	Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?	4
6	To determine the formula of silver ammonia complex by potentiometric method. Determination of binary mixture of halides. (New expt.)	4
7	To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.	4
8	To determine Hammette constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.	4
9	To determine the Michaelis – Menten's constant value (Km) of the enzyme Beta Amylase spectrophotometrically.	

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OJT

Course Description	
Semester	**II**
Course Name	**On Job Training**
Course Code	**PSC2OJT**
Eligibility for Course	**T.Y. B. Sc. (Chemistry)**
Credit	**4**
Hours	**60**

Course (Paper) Name and No.- **On Job Training**		BTL Level
CO1	Practical Skill Development: Trainees will acquire hands-on experience and proficiency in relevant industry tools, techniques, and processes, effectively applying theoretical knowledge to real-world tasks.	Analyse
CO2	Problem-Solving Abilities: Trainees will develop critical thinking and problem-solving skills by addressing practical challenges and troubleshooting issues encountered in the work environment.	Apply
CO3	Professional Competency: Trainees will demonstrate enhanced job	Understan

	readiness and professional competency, including adherence to industry standards, effective communication, and teamwork	d
CO4	Industry Knowledge:Trainees will gain a deeper understanding of industry practices, workflows, and organizational culture, improving their ability to navigate and contribute effectively within their field.	Understand
CO5	Performance Improvement:Trainees will improve their performance and productivity by integrating feedback and learning from experienced professionals, leading to better job performance and career growth.	Apply

Academic Council Date –
Item No. –

Janardan Bhagat Shikshan Prasarak Sanstha's

CHANGU KANA THAKUR

Arts, Commerce and Science College, New Panvel (Autonomous)

Re-accredited A+ Grade by NAAC (Third Cycle-CGPA-3.61)
'College with Potential for Excellence' Status Awarded by UGC
'Best College Award' by University of Mumbai

As per National Education Policy - 2020

Title of the Programme

M. Sc. in Organic Chemistry

(Faculty of Science)

Syllabus for M. Sc. (Organic Chemistry)

Semester III and IV

Approved in the Academic Council meeting held on 13th June 2024.

(With effect from the academic year 2024-25)

Preamble of the Syllabus:

Master of Science (M.Sc.) in Organic Chemistry is a post-graduate course of Changu Kana Thakur Arts, Commerce and Science College, New Panvel (Autonomous).

The students pursuing this course would have to develop in depth understanding of various aspects of the subject. The new curriculum of M.Sc. Organic Chemistry offers the courses which will prepare the students for critical thinking, understanding of the concepts in depth and skills for employability. The learning outcome-based approach is intended to provide a focused and outcome-based syllabus with an agenda to structure the teacher-learning experiences in a more student centric manner. The course combines the opportunity for students to acquire knowledge of wide range of cutting-edge fields in chemistry with sessions on theory, practical, presentation and a project supervised by one of the teachers.

Objectives of the Course:

1. Develop analytical thinking and apply the same for understanding principles, proposing mechanism and logical conclusions.
2. Comprehensive understanding of the interdisciplinary nature of Chemistry and emerging trends in Chemistry.
3. Competency in design and planning of synthesis and carry out with Good Laboratory Practices.
4. Access, search and use of chemical literature and acquiring necessary skills to succeed in research and advance studies.
5. Competency in handling instruments and interpretation of spectral data for structure determination of organic compounds.

MASTERS IN SCIENCE (M.Sc. Organic Chemistry)

Programme Outcomes

After completion of M.Sc. organic chemistry programme students will acquire

S. N.	After completion of M.Sc. program students will acquire	Graduate Attribute
PO1	An ability to identify and describe broadly accepted methodologies of science, and different modes of reasoning.	Disciplinary knowledge
PO2	An ability to demonstrate proficiency in various instrumentation, modern tools, advanced techniques and ICT to meet industrial expectations and research outputs.	Disciplinary knowledge/Digital literacy
PO3	An ability to identify problems, formulates, and proves hypotheses by applying theoretical knowledge and skills relevant to the discipline.	Problem-solving
PO4	An ability to be articulate thoughts, research ideas, information, scientific outcomes in oral and in written presentation to range of audience.	Communication skills
PO5	A capacity for independent, conceptual and creative thinking, analysis and problem solving through the existing methods of enquiry.	Problem solving
PO6	Skills required for cutting edge research, investigations, field study, documentation, networking, and ability to build logical arguments using scholarly evidence.	Research skills
PO7	An ability to portray good interpersonal skills with ability to work collaboratively as part of a team undertaking a range of different team roles	Teamwork
PO8	The ability to understand ethical responsibilities and impact of scientific solutions in global, societal and environmental context and contribute to the sustainable development	Moral and ethical awareness/ multicultural competence
PO9	An ability to demonstrate leadership, to take action and to get others involved.	Leadership
PO10	An openness to and interest in, life-long learning through directed and self-directed study	Self-directed learning
PO11	An ability to translate the knowledge and demonstrate the skills required to be employed and successful professional development.	Life-long learning

Programme: M.Sc. Organic Chemistry

Programme Specific outcomes

PSOs	
PSO1	Develop analytical thinking and apply the same for understanding principles, proposing mechanism and logical conclusions.
PSO2	Comprehensive understanding of the interdisciplinary nature of Chemistry and emerging trends in Chemistry.
PSO3	Enormous employment opportunities at Research and Development as well as synthetic division of chemical, pharmaceutical, dyestuff and food industries.
PSO4	Competency in design and planning of synthesis and carry out with Good Laboratory Practices.
PSO5	Access, search and use of chemical literature and acquiring necessary skills to succeed in research and advance studies.
PSO6	Research opportunities to pursue Ph.D. programme.
PSO7	Competency in handling instruments and interpretation of spectral data for structure determination of organic compounds

Janardan Bhagat Shikshan Prasarak Sanstha's

Changu Kana Thakur

Arts, Commerce and Science College, New Panvel (Autonomous)

Draft Syllabus

Syllabus for the M.Sc. Semester III and IV

Credit Based Semester and Grading System

To be implemented from the academic year 2024-25

SEMESTER III

Course Name & Course Code	Unit	Topics	Credits	L/Week
Theoretical Organic Chemistry-I PSC3TOC (Major-I)	I	Pericyclic Reactions	4	1
	II	Organic Reaction Mechanisms		1
	III	Stereochemistry-I		1
	IV	Photochemistry		1
Synthetic Organic Chemistry-I PSC3SOC (Major-II)	I	Name reactions with mechanism and Application	4	1
	II	Radicals in Organic Synthesis		1
	III	Enamines, Ylides and α-C-H functionalization		1
	IV	Metals / Non-metals in organic synthesis		1
Natural products, Heterocyclic chemistry and Spectroscopy-I PSC3NHS (Major-III)	I	Natural products-I	4	1
	II	Natural products-II		1
	III	Heterocyclic compounds-I		1
	IV	Advanced Spectroscopic Techniques -I		1
Practical in Organic Chemistry-I PSC3POC1 (Major-IV)		Two steps preparations	2	4
Drug discovery, design, development and Synthesis PSC3DDS (Elective-I)	I	Drug discovery, design and development	2	1
	II	Drug design, development and synthesis		1
Biomolecules PSC3BIC (Elective-II)	I	Biomolecules-I	2	1
	II	Biomolecules-II		1
Practical in Organic Chemistry-II PSC3POC2		Single step preparation and purification	2	4
Research Project-I PSC3RP1		Research Project-I	4	

