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

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

Programme: M.Sc. Analytical Chemistry

PSOs No	**After completing the programme in M.Sc. Analytical Chemistry, Student will able to:**	**Graduate Attribute**
PSO1	Understand the principles, methodologies of analytical techniques and their applications in industrial, social, and environmental context.	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 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 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 practical's of courses of two Semesters of the two programmes are 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 last few decades are phenomenal. It is also seen that these developments are crossing the traditional vertical boundaries of scientific disciplines; the 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 industrial scale also is 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.

M. Sc. 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. 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 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

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 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
PSC1PCP + PSC1ACP	-	Practical Course Practical (Physical Chemistry + Analytical Chemistry)	8	16
PSC1IC2 Elective-I	I	Chemical Bonding	2	1
	II	Molecular Symmetry and GroupTheory		1
PSC1IC2 Elective-2	III	Materials Chemistry and Nanomaterials	2	1
	IV	Characterization of Coordination Compounds		

PSC1ICP + PSC1OCP		**Practical's of** **Practical's (Inorganic Chemistry + Organic Chemistry)**	**2**	**8**
PSC1RM	**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
PSC2CH4	I	Chromatography	4	1
	II	X-ray spectroscopy, Mass spectrometry, Radioanalytical Methods		1
	III	• SurfaceAnalytical Techniques • Atomic Spectroscopy		1
	IV	Electroanalytical Methods		1
PSC1PCP + PSC1ACP	-	Practical Course Practical (Physical Chemistry + Analytical Chemistry)	8	16
PSC2IC2 Elective-I	I	Inorganic Reaction Mechanism	4	1
	II	Organometallic Chemistry of Transitionmetals		1
PSC2IC2 Elective-I	III	Environmental Chemistry		1
	IV	Bioinorganic Chemistry		1

PSC1ICP + PSC1OCP		**Practicals Course Practical's (Inorganic Chemistry + Organic Chemistry)**	**2**	**8**
	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, 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	15

	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	**PSC1PCP**
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 synthesi

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 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 centres 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	15

	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)	
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	**PSC1OCP**
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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UniversityPress.

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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 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	**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,	15

	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.	
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 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	15

	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	**PSC1ACP**
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	CO No.	PSO No.	PO No.
1.	**Chemical Bonding:**	15h	CO1	PSO1	PO3
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	CO3	PSO1	PO5
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.

2. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.

3. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.

4. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2ndEdition 2005.

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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.
5. A. SalahuddinKunju and G. Krishnan, Group Theory and its Applications in 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,
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7. Physical Methods in Chemistry, R. S. Drago (2nd Edition) (1977).

Course Description	
Semester	**I**
Course Name	**Inorganic Chemistry Practical**
Course Code	**PSC1IC1**
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	**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 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-	**15**

	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:

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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	**PSC2PCP**
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, 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.	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	15

	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, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro	15

	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	**PSC2OCP**
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**	**CO No.**	**PSO No.**	**PO No.**
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	1-4	1-4	9-11

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]	15

	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]	
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.	15

	4.2 Electrogravimetry: Introduction, principle, instrumentation, factors affecting the nature of the deposit, applications.[3 L] 4.3 Coulometry: Introduction, principle, instrumentation, coulometry at controlled potential and controlled current [2 L]	

References:

Unit I

1. Instrumental Analysis, Skoog, Holler & Crouch

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

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

Unit III

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

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

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

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

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

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

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

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

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

Unit IV

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

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

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

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

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

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

Analytical Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Analytical Chemistry**
Course Code	**PSC2ACP**
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
6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house,2012.
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Unit II

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

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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
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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.

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5. G.N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri& Sons, Calcutta,1988.
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Course Description	
Semester	**II**
Course Name	**Inorganic Chemistry Practical**
Course Code	**PSC2ICP**
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

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 of Syllabus 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 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 Academic year**	2023-2024

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

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

Programme: M.Sc. Organic Chemistry

PSOs No.	After completing the programme in M.Sc. Organic Chemistry, Student will able to:	Graduate Attribute
PSO1	Develop analytical thinking and apply the same for understanding principles, proposing mechanism and logical conclusions, understanding of 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 synthetic division of chemical, pharmaceutical, dyestuff and food industries	Research skills
PSO3	Competency in design and planning of synthesis and carry 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 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 of two Semesters of the two programmes are 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 last few decades are phenomenal. It is also seen that these developments are crossing the traditional vertical boundaries of scientific disciplines; the 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 industrial scale also is 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 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. 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 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

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 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
PSC1OCP + PSC1ACP	-	Practical Course Organic chemistry Practical's + Analytical Chemistry Practical's	2	8
PSC1PC1	I	Thermodynamics-I	2	2

Elective-I	**II**	**Quantum Chemistry**		
PSC1PC2 Elective-II	**III**	**Chemical Dynamics-I**	**2**	**2**
	IV	**Electrochemistry**		
PSC1PCP + PSC1ICP	**-**	**Practical Course Physical chemistry Practical's + Inorganic Chemistry Practical's**	**2**	**8**
PSC1RM	**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	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	• Surface Analytical Techniques • Atomic Spectroscopy		1
	IV	Electroanalytical Methods		1
PSC2OCP + PSC2ACP	-	Practical Course Organic chemistry Practical's + Analytical Chemistry Practical's	2	8
PSC2PC1 Elective-I		Chemical Thermodynamics II	2	1
		Quantum Chemistry II		
PSC2PC Elective-II		Chemical Kinetics and Molecular Reaction Dynamics	2	1
		Solid State Chemistry and Phase Equilibria		
PSC1PCP + PSC1ICP	-	Practical Course Physical chemistry Practical's + Inorganic Chemistry Practical's	2	8
--	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 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.	
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.

4. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2ndEdition 2005.

5. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry–Principles of Structure andReactivity, 4th Ed., Harper Collins, 1993.

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.

9. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.

10. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt.Ltd., 1985.

11. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.

12. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

Unit II

1. F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd.,1989.
2. H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1996.
3. R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, New York,1998.
4. K. V. Reddy. Symmetry and Spectroscopy of Molecules, 2nd Edition, New Age International Publishers, New Delhi, 2009.
5. A. 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	**PSC1IC1**
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 synthesi

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 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 centres 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 aromatic systems. Delocalization and aromaticity. 2.2.2. Application of HMO theory to monocyclic conjugated systems. Frost-Musulin	15

	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	**PSC1OCP**
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.	

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 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	**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	15

	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, 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	**15**

	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.
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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	**PSC1ACP**
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	4

	for calibration of 5 mL pipette. b) Determine mean, deviation, Q value and t value using MS-EXCEL software	
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
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.	15

	c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula.	

Course Description (Elective-II)	
Semester	**I**
Course Name	**Physical Chemistry-II**
Course Code	**PSC1PC1**
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, 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 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	**15**

	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	

References

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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.

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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	**PSC1PCP**
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.

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 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]	**15**

	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.	
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-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
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	**PSC2ICP**
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

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, 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.	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.	15

	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	
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,	15

	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.	

Organic Chemistry Practical

Course Description	
Semester	**II**
Course Name	**Organic Chemistry**
Course Code	**PSC2OCP**
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	30

	insoluble solid, (ii) Non-volatile liquid-Non-volatile liquid (chemical separation) (iii) Water-insoluble solid-Non-volatile liquid.	

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 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]	15

	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] 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	**PSC2ACP**
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	15

	obtaining the approximate solution of the Schrödinger wave equation. 2.4. Hückel Molecular Orbitals theory for ethylene, 1,3-butadiene and benzene. (Derivation expected)	

Course Description (Elective-II)	
Semester	**II**
Course Name	**Physical Chemistry-II**
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 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
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, 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
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.

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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.

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

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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.

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

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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.

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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	**PSC2PCP**
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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3. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

OJT

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

Janardan Bhagat Shikshan Prasarak Sanstha's

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

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

Programme: M.Sc.
Course: M.Sc.-II
Analytical Chemistry
Choice Based Credit System (60:40)
w.e.f. Academic Year 2023-2024

Syllabus

(Approved in the Academic Council Meeting

Held on June 27, 2023)

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	2023-2024

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

Preamble of the Syllabus:

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

Course Outcomes

M.Sc. Part II Analytical Chemistry

Semester III

Paper 1: Theory

CO1. Students will understand importance of GLP and their regulations.
CO2. Students will understand theoretical aspects of sampling, pre-treatment and method validation.
CO3. Students will learn the laboratory accreditation, its benefits and importance of ICH guidelines.
CO4. Student will get knowledge of how to measure uncertainty in measurements, dealing with signal to noise ratio and legislator aspects of pharmaceutical industries.

Paper 1: Practical

CO1: Students will learn the analysis of quality of various types of samples using instrumental methods of analysis.
CO2. Students will learn graphical representation of the data.

Paper 2: Theory

CO1. Student will help to understand the theoretical concepts of surface analytical techniques.
CO2. Student will understand advanced spectroscopic techniques used for characterization of matter.
CO3. Students will get detailed insights of advanced electroanalytical techniques.
CO4. Student will find applications of chemiluminescence, ORD-CD, Photoacoustic spectroscopy in analytical chemistry.

Paper 2: Practical

CO1: Students will learn the various advanced analytical techniques for analysis of different samples.
CO2: Students will get knowledge of quality control methods and understand the importance of accuracy.

Paper 3: Theory

CO1. Student will learn bioanalytical techniques of analysis.
CO2. Student will understand the importance of Immunoassays and its applications.
CO3. Student will get general idea about food processing, food preservation and determination of food contaminant etc.
CO4. Student will understand technique use in food packaging and food analysis.

Paper 3: Practical

CO1. Students will perform practical based upon food analysis
CO2. Students will understand data acquisition and analysis.

Paper 4: Theory

Paper 4 E1: Theory

CO1. Student will learn different aspects of Chemistry of atmosphere and Environmental legislation.
CO2. Student will understand the quality and requirement of potable water and bore well water.
CO3. Student will study the details of sources and hazardous of soil pollutant and monitoring of air pollution.
CO4. Student will do the detail study of control of pollution through Green Chemistry.

Paper 4 E2: Theory

CO1. Student will get general idea regarding the pharmaceutical analysis and quality control methods of pharmaceutical industry.
CO2. Student will know the details of drug analysis on the basis of functional groups and other factors.
CO3. Student will understand the applications of analytical chemistry in forensic science.
CO4. Student will learn the various aspects of cosmetic industry and analysis of different type cosmetics.

Paper 4: Practical

CO1. Students will perform the practical based on estimations of drugs by non-aqueous titration.
CO2. Students will perform the practical based on the analysis of water sample.

Semester IV

Paper 1: Theory

CO1. Students will get detailed insights of modern chromatographic techniques for separation of mixture on the basis of charge, size, and affinity of composition.
CO2. Student will learn details of various separation processes.
CO3. Student will study the separation, analysis and standardization of herbal based products.
CO4. Student will understand the concept of electrophoresis in analysis and basics of nanotechnology.

Paper 1: Practical

CO1. Student will understand the use of various instrumental methods for the analysis of different samples.

Paper 2: Theory

CO1. Student will do the detail study of principle, instrumentation and applications of NMR spectroscopy.
CO2. Student will understand the detail concept of mass spectroscopy and Raman spectroscopy.
CO3. Student will learn principle and interfacing of radio analytical techniques and hyphenated thermal methods
CO4. Student will know the detail concept of hyphenated techniques including GC-MS, GC-IR, LC-MS, and HPLC-MS etc.

Paper 2: Practical

CO1. Student will able to do Interpretation of data using various advanced techniques.
CO2. Student will able to do Interpretation of spectra of NMR, Mass, IR, UV visible.

Paper 3: Theory

CO1. Student will learn the different aspects of effluent treatment.
CO2. Student will understand steps involved in solid waste management.
CO3. Student will get an idea about classifications and applications of plastics, polymer, paints and pigments and their environmental impact.
CO4. Student will study metallurgical analysis.

Paper 3: Practical

CO1. Students will learn quantitative estimation of various types of metallurgical samples.