SEMESTER IV

Course Name & Course Code	Unit	Topics	Credits	L/Week
Theoretical Organic Chemistry-I PSC4TOC (Major-I)	I	Physical Organic Chemistry	4	1
	II	Supramolecular Chemistry		1
	III	Stereochemistry-II		1
	IV	Asymmetric Synthesis		1
Synthetic Organic Chemistry-I**I** PSC4SOC (Major-II)	I	Designing Organic Synthesis-I	4	1
	II	Designing Organic Synthesis-II		1
	III	Electro-organic chemistry and selected methods of organic synthesis		1
	IV	Transition and rare earth metals in organic synthesis		1
Natural products, Heterocyclic chemistry and Spectroscopy-II PSC4NHS (Major-III)	I	Natural products-III	4	1
	II	Natural products-IV		1
	III	Heterocyclic compounds-II		1
	IV	Advanced Spectroscopic Techniques -II		1
Green Chemistry PSC4GC (Elective-I)	I	Introduction to Green Chemistry	2	1
	II	Green Synthesis		1
Intellectual Property Rights PSC4IPR (Elective-II)	I	Intellectual Property Rights-I	2	1
	II	Intellectual Property Rights-II		1
Practical in Organic Chemistry-III PSC4POC3		Separation of Ternary mixture and Spectral analysis	2	4
Research Project-II PSC4RP2		Research Project-II	6	

1. Credit based semester and grading system with effect from the academic year 2024-2025.
2. As per the credit system directives each credit will correspond to 15 hours of lectures or 30 hours of practical work.
3. Each student is expected to take 4 credits for each Major-I, Major-II, Major-III theory

paper and 4 credits for Major-IV practical, 2 credits in Elective theory paper and 2 credits in Elective practical's, and 4 credits in Research project in third semester.

4. Each student is expected to take 4 credits for each Major-I, Major-II, Major-III theory paper, 2 credits in Elective theory paper and 2 credits in Elective practical's, and 6 credits in Research project in fourth semester.
5. At the end of each semester each student will be examined both in the theory and in the practical.
6. For the award of first class, the candidate must obtain at least 50% marks in the theory papers at the Semester I, II, III and IV of the M.Sc. examination taken together, in addition to the marks prescribed for the first class and the other rules of passing in the concerned regulation of the standard of passing.
7. The candidate is expected to submit a journal certified by the Head of the Department /institution at the time of the practical examination.
8. A candidate will not be allowed to appear for the practical examination unless he/she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.
9. Use of non-programmable calculator is allowed both at the theory and the practical examination.

Scheme of Examination for M.Sc. Organic Chemistry Semester III and IV

Major-I, II, III

Internal Theory examination (40 Marks)

Sr. No.	Particular	Marks
01	One periodical class test examination to be conducted in the given semester	20 Marks
02	Any one tools out of these (15 Marks each) 1. Group/ Individual Project 2. Presentation and write up on the selected topics of the subjects / Case studies. 3. Test on Practical Skills 4. Open Book Test	15 Marks
03	Active participation of student	05 Marks

External Theory Examination (60 Marks)

Paper	Time allotted in hours	Maximum marks
Major- I	2.5	60
Major -II	2.5	60
Major -III	2.5	60

It is recommended that a total of five questions be set, based on the syllabus with due weightage to the number of lectures allotted per topic. The candidates are expected to answer all five questions. Question 5 will be based on all four units and the remaining questions will be based on the units as indicated below

Question No.	Semester- III	Semester- IV
01	Unit I	Unit I
02	Unit II	Unit II
03	Unit III	Unit III
04	Unit IV	Unit IV
05	From all four units	From all four units

Major-IV - Semester End Practical Examination (50+50=100 Marks)

Laboratory Work: **40 Marks**

Journal : **05 Marks**

Viva : **05 Marks**

The practical examination will be held for two days as described below. The candidates will be examined practically and orally.

Paper	Day	Experiments	Time duration in hours	Maximum marks
I	Day-1 Morning	01	3.5	50
II	Day-1 Evening	01	3.5	50

There will not be any internal examination for practical.

Elective-I/ Elective-II (50 Marks)

Internal and External Examination

Sr. No.	Examination	Particular	Time allotted	Marks
01	Internal	One periodical class test examination to be conducted in the given semester	40 minutes	20 Marks
02	External	Three questions based on the syllabus: Question 1 - Unit- I - 12 marks Question 2 – Unit-II- 12 marks Question 3 – From both units- 06 marks	1.5 hours	30 Marks

Elective-I/ Elective-II Semester End Practical Examination (50+50=100 Marks)

Laboratory Work: **40 Marks**

Journal : **05 Marks**

Viva : **05 Marks**

The practical examination will be held for two days as described below. The candidates will be examined practically and orally.

Paper	Day	Experiments	Time duration in hours	Maximum marks
I	Day-1 Morning	01	3.5	50
II	Day-1 Evening	01	3.5	50

SEMESTER-III

Course Outcomes

Course Description	Major-I
Semester	III
Course Name	Theoretical Organic Chemistry-I
Course Code	PSC3TOC
Eligibility for the Course	M.Sc.-I Chemistry
Credit	4
Hours	60

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Identify pericyclic reactions and describe cycloaddition reactions, electrocylic reactions and sigmatropic rearrangements.	Understand
CO2	Explain the structure, generation, stability and reactions of organic reactive intermediates and importance of neighbouring group participation, role of FMOs.	Apply
CO3	Analyze conformation of medium size ring, fused ring, bridge ring, steroids and reactivity of addition, elimination, rearrangement and reduction with stereoselective and stereospecific reactions.	Apply
CO4	Apply the principles of photochemistry to carbonyl compounds, olefins, arenes and radical reactions.	Analyse

Unit	Course Description	Hrs
1	**Pericyclic reactions** **1.1 Introduction to pericyclic reactions**: Thermal and photochemical reactions, Explanation for Woodward-Hoffmann Rules, The Aromatic Transition states [Huckel and Mobius], Frontier Orbitals Correlation Diagrams, FMO and PMO approach. Molecular orbital symmetry, Frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. **[5L]** **1.2 Cycloaddition reactions:** Supra and antra facial additions, 4n and 4n+2 Systems. Diels-Alder reactions (Diene, Dienophile, FMO approach, stereochemistry, endo rule, Intramolecular Diels-Alder reactions, regioselectivity/effect of substituents), Synthetic Equivalence in D-A Reaction (ethylene equivalent-Vinyl sulfone, acetylene equivalent-Vinyl sulfoxide, allene equivalent-Vinyl phosphonium salt), 2+2 Cycloadditions: Photocycloadditions, cheletropic reactions. **[5L]**	**15**