Paper 4: Theory

Paper 4E1: Theory

CO1. Student will learn about details intellectual property.
CO2. Student will get knowledge of intellectual property rights (IPR).
CO3. Student will understand concepts in cheminformatics.
CO4. Student will learn about industrial designing and traits in it.

Paper 4E2: Theory

CO1. Student will learn every aspect of publication of research paper such as terms associated with journals, referencing and library resources.
CO2. Student will get conversant with the methods of data analysis and various softwares employed for it.
CO3. Student will get knowledge of actual writing scientific papers.
CO4. Student will get information of the safety and ethical handling of chemicals.

Paper 4: Practical

CO1. Student will actually get involved in research work.
CO2. Student will understand the analysis of data generated by their research work.
CO3. Student will learn how to present research work.

M.Sc. Analytical Chemistry

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

Semester-III

1. Paper-I / Quality in Analytical Chemistry
2. Paper-II / Advanced Analytical Techniques
3. Paper- III / Bio-analytical Chemistry and Food Analysis
4. Paper- IV (Elective course-1)/ Environmental and Certain Industrially Important Materials

   (Elective course-2)/ Pharmaceutical and Organic Analysis

Semester-IV

1. Paper-I / Quality in Analytical Chemistry
2. Paper-II / Advanced Analytical Techniques
3. Paper- III/ Selected Topics in Analytical Chemistry
4. Paper- IV (Optional course-1)/ Intellectual Property Rights & Cheminformatics (Optional course-2)/ Research Methodology

Examination Scheme

Choice Based Credit System (CBCS)

❖ **Revised 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 % 20 Marks

Sr. No.	Particular	Marks
01	One periodical class test / online examination to be conducted in the given semester	20 Marks
02	Any one tool out of these 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 and overall conduct	05 Marks

Question Paper Pattern

(Periodical Class Test for the Courses at Post-Graduate Programmes)

- Maximum Marks: 20
- Duration: 40 Minutes

Particular	Marks
1.Match the Column / Fill in the Blanks / Multiple Choice Questions/ True/False/Answer in One or Two Lines (Concept based Questions) (02Marks each)	10 Marks
2.Answer in Brief(Attempt any two out of three)	10 Marks

A) Semester End Examination: 60 % 60 Marks

- Duration: The examination shall be of 2 $\frac{1}{2}$ hours duration.
- There shall be five questions each of 12 marks.

Question may be subdivided into sub-questions a, b, c… and the allocation of marks depends on the weightage of the unit.

Question Paper Pattern for Semester End Examination

<table>
<tr><td rowspan="8">I</td><td colspan="3">Theory: The Semester End Examination for theory course work will be conducted as per the following scheme.</td></tr>
<tr><td colspan="3">Each theory paper shall be of two and half hour duration.</td></tr>
<tr><td colspan="3">1. There shall be five questions each of 12 marks.
All questions are compulsory and will have internal options.
Question may be subdivided into sub-questions a, b, c… and the allocation of marks depends on the weightage of the unit.</td></tr>
<tr><td>Q-1</td><td colspan="2">From Unit – I (having internal options.) 12 M</td></tr>
<tr><td>Q-2</td><td colspan="2">From Unit – II (having internal options.) 12M</td></tr>
<tr><td>Q-3</td><td colspan="2">From Unit – III (having internal options.) 12M</td></tr>
<tr><td>Q-4</td><td colspan="2">From Unit – IV(having internal options.) 12M</td></tr>
<tr><td>Q-5</td><td colspan="2">Questions from all the FOUR Units with equal weightage of marks allotted to each Unit. 12 M</td></tr>
<tr><td>II</td><td>Practical</td><td colspan="2">The Semester End Examination for Practical course work will be conducted as per the following scheme.</td></tr>
<tr><td>Sr. No.</td><td colspan="2">Particulars of External Practical Examination</td><td>Marks%</td></tr>
<tr><td>1</td><td colspan="2">Laboratory Work</td><td>80</td></tr>
<tr><td>2</td><td colspan="2">Journal</td><td>10</td></tr>
<tr><td>3</td><td colspan="2">Viva</td><td>10</td></tr>
<tr><td></td><td colspan="2">TOTAL</td><td>100</td></tr>
</table>

❖ **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

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

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

M.Sc.-II Analytical Chemistry

Semester- III

Course Code	Unit	Topics	Credits	L / Week
PSC3QAC	I	Quality in Analytical Chemistry-I	4	1
	II	Sample Management system		1
	III	Laboratory Accreditation-I		1
	IV	Uncertainty in Measurement and Calibration of Instrument-II		1
PSC3AIT	I	Spectral Methods –I	4	1
	II	Spectral Methods –II		1
	III	Electroanalytical Methods		1
	IV	Miscellaneous Techniques		1
PSC3BCF	I	Bio-analytical Chemistry-I	4	1
	II	Bio-analytical Chemistry-II		1
	III	Food analysis-I		1
	IV	Food analysis-II		1
PSC3ENC	I	Chemistry of Atmosphere &Environmental legislation	4	1
	II	Water Quality Monitoring		1
	III	Monitoring of Air Pollution and Soli Pollution		1
	IV	Control of Pollution through Green Chemistry		1
PSC3POA	I	Pharmaceutical and Organic Analysis	4	1
	II	Drugs		1
	III	Forensic Analysis		1
	IV	Cosmetics Analysis		1
PSC3QAP PSC3AIP PSC3BCP PSC3ENP/ PSC3POP	-	Practical Course	8	16

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

2023-2024

M.Sc.-II Analytical Chemistry

Semester- IV

Course Code	Unit	Topics	Credits	L / Week
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
PSC4AIT	I	Spectral Methods –III	4	1
	II	Spectral Methods –IV		1
	III	Radiochemical and Thermal Methods		1
	IV	Hyphenated Techniques		1
PSC4STA	I	Effluent Treatment	4	1
	II	Solid Waste Management		1
	III	Plastics and Polymers		1
	IV	Metallurgical Analysis		1
PSC4IPR	I	Introduction to Intellectual Property Rights-I	4	1
	II	Introduction to Intellectual Property Rights-II		1
	III	Introduction to Chemoinformatics		1
	IV	Application of Chemoinformatics		1
PSC4REM	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
PSC4QAP PSC4AIP PSC4STP	-	Practical Course	8	16
PSC4IPP/ PSC3REP		Project Evaluation / Industrial Internship		