	1.3 Electrocyclic reactions: Conrotatory and disrotatory motions, torquoselectivity, (4n) π and (4n+2) π electrons and allyl systems. Synthesis of endiandric acid A from an acyclic polyene. **[2L]** **1.4 Sigmatropic rearrangement:** H-shifts and C-shifts, supra and antarafacial migrations, Alder 'ene' Reaction, Cope rearrangements, Synthesis of Citral from 3-methylbut -2-en-1-ol and 3-methylbut-2-enal. **[3L]**	
2	**Organic reaction mechanisms** **2.1 Organic reactive intermediates:** Methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes**. (6L)** **2.2 Neighbouring group participation:** Mechanism and effects of anchimeric assistance, NGP by unshared/ lone pair electrons, σ-bonds with special reference to norbornyl and bicyclo[2.2.2]octyl cation systems (formation of non-classical carbocation**). [2L]** **2.3 Role of FMOs in organic reactivity:** Reactions involving hard and soft electrophiles and nucleophiles, alpha effect. **[2L]** **2.4 Mechanism of some selected pericyclic reactions:** oxy-Cope and aza-Cope, Claisen rearrangement, Sommelet-Hauser rearrangement, 2+2 Cycloadditions: Ketenes, 1,3-Dipolar cycloadditions. **[5L]**	15
3	**Stereochemistry-I** **3.1** Steric effect of S_N^2 and E-Z reactions. Stereochemistry of disubstituted cyclohexanone. ^{13}C NMR signals in 1,1-dimethyl cyclohexanone. Stereochemistry of syn-addition reactions. [**3L]** Stereochemistry of fused ring and bridged ring compounds: decalins, hydrindanes, perhydroanthracenes, steroids, and Bredt's rule. **[5L]** **3.2** Anancomeric systems**,** Effect of conformation on reactivity of cyclohexane derivatives in the following reactions (including mechanism): electrophilic addition, elimination, molecular rearrangements, reduction of cyclohexanones **(**with $LiAlH_4$, L-selectride and MPV reduction) and oxidation of cyclohexanols**. [5L]** **3.3** Stereospecific and Stereoselective reactions with specific examples. [**2L]**	
4	**Photochemistry** **4.1 Principles of photochemistry:** Electronic state and transitions, modes of dissipation of energy **(**Jablonski diagram), photosensitization and quenching process, experimental set up for photochemical reactions. **[3L]** **4.2 Photochemistry of carbonyl compounds:** π→′π*, n→′π* transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enone's, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadiene's. Photo Fries rearrangement, Barton reaction, DeMayo reaction. **[7L]** **4.3 Photochemistry of olefins:** cis-trans isomerization's, dimerization's, hydrogen abstraction, addition and di- π- methane rearrangement including oxa- di-π--methane and aza-di-π--methane. Photochemical Cross-Coupling of Alkenes, Photodimerization of alkenes. **[3L]** **4.4 Photochemistry of arenes:** 1, 2-, 1, 3- and 1, 4- additions. Photocycloadditions of aromatic Rings. **[1L]** **4.5** Singlet oxygen and photo-oxygenation reactions. Photochemically induced Radical Reactions. **[1L]**	15

References:

1. March's Advanced Organic Chemistry, Jerry March, sixth edition, 2007, John Wiley and sons.

2. A guide to mechanism in Organic Chemistry, 6**th** edition, 2009, Peter Sykes, Pearson education, New Delhi.

3. Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002)

4. Mechanism and theory in Organic Chemistry, T. H. Lowry and K. C. Richardson, Harper and Row.

5. Organic Reaction Mechanism, 4th edition, V. K. Ahluvalia, R. K. Parashar, Narosa Publication.

6. Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh, Macmillan Publishers, India.

7. Organic Chemistry, Part A and B, Fifth edition, 2007, Francis A. Carey and Richard J. Sundberg, Springer.

8. Carbenes, Nitrenes and Arynes. Von T. L. Gilchrist, C. W. Rees. Th. Nelson and Sons Ltd., London 1969.

9. Organic reactive intermediates, Samuel P. MacManus, Academic Press.

10. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press (2001)

11. Organic Chemistry, Seventh Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson. Advanced Organic Chemistry: Reactions & Mechanisms, second edition, B. Miller and R. Prasad, Pearson.

12. Organic reactions & their mechanisms, third revised edition, P.S. Kalsi, New Age International Publishers.

13. Organic Chemistry: Structure and Function, P. Volhardt and N. Schore, 5th Edition, 2012

14. Organic Chemistry, W. G. Solomons, C. B. Fryhle, , 9th Edition, Wiley India Pvt. Ltd.,2009

Course Description (Theory)	Major-II
Semester	III
Course Name	Synthetic Organic chemistry-I
Course Code	PSC3SOC
Eligibility for Course	M.Sc.-I Chemistry
Credit	4
Hours	60

Course Outcomes:

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Summarize generation, stability, structure, stereochemical aspects of freeradicals, its characteristic reactions and use in organic synthesis.	Understand
CO2	Explain preparation of organometallic compound, its applications, mechanism and regiochemistry of reactions involving metals/non-metals in organic synthesis.	Understand
CO3	Compare between enamines and enolates, methods of preparation, applications with stereochemical aspects in synthetic reactions.	Analyse
CO4	Predict the products of name reactions, domino reactions, click reactions, multicomponent reactions and describes their mechanism.	Create

Unit	Course Description	Hrs
1	**Name reactions with mechanism and application** **1.1** Mukaiyama esterification, Mitsonobu reaction, Darzen's Glycidic Ester Synthesis, Ritter reaction, KochHaaf Carbonylation reaction, Eschenmoser-Tanabe frangmentation, Appel reaction, Mozingo reduction reaction **[6L]** **1.2** Domino reactions: Characteristics; Nazerov cyclization **[2L]** **1.3** Multicomponent reactions: Strecker Synthesis, Ugi 4CC, Biginelli synthesis, Boger synthesis, Pictet-Spengler synthesis. **[5L]** **1.4** Click Reactions: Characteristics; Huisgen 1,3-Dipolar Cycloaddition **[2L]**	**15**
2	**Radicals in organic synthesis** **2.1 Introduction:** Generation, stability, reactivity and structural and stereochemical properties of free radicals, Persistent and charged radicals, Electrophilic and nucleophilic radicals. **[3L]** **2.2 Radical Initiators:** azobisisobutyronitrile (AIBN) and dibenzoyl peroxide**. [1L]** **2.3 Characteristic reactions:** Free radical substitution, addition to multiplebonds. Radical chain reactions, Radical halogenation of hydrocarbons (Regioselectivity), radical cyclizations, autoxidations: synthesis of cumene hydroperoxide from cumene. Free radical displacement, Fragmentation, reduction, and rearrangements. **[4L]** **2.4 Radicals in synthesis:** Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors. Cleavage of C-X, C-Sn, C-Co, C-S, O-O bonds.omatic substitution Oxidative coupling, C-C bond formation in aromatics: $S_{RN}Ar$- Radical-nucleophilic aromatic substitution reactions **[4L]** **2.5** Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation. **[3L]**	15
3	**Enamines, Ylides and α-C-H functionalization** **3.1 Enamines:** Generation & application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison	15

	between enamines and enolates. Synthetic reactions of enamines including asymmetric reactions of chiral enamines derived from chiral secondary amines. **[4L]** **3.2 Phosphorus, Sulfur and Nitrogen Ylides:** Preparation and their synthetic applications along with their stereochemical aspects. Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination. Sommelet-Hauser rearrangement reaction, Thia-Sommelet-Hauser rearrangement reaction, Corey-Chaykovsky reagent as well as reaction**[6L]** **3.3 α-C-H functionalization:** By nitro, sulfoxide, sulfone and phosphonate groups, applications in C-C bond formation. Bamford-Stevens reaction, Julia olefination and its modification, Steven's rearrangement. Thia-Steven's rearrangement. **[5L]**	
4	**Metals / Non-metals in organic synthesis** **4.1 Mercury in organic synthesis:** Mechanism and regiochemistry of oxymercuration and demercuration of alkenes, mercuration of aromatics, transformation of aryl mercurials to aryl halides. Organomercurials as carbene transfer reagents. **[3L]** **4.2 Organoboron compounds:** Mechanism and regiochemistry of hydroboration of alkenes and alkynes, asymmetric hydroboration using chiral boron reagents, 9-BBN hydroboration, oxazaborolidine (CBS catalyst) and functional group reduction by diborane. **[3L]** **4.3** Sulphur, Silicon And Phosphorus in Organic Chemistry Sulphoxide anion in a synthesis, anion from sulphone, sulphonium salts. Nucleophilic substitution at silicon, Peterson elimination, alkynyl silane, aryl silane, vinyl silane, witting reaction, Z- selective wittig reaction and E-Selective wittig reaction. [**5L]** **4.4 Organotin compounds:** Preparation of alkenyl and allyl tin compounds; application in C-C bond formation, in replacement of halogen by H at the same C atom. **[2L]** **4.5 Selenium in organic synthesis:** Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and seleno acetals as α-C-H activating groups **[2L]**	15

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8. Organic Chemistry, 7th Edn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee,

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9. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti & B. Czako (2005), Elsevier Academic Press
10. Advanced Organic Chemistry: Reactions & Mechanisms, 2nd Edn., B. Miller & R. Prasad, Pearson
11. Organic reactions and their mechanisms, 3rd revised edition, P.S. Kalsi, New Age International Publishers
12. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004
13. Name Reactions and Reagents in Organic Synthesis, 2nd Edn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
14. Name Reactions, Jie Jack Lie, 3rd Edn., Springer
15. Organic Electrochemistry, H. Lund, and M. Baizer, 3rd Edn., Marcel Dekker.