	M.Sc. ANALYTICAL CHEMISTRY SEMESTER – III PSC3QAC **Quality in Analytical Chemistry**	
UNIT 1	**Quality Management system**	**15L**
	1.1 Review of GLP 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]**	
UNIT II	**Sample Management system**	**15**
	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]**	
UNIT III	**Laboratory Accreditation- I**	**15**
	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), Q3Ato Q3D (Impurities) Q6Ato Q6B (Specifications) Q10 (Pharmaceutical Quality System) ICH guidelines – Quality Risk assessment Q 9. **[7L]**	
UNIT IV	**Uncertainty in Measurement and Calibration of Instrument**	**15**
	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 2.1 and 2.2). **[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]**	

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SEMESTER-III
PSC3AIT
Advanced Instrumental Techniques

UNIT I	**Spectral Methods I**	**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]** Low-Energy Ion Scattering and Rutherford Backscattering **[4L]**	
	1.3 Atomic Emission Spectroscopy: electrical discharge sources **[2L]**	
UNIT II	**Spectral Methods – II**	**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]**	
UNIT III	**Electroanalytical Methods**	**15**
	Advanced ElectroanalyticalTechniques: **3.1** Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography **[3L]** **3.2** Potential Sweep methods- Linear Sweep Voltammetry and Cyclic Voltammetry**.[3]** **3.3** Potential Step method- Chronoamperomertry **[2L]** **3.4** Controlled potential technique- Chronopotentiometry **[2L]** **3.5** Stripping Voltammetry- anodic, cathodic, and adsorption **[2L**] **3. 6** Chemically and electrolytically modified electrodes and ultra-microelectrodes in voltammetry **[3L**]	
UNIT IV	**Miscellaneous Techniques**	**15**
	1.1 Principle, Instrumentation and Applications of: Chemiluminesescence techniques**[3L**] Chirooptical Methods : ORD, CD **[5L]** Photoacoustic spectroscopy **[3L**] Spectroelectrochemistry **[4L]**	

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SEMESTER – III

PSCH3BCF

Bioanalytical Chemistry and Food Analysis

UNIT I	**Bioanalytical chemistry -I**	**15**
	1.1 Body Fluids **1.2** 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]** **1.3** Physiological and nutritional significance of vitamins (water Soluble and fat soluble) and minerals. **[5L]** **1.4** Analytical techniques (including microbiological techniques) for Vitamins. **[5L]**	
UNIT 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]**	
UNIT III	**Food Analysis - I**	**15**
	3.1 Fuel value of food and importance of food nutrients **[2L]** **3.2** General idea about Food processing and preservation; Food Additives: Legislation**. [3L]** Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. Analysis of food for additives. **[5L]** Determination of SO_2, nitrate and nitrites; determination of ascorbic acid; identification and determination of saccharine and identification of colors in food, natural colours **[5L]** **3.3** 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. **[8L]**	
UNIT IV	**Food Analysis - II**	**15**
	4.1 Aspects of food safety: HACCP, GMP, role of FDA, Agmark, ISI Concept of sanitation and hygienic production of food **[6L]** **4.2 Food packaging**: Introduction, types of packing materials, and industrial requirements. **[2L]**	

	4.3 Analysis of Milk: Fat content, proteins, acidity, bacteriological quality and milk adulterants. **[2L]** acid value, sap value, iodine value. Determination of rancidity and antioxidants**. [2L]** **4.5 Analysis of spices:** cloves, cinnamon, pepper, mustard Determination of volatile oils and fixed oils. **[3L]**	

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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.
5. Food Analysis: Theory and practice, Yeshajahu Pomeranz, Clifton E. Meloan, Springer.
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8. Food Analysis, Edited by S. Suzanne Nielsen, Springer
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SEMESTER-III

PSC3ENC

Environmental Chemistry

UNIT I	**Chemistry of atmosphere & Environmental legislation**	**15**
	1.1 Atmosphere, nitrogen, hydrogen, halogen, sulphur, carbon containing compounds in the atmosphere. **[2L]** **1.2** Ozone Chemistry, Evolution of ozone layer, Chemical and photochemical Processes. **[2L]** **1.3** Sources and sink of Chlorofluorocarbons and UV radiations Photochemical smog-Effects and control. **[2L]** **1.4** Carbon credit and global issues related to environmental pollution. **[2L]** **1.5** Pollutants in the environment and their sources; general classifications of pollutants and their chemical structures, properties, toxicity. **[2L]** **1.6** Environmental Impact Assessment: Environmental Impact Assessment process in India [2L] **1.7** Environmental Legislation: role and responsibilities of pollution control boards, Motor Vehicle Act and method of analysis with respect to PUC. **[3L]**	
UNIT II	**Water quality Monitoring**	**15**
	Water: Types – Potable water, Waste water **2.1 Potable water** Quality and requirements of potable water, direct and indirect pollutants for potable water reservoirs Regulatory requirements for packaged drinking water. **[7L]** **2.2 Waste water** Sources of water, Constituents – Microorganisms; Solids; Inorganic pollutants, Organic pollutants, Pollution indicators – DO, BOD, COD, pH, Suspended solids, Waste water treatment **[8L]**	
UNIT III	**Monitoring of Air pollution and soil pollution**	**15**
	3.1 Monitoring of Air pollution: Sampling methods for air, flew gas ,industrial exhaust, stag samples etc. **[3L]** **3.2** Importance of automobile exhaust control and its limits**[3L]** **3.3** Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors. **[3L]** **3.4** Monitoring of air pollutants by Instrumental Methods-Control of air pollution by raw material change, process modification, adsorption, absorption and combustion methods. **[3L]** **3.5 Soil pollution:** Soil fertility, Sources of soil pollution, effect of pollution on soil fertility. Pollution indicators and their determination. **[3L]**	

UNIT IV	**Control of pollution through Green Chemistry**	**15**

	4.1 Green Chemistry Basic principles of Green Chemistry, Definition, Design aim and Principles of Green Chemistry**. [3L]** **4.2 Green catalysts** Role of green catalyst in Green Chemistry, Enzymes as green catalysts. Green catalysis for Chemical transformation. **[4L]** **4.3 Green synthesis** Methods of Green Synthesis, Applications of Green Synthesis, Green Synthesis of Nanoparticles. **[3L]** **4.4 Green solvents** Sustainable solvent in Chemical Processes, Types of Green Solvent Applications of Green Solvent**. [4L]** **4.5 Environmental Audits:** concept of audit, authorities, evaluation methodology, benefits and certification **[2L]**	

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18. Pesticide Analysis Ed K. G. Das, Dekker (1981)
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20. Soil and plant Analysis C.S Piper , Hans Publication
21. Green chemistry and catalyst, R. A. Sheldon, Isabella Arends, Ulf Hanefeld Wiley VCH verlag GmBH & co.