Course Description (Theory)	Major-III
Semester	III
Course Name	Natural Products, Heterocyclic Chemistry and Spectroscopy-I
Course Code	PSC3NHS
Eligibility for Course	M.Sc.-I Chemistry
Credit	4
Hours	60

Course Outcomes:

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Explain the occurrence, structural features, and biological importance and multistep synthesis of natural products.	Understand
CO2	Draw conclusion based on evidence for structure elucidation and synthesis of natural products.	Analysis
CO3	Construct the names of heterocyclic compounds by IUPAC nomenclature and explain synthesis and reactivity of heterocyclic compounds	Analysis
CO4	Interpret the data for the structure elucidation of organic compounds based on UV, IR, ^{1}H-NMR and ^{13}C-NMR.	Evaluate

Unit	Course Description	Hrs
1	**Natural products-I** **1.1: Carbohydrates:** Introduction to naturally occurring sugars: Deoxysugars, aminosugars, branched sugars. Structure elucidation of lactose and Inositol (synthesis not expected). Structural features and applications of inositol, starch, cellulose, chitin and heparin**. [5L]** **1.2: Natural pigments:** General structural features, occurrence, biological importance and applications of: carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll). Structure elucidation of β-carotene and	**15**

	Cyanidin (with synthesis). **[4L]** **1.3: Terpenoids:** Occurrence, classification, structure elucidation, Stereochemistry, spectral data and synthesis of zingiberene. **[2L]** **1.4: Alkaloids:** Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of morphine. **[3L]** Medicinal importance of hygrine, quinine, and reserpine. [**1L]**	
2	**Natural products-II** **2.1: Multi-step synthesis of natural products**: Synthesis of the following natural products with special reference to reagents used, stereochemistry and functional group transformations: a) Corey synthesis of Longifolene from resorcinol b) Gilbert-Stork synthesis of Griseofulvin from phloroglucinol c) Corey's Synthesis of Caryophyllene from 2-Cyclohexenone and Isobutylene d) Synthesis of Juvabione from Limonene e) Woodward synthesis of Colchicine **[9L]** 2.2: Prostaglandins: Classification, general structure and biological importance. Structure elucidation of PGE1. **[2L]** **2.3:** Insect Growth Regulators: General idea, structures of JH1, JH2 and JH3. Synthesis of JH1 **[2L]** 2.4: Plant Growth Regulators: Structural features and applications of Cytokinis brassinosteroids and triacontanol. Synthesis of triacontanol (synthesis of stearyl magnesium bromide and 12- bromo-1-tetrahydropyranyloxydodecane expected) **[2L]**	15
3	**Heterocyclic Chemistry-I** **3.1:** Heterocyclic compounds: Introduction, classification, Nomenclature of heterocyclic compounds of monocyclic (3-6 membered) (Common, systematic (Hantzsch- Widman) and replacement nomenclature). **[3L]** **3.2:** Structure and nucleophilic ring opening reactions of aziridines, oxiranes, oxetanes and azetidines. **[2L]** **3.3:** Structure, reactivity, synthesis and reactions of pyridazine, pyrimidine, pyrazine, pyrrole, pyrazoles, Imidazoles, triazole and tetrazole **[9L]** **3.4:** Synthesis of Papavarin. **[1L]**	15
4	**Advanced Spectroscopic Techniques-I** **4.1:** Proton NMR spectroscopy: Recapitulation, chemical and magnetic equivalence of protons, First order, second order, Spin system notations (A2, AB, AX, AB2, AX2, AMX and A2B2-A2X2 spin systems with suitable examples). Long range coupling (Allylic coupling, 'W' coupling and Coupling in aromatic and hetero aromatic systems), Temperature effects, Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents. **[5L]** **4.2**: **^{13}C–NMR spectroscopy:** Recapitulation, equivalent and non-equivalent carbons (examples of aliphatic and aromatic compounds), ^{13}C- chemicalshifts, calculation of ^{13}C- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to ^{19}F and ^{31}P. **[4L]** **4.3 Mass Spectrometry:** Introduction, Basic Principles, Basic fragmentation types and rules **[2L]** **4.4:** Spectral problems based on UV, IR, ^{1}HNMR and ^{13}CNMR and Mass Spectrometry. **[4L]**	15

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3. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan, 2011.
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Course Description	Major-IV
Semester	III
Course Name	Practicals in Organic Chemistry-I
Course Code	PSC3POC1
Eligibility for the Course	M.Sc.-I Chemistry
Credit	2
Hours	60

Course Outcomes:

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Plan the synthesis of organic compounds.	Apply
CO2	Make use of thin layer chromatography and physical constant to know the purity of organic compounds	Apply
CO3	Apply principles of purification techniques such as recrystallization and distillation for purification of organic compounds.	Analyse
CO4	Compare spectral data of reactant and product and explain mechanism of reactions and MSDS of chemicals.	Apply

	Course Description	Hrs
1	**Two steps preparations (Minimum 08)** 1) Acetophenone → Acetophenone phenyl hydrazine → 2-phenyl indole. 2) 2-naphthol → 1-phenyl azo-2-naphthol → 1-amino-2-naphthol. 3) Cyclohexanone → Cyclohexanone oxime → Caprolactam. 4) 4-nitrotoluene → 4-nitrobenzoic acid → 4-aminobenzoic acid. 5) o-nitroaniline → o-phenylene diamine → Benzimidazole. 6) Benzophenone → benzophenone oxime → benzanilide. 7) Benzoin → benzil → benzilic acid. 8) Phthalic acid → phthalimide → anthranilic acid. 9) Resorcinol → 4-methyl-7-hydroxy coumarin → 4-methyl-7-acetoxy Coumarin. 10) Anthracene → anthraquinone → anthrone. 11) Acetophenone → Oxime → Acetanilide. 12) Acetanilide → pBromoacetanilide → pBromoaniline.	**60**

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1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
2. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
3. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
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Course Description	Elective-I
Semester	III
Course Name	Drug Discovery, Design, Development and Synthesis
Course Code	PSC3DDDS
Eligibility for the Course	M.Sc-I Chemistry
Credit	2
Hours	30

Course Outcomes

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Explain the basic terms used in medicinal chemistry, the pharmacokinetics of drug, drug structure activity relationship, physical chemical parameters of drugs and procedures in drug design.	Understand
CO2	Apply skills required for drug design, development of modern methods of synthesis required for employment in the pharmaceutical industries.	Apply

Unit	Course Description	Hrs
1	**Drug discovery, design and development** **1.1:** Introduction, important terms used in medicinal chemistry: receptor, therapeutic index, bioavailability, drug assay and drug potency. Drug receptor interactions enzyme inhibitor and drug target. Basic pharmacokinetics: drug absorption, distribution, metabolism (biotransformation) and elimination. Physical and chemical parameters like solubility, lipophilicity, ionization, pH, redox potential, H- bonding, partition coefficient and isomerism in drug distribution and drug- receptor binding. **[7L]** **1.2:** Procedures in drug design: Drug discovery without a lead: Penicillin, Librium. Lead discovery: random screening, non-random (or targeted) screening. Lead modification: Identification of the pharmacophore, Functional group modification. Structure-activity relationship, Structure modification to increase potency and therapeutic index: Homologation, chain branching, ring-chain transformation. Combinatorial chemistry- general aspects, split synthesis, peptide and non peptide libraries **[8L]**	15
2	**Drug design and synthesis** **2.1:** Introduction to quantitative structure activity relationship studies. QSAR parameters: - steric effects: The Taft and other equations; Methods used to correlate regression parameters with biological activity: Hansch analysis- A linear multiple regression analysis. **[5L]** **2.2:** Introduction to modern methods of drug design and synthesis- computer aided molecular graphics based drug design, drug design via enzyme inhibition (reversible and irreversible), bioinformatics and drug design. **[3L]** **2.3:** Concept of prodrugs and soft drugs. (a) Prodrugs: Prodrug design, types of prodrugs, functional groups in prodrugs, advantages of prodrug use. (b) Soft Drugs: concept and properties. **[3L]** **2.4:** Synthesis and application of the following drugs: Phenacetine, Benadryl, Veronal, Metharbital, Coramine, Sulphanilamide, Tolbutamide. **[4L]**	15

References:

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3. Introduction to Medicinal chemistry. by Graham Patrick
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Course Description	Elective-II
Semester	III
Course Name	Biomolecules-I
Course Code	PSC3BIC
Eligibility for the Course	M.Sc-I Chemistry
Credit	2
Hours	30

Course Outcomes

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Summarize amino acids, peptides, proteins and nucleic acids and chemical synthesis of oligonucleotides.	Understand
CO2	Explain importance of enzymatic reactions and factors affecting enzyme kinetics.	Understand

Unit	Course Description	Hrs
1	**Amino acids, peptides and proteins**	**15**
	1.1 Amino acids, peptides and proteins: Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures, α- helix, β-sheets, super secondary structure. Tertiary structure of protein: folding and domain structure. Quaternary structure.**[2L]** **1.2** Nucleic acids: Structure and function of physiologically important nucleotides (c-AMP, ADP, ATP) and nucleic acids (DNA and RNA), replication, genetic code, protein biosynthesis, mutation. **[3L]** **1.3** Structure: Purine & pyrimidine bases, ribose, deoxyribose, nucleosides and nucleotides (ATP, CTP, GTP, TTP, UTP) formation of polynucleotides strand with its shorthand representation**.[3L]** **1.4** RNAs (various types in prokaryotes and eukaryotes) m- RNA and r-RNA– general account , t- RNA-clover leaf model, Ribozymes**.[2L]**	

	1.5 DNA: Physical properties – Effect of heat on physical properties of DNA (Viscosity, buoyant density and UV absorption), Hypochromism, Hyperchromism and Denaturation of DNA. Reactions of nucleic acids (with DPA and Orcinol). **[2L]** **1.6** Chemical synthesis of oligonucleotides: Phosphodiester, Phosphotriester, Phosphoramidite and H- phosphonate methods including solid phase approach.**[3L]**	
2	**Enzymes**	**15**
	2.1 Chemistry of enzymes: Introduction, nomenclature, classes and general types of reactions catalyzed by enzymes. Properties of enzymes: a) enzyme efficiency/ catalytic power b) enzyme specificity; Fischer's 'lock and key' and Koshland 'induced fit' hypothesis. Concept and identification of active site. **[6L]** **2.2** Factors affecting enzyme kinetics: Substrate concentration, enzyme concentration, temperature, pH, product concentration etc. Reversible and irreversible inhibition. **[4L]** **2.3** Mechanism of enzyme action: transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Mechanism of chymotrypsin catalyzed hydrolysis of a peptide bond. **[5L]**	

References:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.
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Course Description (Practical)	Elective-I/ Elective-II
Semester	III
Course Name	Practicals in Organic Chemistry-II
Course Code	PSC3POC2
Eligibility for the Course	M.Sc-I Chemistry
Credit	2
Hours	60

Course Outcomes

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Demonstrate the skills in organic preparations required for pursuing a career in the pharmaceutical, chemical industry, research etc.	Understand
CO2	Make use of column chromatography, crystallization steam and vacuum distillation for purification of the organic compounds	Apply
CO3	Identify the prepared organic compounds by Thin Layer Chromatography	Apply

	Course Description	Hrs
	Single step organic preparation (1.0 g scale) involving purification by Steam distillation/Vacuum distillation or Column chromatography (Minimum 08) 1. Preparation of acetanilide from aniline and acetic acid using Zn dust. (Purification by column chromatography) 2. Preparation of 1-nitronaphthalene from naphthalene. (Purification by steam distillation) 3. Preparation of acetyl ferrocene from ferrocene. (Purification by column chromatography) 4. Preparation of 3-nitroaniline from 1, 3-dinitrobenzene. (Purification by column chromatography) 5. Preparation of benzyl alcohol from benzaldehyde. (Purification by vacuum distillation). 6. Preparation of methyl salicylate from salicylic acid. (Purification by vacuum distillation). 7. Preparation of 4-methylacetophenone from toluene. (Purification by vacuum distillation). 8. Preparation of phenyl acetate from phenol. (Purification by vacuum distillation) 9. Preparation of 2-chlorotoluene from *o*-toluidine. (Purification by steam distillation) 10. Preparation of fluorenone from fluorene. (Purification by column chromatography) 11. Preparation of dimethylphthalate from phthalic anhydride. (Purification by vacuum distillation) 12. Preparation of biginelli pyridiminone using vanallin by green method. (purification by column chromatography)	**60**

	13.	

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1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
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6. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
7. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
8. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
9. Handbook of Organic Analysis- Qualitative and Quantitative, H. Clark, Adward Arnold.
10. Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008, B.S.Furniss, A. J.Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
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Course Description	Research Project-I
Semester	III
Course Name	Research Project-I
Course Code	PSC3RP1
Eligibility for the Course	M.Sc-I Chemistry
Credit	4
Hours	120

Course Outcomes

COs.	**After successful completion of the course students will be able to**	**Bloom Taxonomy Level (BTL)**
CO1	Review appropriate methods to determine research aims and objectives.	Understand
CO2	Understand depth knowledge of topic chosen for research work.	Understand
CO3	Use of search engine like scopus, web of science, sci-finder etc. and reference software like mendeley, zotero etc.	Apply

CO4	Summarize report research in the form of review articles, research articles and thesis.	Evaluate

	Course Description	**Hrs**
	Research Project-I	120

SEMESTER-IV

Course Description (Theory)	Major-I
Semester	IV
Course Name	Theoretical Organic Chemistry-II
Course Code	PSC4TOC
Eligibility for Course	M.Sc.-I Chemistry
Credit	4
Hours	60

Course Outcomes

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Explain the principles of molecular association and organization, host- guest interaction, structure and properties of crown ether, cryptands, cyclophanes, rotaxanes, cyclodextrines, molecular self-assembly and Supramolecular polymers	Understand
CO2	Explain principles, methods of asymmetric synthesis and use of chiralauxiliaries in asymmetric synthesis	Understand
CO3	Apply the linear free energy relationship for determination of organicreaction mechanism using Hammett equation and Taft equation.	Apply
CO4	Determine the enantiomer and diastereomer composition by different methods, asymmetric transformation, molecular dissymmetry and chiroptical properties and explain the ORD and CD curves, Cotton effects, octane rule and its applications.	Evaluate