SEMESTER – III

PSC3POA

Pharmaceutical and Organic Analysis

UNIT I	**Pharmaceutical Analysis**	**15**
	1.1 General idea regarding the Pharmaceutical Industry, introduction to pharmaceutical formulations and novel drug delivery system, classification of dosage forms. Role of FDA in pharmaceutical industries, Pharmacopeia. **[7L]** **1.2** Standardization and quality control of raw material and finished product Assay as per IP i) adrenaline, ii) Cephalexin, iii) ferrous fumarate, iv) paracetamol. **[8L]**	
UNIT II	**Drugs**	**15**
	2.1 Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests. **[8L]** **2.2** Limit tests, Sources of impurities and impurity profiling, solubility tests, disintegration tests, stability studies, bioequivalence and bioavailability studies. **[7L]**	
UNIT III	**Forensic Science**	**15**
	3.1 Analytical Chemistry in Forensic Science: General idea. **[2L]** **3.2** Forensic Serology & DNA Analysis **3.3 Blood**: Blood preservation, bloods stain analysis. **3.4 DNA Analysis**: RELP & PCR **3.5**Hair analysis: Structure and composition of hair, morphological examination, Chemical analysis of hair components and components remaining on or in hair. **3.6 Alcohol in body fluids:** Sampling and sample preservation, analysis - GC, IR, enzymatic and other methods **[5L]** **3.7Analytical Toxicology:** Isolation, identification and determination of: 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. **[8L]**	

UNIT IV	Cosmetic Analysis	15
	4.1 Cosmetics: Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis. **[2L]** **4.2 Deodorants and antiperspirants:** Al, Boric acid, chlorides, sulphates, and methanamine. **[3L]** **4.3 Face powder:** Ti, Fe, oxides of Ti, Fe and Al (total). **[2L]**	
	4.4 Hair tonic: 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers) **[5L]** **4.5 Creams and Lotions:** Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) **[3L]**	

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14. Manual of Medical Laboratory Techniques, S Ramakrishnan and K N Sulochana, Jaypee BrothersMedical Publishers (P) Ltd, 2012.
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19. AOAC volume I and II.

SEMESTER-III PRACTICALS
PSC3QAP

1. Determination of the pK value of an indicator.
2. Canned food: Limits test for tin/zinc
3. Estimation of strong acid, weak acid and salt in the given mixture conductometrically.
4. Determination of percentage purity of methylene blue indicator.
5. Spectrophotometric Determination of Fe in Water Sample using Standard Addition Method.

PSC3AIP

1. Estimation of fluoride in a tooth paste spectrophotometrically.
2. Estimation of Vitamin C in lemon Juice/squash by colorimetric method.
3. Analysis of mixture of carbonate and bicarbonate (present in ppm range) using pH metry.
4. Estimation of Na+ in dairy whitener by flame photometry.
5. Spectrophotometric determination of pH of buffer solution.
6. Estimation of micronutrient from food by AAS (any two elements such as Fe, Cu, Zn, Mo, B, Mn) [Demonstration]

PSC3BCP

1. Estimation of amino acid by Ninhydrin method (Spectrophotometrically).
2. Analysis of lactose in milk
3. Estimation of Caffeine in tea
4. Estimation of Iodine value of oil / fat
5. Estimation of cholesterol and uric acid in given blood sample.
6. Estimation of Protein by Biuret Method.(Colorimeter)

PSC3ENP/ PSC3POP

1. Estimation of drugs by non-aqueous titration: Pyridoxine hydrochloride, Sulphamethoxazole.
2. Analysis of water sample: Acidity and sulphate (Benzidine method).
3. Analysis of smear of lipstick on the napkin and its identification by comparing with lipstick samples.
4. Determination of nicotine content in cigarette tobacco.
5. Estimation of Ca in Ca-pentathonate/calcium lactate tablets
6. Analysis of Aspirin/paracetamol as per IP with respect to identification and assay.

NOTE:

1. The candidate is expected to submit a journal certified by the Head of the Department / institution at the time of the practical examination.
2. 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.
3. The list of the experiments performed by the candidate should be attached with such certificate.
4. Use of non-programmable calculator is allowed both at the theory and the practical examination.

SEMSTER-IV

PSC4QAC

Separation Techniques

UNIT I	**Separation Techniques - I**	**15**
	3.1 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]** **3.2 Ion chromatography:** Principle, instrumentation with special reference to Separation and suppressor columns, applications. **[2L]** **3.3 Exclusion chromatography:** Theory, instrumentation and applications of gel permeation chromatography, retention behaviour, inorganic molecular sieves, determination of molecular weight of polymers. **[5L]** **3.4 Affinity Chromatography:** principle, instrumentation and applications Optimum pressure liquid chromatography (OPLC) **[3L]**	
UNIT II	**Separation Techniques - II**	**15**
	2.1Membrane 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]**	

UNIT III	**Separation, Analysis and Standardization of Herbal based products**	**15**
	3.1: Herbs as a raw material: Defination 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 toxicogical standardization, qualitative and quantitative estimations**. [6L]**	
UNIT 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.**[5]**	

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8. Analytical Chemistry, G. D. Christain, Wiley
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SEMESTER-IV