Unit	Course Description	Hrs
1	**Physical organic chemistry** **1.1**Structural effects and reactivity: Linear free energy relationship (LFER) in determination of organic reaction mechanism: The Hammett equation, Substituent constant (σ) and σ values, Reaction constants (ρ), reactions with positive and negative ρ values, Nonlinear Hammett plots (concave upwards and downwards deviations) **[9L]** **1.2** Uses of Hammett equation, deviations from Hammett equation. Dual parameter correlations, Inductive substituent constants, Calculation of k values, Taft equation, Solvent effects, Grunwald-Winstein equation, General tools for mechanistically studies of organic reactions, e.g. crossover experiments (intramolecular or intermolecular reaction) and isotope labelling experiments **[6L]**	15

2	**Supramolecular chemistry** **2.1** Principles of molecular associations and organizations as exemplified in biological macromolecules like nucleic acids, proteins and enzymes. [2L] **2.2** Synthetic molecular receptors: receptors with molecular cleft, molecular, tweezers, receptors with multiple hydrogen sites. [3L] **2.3** Structures and properties of crown ethers, cryptands, cyclophanes, calixarenes, rotaxanes and cyclodextrins. Synthesis of crown ethers, cryptands and calixarenes, Applications of cyclodextrins in oxidation, reduction, addition etc [6L] **2.4** Molecular recognition, Molecular interactions and catalysis, molecular self-assembly. Supramolecular Polymers, Gels and Fibers. [4L]	15
3	**Stereochemistry- II** **3.1** Racemization and resolution of racemates including conglomerates: Mechanism of racemization, methods of resolution: mechanical, chemical, kinetic and equilibrium asymmetric transformation and through inclusion compounds with stereospecific reactions. **[3L]** **3.2** Determination of enantiomer and diastereomer composition: enzymatic method, chromatographic methods. Methods based on NMR spectroscopy: use of chiral derivatising agents (CDA), chiral solvating agents (CSA) and Lanthanide shift reagents (LSR). **[3L]** **3.3** Structure of amine, isomerism of amines, Nomenclature, special structure of amines determination of configuration of amines. Stereochemistry of schiff's base, hydrazones azobenzenes, amides, conformations of thioamides. **[4L]** **3.4** Molecular dissymmetry and chiroptical properties: Linearly and circularly polarized light. Circular birefringence and circular dichroism. ORD and CD curves. Cotton effect and its applications. The octant rule and the axial α–haloketone rule with applications. **[5L]**	15
4	**Asymmetric synthesis** **4.1** Principles of asymmetric synthesis: Introduction, the chiral pool in Nature, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions. **[2L]** **4.2** Synthesis of L-DOPA [Knowles's Mosanto process], Synthesis of L-Alanine, Asymmetric reactions with mechanism: Aldol and related reactions, Cram's rule, Felkin-Anh model, Sharpless enantioselective epoxidation, hydroxylation, aminohydroxylation, Diels-Alder reaction, reduction of prochiral carbonyl compounds and olefins, Woodward cis-hydroxylation, Alkylation of chiral enolates. **[9L]** **4.3** Use of chiral auxiliaries in diastereoselective reductions, asymmetric amplification. Use of chiral BINOLs, BINAPs and chiral oxazolines asymmetric transformations. **[4L]**	15

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34. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill
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36. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
37. Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A john Wiley and Sons, Ltd., Publication

Course Description (Theory)	Major-II
Semester	IV
Course Name	Synthetic Organic chemistry-II
Course Code	PSC4SOC
Eligibility for Course	M.Sc.-I Chemistry
Credit	4
Hours	60

Course Outcomes:

COs.	**After successful completion of the course students will be able to**	**Bloom Taxonomy Level (BTL)**
CO1	Explain the concepts of retrosynthesis, protecting groups, synthetic planning and selective transformations in organic synthesis.	Explain
CO2	Apply disconnection approach, FGI, FGA, FGR and recognize starting compounds in designing organic synthesis of target molecules.	Apply
CO3	Summarize electro-organic chemistry and use of organocatalyst, lewis acid, crown ethers, cryptands, micelles etc. in selected methods of organic synthesis.	Understand
CO4	Predict the products of organic synthesis in which transition and rare earthmetals are used.	Create

Unit	Course Description	Hrs
1	**Designing Organic Synthesis-I** **1.1** Protecting groups in Organic Synthesis: Protection and deprotection of the hydroxyl, carbonyl, amino and carboxyl functional groups and its applications. **[3L]** **1.2** Concept of umpolung (Reversal of polarity): Generation of acyl anion equivalent using 1,3-dithianes, methyl thiomethyl sulfoxides, cyanide ions, cyanohydrin ethers, nitro compounds and vinylated ethers. **[3L]** **1.3** Introduction to Retrosynthetic analysis and synthetic planning: Linear and convergent synthesis; Disconnection approach: An introduction to synthons, synthetic equivalents, disconnection approach, functional group interconversions (FGI), functional group addition (FGA), functional group removal (FGR) importance of order of events in organic synthesis, one and two group C-X disconnections (1,1; 1,2; 1,3 difunctionalized compounds) **[7L]** **1.4** General strategy: choosing a disconnection simplification, symmetry, high yielding steps, and recognisable starting material. **[2L]**	**15**
2	**Designing Organic Synthesis-II** **2.1** One group C-C Disconnections: Alcohols (including stereoslectivity), carbonyls (including regioselectivity), Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. **[7L]** **2.2** Two group C-C Disconnections: 1,2- 1,3- 1,4- 1,5- and 1,6-difunctionalized compounds, Diels-Alder reactions, α, β-unsaturated compounds. **[3L]** **2.3** Application of the retrosynthesis in the synthesis of molecules: Camphore, Longifolene, Cortisone, Vitamin D, Aphidicolin. **[5L]**	**15**
3	**Electro-organic chemistry and Selected methods of Organic synthesis** **3.1** Electro-organic chemistry: **[7L]** 3.1.1 Introduction: Electrode potential, cell parameters, electrolyte, working electrode, choice of solvents, supporting electrolytes. 3.1.2 Cathodic reduction: Reduction of alkyl halides, aldehydes, ketones, nitro compounds, olefins, arenes, electro-dimerization. 3.1.3 Anodic oxidation: Oxidation of alkylbezene, Kolbe reaction, Non-Kolbe oxidation, Shono Oxidation. **3.2** Selected Methods of Organic synthesis Applications of the following in organic synthesis: **[8L]** 3.2.1 Crown ethers, cryptands, micelles, cyclodextrins, catenanes. 3.2.2 Pd catalysed cycloaddition reactions: Stille reaction, Saeguse-Ito oxidation to enones, Negishi coupling. 3.2.3 Epoxidation: m-CPBA, BuOOH, H_2O_2, Dimethyldioxirane, Potassium peroxomonosulphate 3.2.4 Aziridination.	**15**
4	**Transition and rare earth metals in organic synthesis** **4.1** Introduction to basic concepts: 18 electron rule, oxidative addition, reductive elimination, migratory insertion. Kumada reaction, Hiyama reaction, Buchwald Hartwig reaction.,Carbonylation reaction. **[3L]**	**15**

	4.2 Palladium in organic synthesis: π-bonding of Pd with olefins, applications in C-C bond formation, carbonylation, alkene isomerisation, cross-coupling of organometallics and halides. Representative examples: Heck reaction, Suzuki-Miayura coupling, Sonogashira reaction and Wacker oxidation. Heteroatom coupling for bond formation between aryl/vinyl groups and N, S, or P atoms. **[5L]** **4.3** Olefin metathesis using Grubb's catalyst. **[1L]** **4.4** Application of Ni, Co, Fe, Rh, and Cr carbonyls in organic synthesis. **[4L]** **4.5** Application of samarium iodide including reduction of organic halides, aldehydes and ketones, α-functionalised carbonyl and nitro compounds. **[2L]**	

References:

1. Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5th Edition, Springer Verlag
2. Modern Methods of Organic Synthesis, 4th Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004.
3. Chem. Rev. 2002, 102, 2227-2302, Rare Earth Metal Triflates in Organic Synthesis, S. Kobayashi, M. Sugiura, H. Kitagawa, and W.W.L. Lam.
4. Organic Chemistry, Clayden Greeves Warren and Wothers, Oxford Press (2001).
5. Modern Organic Synthesis: An Introduction, G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, (2007).
6. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Academic Press (2002).
7. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon, 3rd Edn., Nelson Thornes
8. Organic Chemistry, 7th Edn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
9. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti & B. Czako (2005), Elsevier Academic Press
10. Advanced Organic Chemistry: Reactions & Mechanisms, 2nd Edn., B. Miller & R. Prasad, Pearson
11. Organic reactions and their mechanisms, 3rd revised edition, P.S. Kalsi, New Age International Publishers
12. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004
13. Name Reactions and Reagents in Organic Synthesis, 2nd Edn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
14. Name Reactions, Jie Jack Lie, 3rd Edn., Springer
15. Organic Electrochemistry, H. Lund, and M. Baizer, 3rd Edn., Marcel Dekker.

Course Description (Theory)	Major-III
Semester	IV
Course Name	Natural Products, Heterocyclic Chemistry and Spectroscopy-II
Course Code	PSC4NHS
Eligibility for Course	M.Sc.-I Chemistry
Credit	4
Hours	60

Course Outcomes:

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Explain occurrence, classification, structural and stereochemical features of steroids, insect pheromones, insecticides, vitamins and their biological role in life related processes.	Understand
CO2	Plan the synthesis of biologically important steroids, vitamins, antibiotics, insecticides.	Apply
CO3	Apply fundamentals of heterocyclic reactivity and synthesis skills required for heterocyclic compounds in research and industry and explain the names of heterocyclic compounds by IUPAC nomenclature and replacement nomenclature.	Apply
CO4	Interpret the data for the structure elucidation of organic compounds based on UV, IR, ^{1}H-NMR, ^{13}C-NMR two dimensional spectroscopic techniques, COSY and HETCOR spectra, NOE and NOESY, INEPT, APT and INADEQUATE techniques.	Evaluate

Unit	Course Description	Hrs
1	**Natural products-III** **1.1: Steroids:** General structure, classification. Occurrence, biological role, important structural and stereochemical features of the following: corticosteroids, steroidal hormones, steroidal alkaloids, sterols and bile acids. **[5L]** **1.2:** Synthesis of 16-DPA from cholesterol and plant sapogenin. **[2L]** **1.3:** Synthesis of the following from 16-DPA: androsterone, testosterone, oestrone, and progesterone. **[3L]** **1.4: Insect pheromones**: General structural features and importance. Types of pheromones (aggregation, alarm, releaser, primer, territorial, trail, sex pheromones etc.), advantage of pheromones over conventional pesticides. Synthesis of bombykol from acetylene, disparlure from 6-methylhept-1-ene, grandisol from 2-methyl-1, 3-butadiene**.** Pheromones-production, and their use in pest surveillance and management of pests. Merits and demerits in using	**15**

	pheromones for pest management. Pheromones in yeast, bacteria and protozoa. Primer and releaser pheromones effects in gold fish. Pheromones in masking the poison-based shyness in rodents. **[5L]**	
2	**Natural products-IV** **2.1: Vitamins:** Classification, sources and biological importance of vitamin B1, B2, B6, folic acid, B12, C, D1, E (α-tocopherol), K1, K2, H (β- biotin). Synthesis of the following: Vitamin A from β-ionone and bromoester moiety. Vitamin B1 including synthesis of pyrimidine and thiazole moietiesVitamin B2 from 3, 4-dimethylaniline and D(-) ribose Vitamin B6 from: 1) ethoxyacetylacetone and cyanoacetamide, 2) ethyl ester of N-formyl-DL-alanine (Harris synthesis) Vitamin E (α-tocopherol) from trimethylquinol and phytyl bromideVitamin K1 from 2-methyl-1, 4-naphthaquinone and phytol Synthesis of Vitamin H **[8L]** **2.2: Antibiotics: Antibiotics:** Structure elucidation, spectral data of penicillin-G and chloramphenicol. Synthesis of chloramphenicol (from benzaldehyde and β-nitroethanol) penicillin-G and phenoxymethylpenicillin from D-penicillamine and t-butyl phthalimide malonaldehyde (synthesis of D-penicillamine and t-butyl phthalimide malonaldehyde expected). **[5L]** **2.3: Naturally occurring insecticides:** Sources, structure and biological properties of pyrethrums (pyrethrin I), rotenoids (rotenone). Synthesis of pyrethrin I. **[2L]**	15
3	**Heterocyclic Chemistry-II** **3.1:** Nomenclature of heterocyclic compounds of bicyclic/tricyclic (5-6 Membered) fused heterocycles (up to three hetero atoms)**.** (Common, systematic (Hantzsch-Widman) and replacement nomenclature). **[3L]** **3.2:** Structure, reactivity, synthesis and reactions of quinoline, isoquinoline indole, coumarines, benzimidazoles, benzothiazoles, quinoxaline, benzofuran, benzothiophene, Acridine **[12L]**	15
4	**Advanced Spectroscopic Techniques-II** **4.1: Advanced NMR techniques:** DEPT experiment, determining number of Attached hydrogens (methyl/methylene/ methine and quaternary carbons), two dimensional spectroscopic techniques, COSY and HETCOR spectra, NOE and NOESY, INEPT, APT and INADEQUATE techniques. **[10L]** **4.2:** Spectral problems based on UV, IR, ^{1}HNMR, ^{13}CNMR (Including 2D technique) and Mass spectrometry. **[5L]**	15

References:

1. Natural product chemistry, A mechanistic, biosynthetic and ecological approach, Kurt

B.G. Torssell, Apotekarsocieteten –Swedish Pharmaceutical Press.

2. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.
3. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan,2011.
4. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974

5. Natural Product Chemistry Vol.1 and 2, K. Nakanishi J. Goto. S. Ito Majori and S.Nozoo, Academic Press, 1974.
6. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co. 2008.
7. Heterocyclic chemistry, 3rd edition, Thomas L. Gilchrist, Pearson Education, 2007.
8. Heterocyclic Chemistry, Synthesis, Reactions and Mechanisms, R. K. Bansal, Wiley Eastern Ltd., 1990.
9. Heterocyclic Chemistry, J. A. Joule and G. F. Smith, ELBS, 2nd edition, 1982.
10. The Conformational Analysis of Heterocyclic Compounds, F.G. Riddell, AcademicPress, 1980.
11. Principles of Modern Heterocyclic Chemistry, L.A. Paquette, W.B. Benjamin, Inc.,1978.
12. An Introduction to the Chemistry of Heterocyclic Compounds, 2nd edition, B.M.Acheson, 1975.
13. Natural Products: Chemistry and Biological Significance Interscience, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J. B. Harborne, Longman, Essex, 1994.
14. Organic Chemistry, Vol 2, I.L. Finar, ELBS, 6th edition, Pearson.
15. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.
16. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
17. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the mericas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
18. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers, 1998.
19. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers, 1998.
20. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.
21. Comprehensive Organic Chemistry by Barton and Olis, Pergamon Press, Oxford,1979.
22. Medicinal Natural Products, a Biosynthetic Approach, Derick Paul, John Wiley andSons, 2002.
23. Biosynthesis of Natural Products, Mannitto Paolo, Ellis Horwoocl Limited, 1981.
24. Selected Organic synthesis, Ian Fleming, John Wiley and Sons, 1973.