PSC4AIT

Advanced Instrumental Techniques

UNIT I	**Spectral Methods III**	**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 imagin**: principal instrumentation and applications of MRI **[3L]** **1.3** Application of NMR to other nuclei C^{13}, P^{31} and F^{19} spectroscopy **[3L]**	
UNIT II	**Spectral Methods IV**	**15**
	2.1Mass 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(SERS and Resonance Raman) and Applications of Raman spectroscopy **[6L]** **2.3 Spectrofluorimetry and Phosphorimetry [4L]**	
UNIT 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]**	
UNIT IV	**Hyphenated Techniques**	**15**
	4.1 Concept of hyphenation, need for hyphenation, possible hyphenations. **[2 L]** **4.2** Principle, Interfacing , instrumentation and Applications of GC – MS, ICP –MS, GC – IR, Tandem Mass Spectrometry, LC – MS: HPLC-MS, CE-MS. **[13L]**	

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10. A Complete Introduction to Modern NMR Spectroscopy 1st Edition by Roger S. Macomber
11. Spectrometric Identification of Organic Compounds Hardcover – by Robert M. Silverstein Wiley
12. Tandem Techniques (Separation Science Series) 1st Edition by Raymond P. W. Scott John Wiley & Sons Ltd, 1997
13. Encyclopedia of Analytical Science, Editors-in-Chief: Paul Worsfold, Alan Townshend, and Colin Poole ISBN: 978-0-12-369397-6
14. Encyclopedia of Analytical Chemistry: Applications, Theory, and Instrumentation. Meyers Robert A Meyers
15. Introduction to Thermal Analysis Techniques and Applications Edited by Michael E. Brown
16. Principles and Applications of Thermal Analysis Edited by Paul Gabbott

SEMESTER – IV
PSC3STA
Selected Topics in Analytical Chemistry

UNIT 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** 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]**	
UNIT 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. **[2L]** **2.3** Treatment and disposal of sludge / dry cake **[3L**] **2.4** Managing non-decomposable solid wastes**[2L]** **2.5 Bio- medical waste:** Introduction, Classification and methods of disposal **[5]**	
UNIT III	**Plastics and Polymers**	**15**
	3.1 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]** **3.2** Metallic impurities in plastic and their determination. **[2L]** **3.3** Impact of plastic on environment as pollutant. **[2L]** **3.4 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]** **3.5** Role of Organo silicones in paints and their impact on environment. **[3L]**	
UNIT IV	**Metallurgical Analysis**	**15**
	4.1 Analysis of Ferroalloys: Analysis of steel, Molybdenum, Phosphorous. **4.2 Analysis of non- Ferrous alloys:** Analysis of Tin, Zinc and Copper in Brass and Bronze. **4.3** Analysis of Tin and lead in Solder. **4.4 Analysis of Cement:** Composition of Portland cement, estimation of Aluminium oxide and Ferrous oxide. Determination of Alumina in Cement by Polarography **4.3 Ore Analysis**: Iron ore- Analysis of the Constituents – Moisture, loss of ignition, Total Iron, ferrous Iron, ferric Iron, alumina, Silica, Titania, Lime, Magnesia, Sulphur, phosphorous, manganese, alkalies, combined water, Carbon in blast furnace, flue dust and sinter.	

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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.
11. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).
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SEMESTER – IV
PSC4IPR
Intellectual Property Rights & Cheminformatics

UNIT I	**Introduction to Intellectual Property-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]**	
UNIT – II	**Introduction to Intellectual Property-II**	**15**
	2.1Trade 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]** **2.3Economic Value of Intellectual Property:** Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. **[3L]** **2.4Different 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]**	
UNIT III	**Introduction to Chemoinformatics**	**15**
	3.1 History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation**.[5L]** **3.2** Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification. **[5L]** **3.3** Searching Chemical Structures: Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods**.**	

	basics of computation of physical and chemical data and structure descriptors, data visualization**. [5L]**	
UNIT – IV	**Applications of Chemoinformatics**	**15**
	Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target, Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand based and Structure based Drug design, Application of Cheminformatics in Drug Design**.[15L]**	

SEMESTER – IV
PSC4REM
Research Methodology

UNIT I	**Research and Literature Survey**	**15**
	1.1Scientific Research: Research: Definition, types, Need of research. Identification of the problem, , formulating the objectives, Hypotheses, Research Methods and Methodology **1.2** Selecting & defining Research problem, Research Process Research Design: preparing Research design (experimental or otherwise), Actual investigation, Data analysis and interpretation. **[5L]** **1.3Literature survey:** Need for Literature Survey, References, Sources of literature: Primary, Secondary and Tertiary sources **1.4 Journals:** Peer-reviewed, indexed, UGC-care listed, predatory, fake journals**[3L]** **1.5** Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. **[2L]** **1.6 Digital Web sources:** 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, Chem Spider, Science Direct, SciFinder, Scopus. **[5L]**	
UNIT – II	**Data Analysis**	**15**
	2.1The 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]**	
UNIT – III	**Methods of Scientific Research and Writing**	**15**
3.1	**3.1Scientific papers**: Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.(7L) **3.2 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.(8L)	

UNIT – IV	Chemical Safety & Ethical Handling of Chemicals	15
	4.1 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.	

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2. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press.
3. Topping, J., (1984) Errors of Observation and their Treatment 4 th 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 general scientific data analysis Cambridge University Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

PRACTICALS
PSC4QAP

PSC4IPP/PSC4REP

1. Separation of cadmium and zinc on an ion exchange resin.
2. Determination of nickel by extractive photometry using dimethyl glyoxime.
3. Determination of the partition coefficient of iodine between carbon tetrachloride and water.
4. Simultaneous determination of Ti^{3+} and V^{5+} spectrophotometrically by H2O2 method.
5. Determination of percent purity of methyl alcohol by Gas chromatography.