Course Description (Theory)	Elective-I
Semester	IV
Course Name	Green Chemistry
Course Code	PSC4GC
Eligibility for Course	M.Sc.-I Chemistry
Credit	02
Hours	30

Course Outcomes

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Demonstrate the knowledge of the twelve principles of green Chemistry and importance of green chemistry which they can practice to a range of workplace for a safer less toxic and healthier environment.	Understand
CO2	Apply the principles of green chemistry for synthesis	Apply

Unit	Course Description	Hrs
1	**Introduction to Green Chemistry** **1.1:** Introduction, basic principles of green chemistry, Need of Green chemistry, Goals of green chemistry, limitations/ obstacles in the persuit of the goals in green chemistry **[2L]** **1.2** Importance of green chemistry in Day to Day life, Industries and solving human health problems (Four examples each) [**2L**] **1.3** Real world cases in green chemistry: Surfactants for carbon dioxide-replacing smoke producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifaulant [**3L**] **1.4** Future trends in Green Chemistry: Oxidation reagents and catalysts, biomimetic multifunctional reagents, combinational green chemistry, proliferation of solvent-free reactions, co-crystal controlled solid state synthesis, Green chemistry in sustainable development **[8L]**	**15**
2	**Green synthesis** **2.1** Use of the following in green synthesis with suitable examples a) Green reagents: dimethylcarbonate, polymer supported reagents. b) Green catalysts: Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts [Aliquat 336, benzyltrimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers], biocatalysts. c) Green solvents: water, ionic liquids, deep eutectic solvents, supercritical carbon dioxide. d) Solid state reactions: solid phase synthesis, solid supported synthesis	**15**

	e) Aqueous phase reactions f) Microwave - assisted synthesis: reactions in water, reactions in organic solvents, solvent free reactions. g) An efficient green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn. h) Ultrasound assisted reactions. i) Healthier fat and oil by green chemistry: Enzymatic inter esterification for production of no Trans-fats and oils. [**12L**] **2.2** Comparison of traditional processes versus green processes in the synthesis of ibuprofen, Adipic acid, 4-aminodiphenylamine, p-bromotoluene and Benzimidazole. [**3L**]	

References:

1. Green Chemistry: An Introductory Text, 2nd Edition, Published by Royal Society of Chemistry, Authored by Mike Lancater.
2. Organic synthesis in water. By Paul A. Grieco, Blackie.
3. Green chemistry, Theory and Practical, Paul T. Anastas and John C. Warner.
4. Anamaya Publishers, New Delhi.
5. 46. An introduction to green chemistry, V. Kumar, Vishal Publishing Co.
6. 47. Organic synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal.
7. New Trends in Green Chemistry, V.K.Ahluwalia and M.Kidwai

Course Description (Theory)	Elective-II
Semester	IV
Course Name	Intellectual Property Rights
Course Code	PSC4IPR
Eligibility for Course	M.Sc.-I Chemistry
Credit	02
Hours	30

Course Outcomes:

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Define various terminologies related to IPR	Remember
CO2	Explain the role of law in the violation of IPR	Understand

Unit	Course Description	Hrs
1	**Introduction to Intellectual Property-I** **1.1** Introduction to Intellectual Property:Historical Perspective, Differenttypes of IP, Importance of protecting IP. **[2L]** **1.2** Patents: Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovationwith public health, Software patents and their importance for India. **[5L]** **1.3** Industrial Designs: Definition, How to obtain, features, International design registration. **[2L]** **1.4** Copyrights: Introduction, How to obtain, Differences from Patents. **[2L]** **1.5** Trade Marks: Introduction, How to obtain, Different types of marks, Collective marks, certification marks, service marks, trade names etc.**[2L]** **1.6** Geographical Indications: Definition, rules for registration, prevention of illegal exploitation, importance to India. **[2L]**	**15**
2	**Introduction to Intellectual Property-II** **2.1** Trade Secrets: Introduction and Historical Perspectives, Scope ofProtection, Risks involved and legal aspects of Trade Secret Protection. **[2L]** **2.2** IP Infringement issue and enforcement: Role of Judiciary, Role of law enforcement agencies- Police, Customs etc. **[2L]** **2.3** Economic Value of Intellectual Property: Intangible assets and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. **[5L]** **2.4** Different International agreements: a) World Trade Organization (WTO): 1. General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement 2. General Agreement on Trade Related Services (GATS) Madrid Protocol. 3. Berne Convention 4. Budapest Treaty b) Paris Convention WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity. **[6L]**	**15**

References:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.
2. Stryer, Lubert; Biochemistry; W. H. Freeman publishers**.**
3. Voet, D. and J. G. Voet (2004) Biochemistry, 3rd Edition, John Wiley & sons, Inc. USA.
4. Zubay, Goffrey L; Biochemistry; Wm C. Brown publishers.
5. Biochemistry: The chemical reactions in living cells, by E. Metzler Academic Press.
6. Concepts in biotechnology by D. Balasubrarnanian & others

Course Description (Practical)	Elective-I/ Elective-II
Semester	IV
Course Name	Practicals in Organic Chemistry-III
Course Code	PSC4POC3
Eligibility for Course	M.Sc.-I Chemistry
Credit	2
Hours	60

Course Outcomes:

COs.	After successful completion of the course students will be able to	Bloom Taxonomy Level (BTL)
CO1	Identify the chemical type of components present the in ternary mixture of organic compounds.	Apply
CO2	Apply skills in separation of organic compounds of ternary mixtures by micro scale technique.	Apply
CO3	Compare spectral data of reactant and product and explain mechanism of reactions and MSDS of chemicals.	Apply
CO4	Interpret spectral data like FT-IR, ^{13}C NMR, $^{1}HNMR$, UV-Visible spectrum and Mass spectrum for structure elucidation of organic compound	Evaluate

	Course Description	Hrs
1.	**Separation of a ternary mixture of organic compounds using micro-scale technique (Minimum 08)** Separation of a ternary mixture (S-S-S, S-S-L, S-L-L and L-L-L) (for solid mixture: water insoluble/ soluble including carbohydrates) based upon differences in the physical and the chemical properties of the components.	**30**
2.	**Combined spectral identification: Interpretation of spectral data of organic compounds (UV, IR, PMR, CMR and Mass spectra). (Minimum 08)** A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard text-book/reference material etc.	**30**

References:

1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis- V. K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
2. Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd

3. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
4. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
5. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
6. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
7. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
8. Handbook of Organic Analysis- Qualitative and Quantitative, H. Clark, Adward Arnold.
9. Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008, B.S.Furniss, A. J.Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
10. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
11. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

Course Description	Research Project-II
Semester	IV
Course Name	Research Project-II
Course Code	PSC4RP2
Eligibility for the Course	M.Sc-I Chemistry
Credit	6
Hours	180

Course Outcomes

COs.	**After successful completion of the course students will be able to**	**Bloom Taxonomy Level (BTL)**
CO1	Understand the research problems.	Understand
CO2	Apply skills in qualitative and quantitative data analysis and presentation.	Apply
CO3	Analyze scientific data by statistical and graphical methods.	Analyse
CO4	Develop methodologies preferably with green and safe approach to conduct research.	Create

	Course Description	**Hrs**
	Research Project-II	180