PSC4AIP

1. Interpretation of thermograms TGA,DTA .DSC (4 sample thermograms)
2. Interpretation of spectra NMR, Mass, IR.UV visible (at least 4 sample spectra of each)

PSC4STP

1. To analyze Bronze for Zn by complexometric method.
2. Analysis of detergents: Active detergent matter and alkalinity
3. Estimation of Nitrogen from Soil sample using Kjeldahl Method.
4. Analysis of water sample : Mn^{2+} by colorimetric method
5. Analysis of Bauxite for Ti by colorimetry / Al by gravimetry / Fe (volumetry)

PSC4IPP/PSC4REP

Project Evaluation/ Industrial Internship

NOTE:

1. The candidate is expected to submit a journal certified by the Head of the Department / institution at the time of the practical examination.
2. 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.
3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

UNIVERSITY OF MUMBAI

Janardan Bhagat Shikshan Prasarak Sanstha's

Changu Kana Thakur

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

Re-accredited A^+ Grade by NAAC

'College with Potential for Excellence 'Status Awarded by UGC

'Best College Award' by University of Mumbai

Programme: M.Sc.

(Choice Based Credit System)

Total Credits:96

Course: Organic Chemistry

Programme Code: MSCOC1018

Syllabus for Semester III and IV

(Approved in the Academic Council Meeting held on 27/06/2023)

(To be implemented from the Academic Year 2023-2024)

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 teacher.

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 andemerging 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 tosucceed 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 No.	After completing the programme in M.Sc. Organic Chemistry, Student will able to:	Graduate Attribute
PSO1	Develop analytical thinking and apply the same for understanding principles, proposing mechanism and logical conclusions, understanding of 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 synthetic division of chemical, pharmaceutical, dyestuff and food industries	Research skills
PSO3	Competency in design and planning of synthesis and carry out with Good Laboratory Practices, handling instruments and interpretation of spectral data for structure determination of organic compounds	Research skills

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 2023-24

SEMESTER III

Course Code	Unit	Topics	Credits	L/Week
PSC3TOC	I	Organic Reaction Mechanisms	4	1
	II	Pericyclic Reactions		1
	III	Stereochemistry-I		1
	IV	Photochemistry		1
PSC3SOC	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
PSC3NPHS	I	Natural products-I	4	1
	II	Natural products-II		1
	III	Heterocyclic compounds-I		1
	IV	Advanced Spectroscopic Techniques -I		1
PSC3MBG	I	Drug discovery, design and development	4	1
	II	Drug design, development and synthesis		1
	III	Biogenesis and biosynthesis of natural products		1
	IV	Green chemistry		1
PSC3BIC	I	Biomolecules-I	4	1
	II	Biomolecules-II		1
	III	Biomolecules-III		1
	IV	Biomolecules-IV		1
PSC3TOP & PSC3SOP		Practical	4	8
PSC3NPP & (PSC3MBP or PSC3BIP)		Practical	4	8

SEMESTER IV

Course Code	Unit	Topics	Credits	L/Week
PSC4TOC	I	Physical Organic Chemistry	4	1
	II	Supramolecular Chemistry		1
	III	Stereochemistry-II		1
	IV	Asymmetric Synthesis		1
PSC4SOC	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
PSC4NPHS	I	Natural products-III	4	1
	II	Natural products-IV		1
	III	Heterocyclic compounds-II		1
	IV	Advanced Spectroscopic Techniques -II		1
PSC4IPR	I	Introduction to Intellectual Property	4	1
	II	Trade Secrets		1
	III	Introduction to Cheminformatics		1
	IV	Applications		1
PSC4RMT	I	Print	4	1
	II	Data Analysis		1
	III	Methods of scientific research and writing scientific papers		1
	IV	Chemical Safety & Ethical Handling of Chemicals		1
PSC4TOP & PSC4SOP		Practical	4	8
PSC4NPP0 & (PSC4IPP or PSC4RMP)		Practical	4	8

1. Credit based semester and grading system with effect from the academic year 2023-2024.
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 per theory paper and 2 credits per practical per semester.
4. At the end of each semester each student will be examined both in the theory and in the practical.
5. 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.
6. The candidate is expected to submit a journal certified by the Head of the Department /institution at the time of the practical examination.
7. 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.
8. 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

Internal Theory examination (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 of student	05 Marks

There will not be any internal examination for practical.

External Theory Examination (60 Marks)

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

Semester End Practical Examination (50 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 on each day.

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
III	Day-2 Morning	01	3.5	50
IV	Day-2 Evening	01	3.5	50

M.Sc. Organic Chemistry
Semester III
Course Code - PSC3TOC
Paper I- Theoretical Organic Chemistry-I

Course Outcomes

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

Unit	Course Description	Hrs
1	**Organic reaction mechanisms**	
	1.1 Organic reactive intermediates: Methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes**. (6L)** **1.2 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]**	**15**

	1.3 Role of FMOs in organic reactivity: Reactions involving hard and soft electrophiles and nucleophiles, alpha effect. **[2L]** **1.4 Pericyclic reactions:** Introduction and classification of pericyclic reaction. Thermal and photochemical reactions. Recapitulation Explanations for Woodward- Hoffmann Rules The Aromatic Transition structures [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]**	
2	**Pericyclic reactions**	
	2.1 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, Ketenes, 1,3-Dipolar cycloadditions and cheletropic reactions. **[7L]** **2.2 Electrocyclic reactions:** Conrotatory and disrotatary motions, torquoselectivity, (4n) π and (4n+2) π electrons and allyl systems. Synthesis of endiandric acid A from an acyclic polyene. **[3L]** **2.3 Sigmatropic rearrangements:** H-shifts and C- shifts, supra and antarafacial migrations, Alder 'ene' Reaction, Cope (including oxy-Cope and aza- Cope), Claisen and Sommelet-Hauser rearrangements. Synthesis of Citral from 3-methylbut -2-en-1-ol and 3-methylbut-2-en1a0l. **[5L]**	**15**

3	**Stereochemistry-I**	**15**
	3.1 Steric effect of S_N2 and Ez 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 LiAlH4, selectride and MPV reduction) and oxidation of cyclohexanols**. [5L]** 3.3 Stereospecific and Stereoselective reactions with specific examples. [**2L]**	
4	**Photochemistry**	**15**
	4.1 Principles of photochemical reaction: Grotthuss draper law,Stark - Einstein law, Beer- Lambert law, Types, Examples and Applications of photochemical reaction, experimental set up for photochemical reactions. **[3L]** **4.2 Photochemistry of carbonyl compounds:** $\pi \rightarrow {}^{'}\pi^*$, $n \rightarrow {}^{'}\pi^*$ transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of α, β- unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction, DeMayo reaction. **[7L]** **4.3 Photochemistry of olefins:** cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di- π- methane	

	rearrangement including oxa- di-π--methane and aza-di-π--methane. Photochemical Cross-Coupling of Alkenes, Photodimerisation 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. **[IL]**	

REFERENCES:

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2. A guide to mechanism in Organic Chemistry, 6th 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

15. Pericyclic Reactions, S. Sankararaman, Wiley VCH, 2005.
16. Advanced organic chemistry, Jagdamba Singh L. D. S. Yadav, Pragati Prakashan, 2011
17. Pericyclic reactions, Ian Fleming, Oxford University press, 1999.
18. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.
19. Organic chemistry, 8th edition, John McMurry.
20. Modern methods of Organic Synthesis, 4th Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004.
21. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books,2006
22. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman
23. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd.
24. Stereochemistry of Organic Compounds, Ernest L. Eliel and SamuelH. Wilen, Wiley-India edit
25. Stereochemistry, P. S. Kalsi, 4th edition, New Age International Ltd
26. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005
27. Bioorganic, Bioinorganic and Supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers
28. Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH.
29. Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992.
30. Large ring compounds, J.A.Semlyen, Wiley-VCH, 1997.
31. Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wiley-Eastern
32. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Sciertific Publication.
33. Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
34. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill
35. Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
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 Code- PSC3SOC
Paper II - Synthetic Organic Chemistry –I

Course Outcomes

COS.	After successful completion of this 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-metalsin 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 describe the mechanisms showing how the products are formed	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, Koch- Haaf Carbonylation reaction, Eschenmoser-Tanabe frangmentation. **[5L]** **1.2 Domino reactions:** Characteristics; Nazerov cyclization **[3L]** **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.	**15**

	[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. Oxidative coupling, C-C bond formation in aromatics: SRNAr reactions **[4L]** **2.5** Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation. **[3L]**	
3	**Enamines, Ylides and α-C-H functionalization**	
	3.1 Enamines: Generation & application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison 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-	**15**

	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]** **Selenium in organic synthesis:** Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and seleno acetals as α-C-H activating groups **4.5 [2L]**	**15**

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Course code - PSC3NPHS
Paper III- Natural products Heterocyclic chemistry and Spectroscopy-I

Course Outcomes

COS.	After successful completion of this 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 Product-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 Cyanin (with synthesis). **(4L)** **1.3: Terpenoids:**Occurrence, classification, Stereochemistry, spectral data and synthesis of zingiberene. **(2L)**	**15**

	1.4: Alkaloids: Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of morphine. **(3L)** Medicinal impotance of hygrine, quinine, and reserpine. **(1L)**	
2	**Natural Product-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 andIsobutylene 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 Regulator**s: 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)	**15**

	(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)**	
4	**Advanced Spectroscopy-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. **(6L)** **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:** Introduction of Mass Spectroscopy. **(1L)** **4.4:** Spectral problems based on UV, IR, ^{1}HNMR and ^{13}CNMR and Mass Spectroscopy. **(4L)**	**15**

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41. Structure Determination of Organic Compounds, E Pretsch, P. Buhlmann, C. Affolter, Springer

Course code - PSC3MBG
Paper IV- Medicinal, Biogenesis and Green Chemistry

Course Outcomes

COS.	After successful completion of this course Students will be able to..,	Bloom Taxonomy Level (BTL)
CO1	Demonstrate the knowledge of the twelve principles of green chemistry which they can practice to a range of workplace for a safer less toxic and healthier environment.	Understand
CO2	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
CO3	Apply skills required for drug design, development of modern methods of synthesis required for employment in the pharmaceutical industries.	Apply
CO4	Build the Biogenesis and biosynthesis of natural products by acetate pathway, shikimate pathway and mevalonate it pathway.	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, Librium2.3 Lead	**15**

	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)	
2	**Drug design, development 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 enzymeinhibition (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**
3	**Biogenesis and biosynthesis of natural products**	
	3.1: Primary and secondary metabolites and the building blocks, general pathway of amino acid	**15**

	biosynthesis.(1L) 3.2: Acetate pathway: Biosynthesis of malonyl CoA, saturated fatty acids, prostaglandins from arachidonic acid, aromatic polyketides (3L) 3.3: Shikimic Acid pathway: Biosynthesis of shikimic acid, aromatic amino acids, cinnamic acid and its derivatives, lignin and lignans, benzoic acid and its derivatives, flavonoids and isofalvonoids. (4L) 3.4 Mevalonate pathway: Biosynthesis of mevalonic acid, monoterpenes-geranyl cation and its derivatives, sesquiterpenes-farnesyl cation and its derivatives, triterpenes, tetraterpenes and its derivatives diterpenes. (7L)	
4	**Green chemistry**	
	4.1: Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and reaction conditions, green catalysts.(1L) **4.2: 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 e) Microwave assisted synthesis : reactions in water, reactions in organic solvents, solvent free reactions. e) Surfactants for carbon dioxide- replacing smoke producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.	**15**

	f) An efficient green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.(11L) Ultrasound assisted reactions. **4.3:** Comparison of traditional processes versus green processes in the syntheses of ibuprofen, adipic acid, 4-aminodiphenylamine, p-bromotoluene and benzimidazole. (3L)	

Course code - PSC3BIC
Paper IV- Bioorganic Chemistry

Course Outcomes

COS.	After successful completion of this 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
CO3	Relate the importance of enzymes in the synthesis of organic compound.	Understand
CO4	Explain biological importance and metabolism of carbohydrates and lipids.	Evaluate

Unit	Course Description	Hrs
1	**Biomolecules-I**	
	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]**	15

2	**Biomolecules-II**	
	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]	**15**
3	**Biomolecules-III**	
	3.1 Chemistry of coenzymes. Structure, mechanism of action and bio-modeling studies of the following coenzymes: nicotinamide adenine dinucleotide, flavin adenine dinucleotide, thiamine pyrophosphate, pyridoxal phosphate, Vitamin B12, biotin, lipoic acid, Coenzyme A. [12L] 3.2 Oxidative phosphorylation, chemiosmosis, rotary model for ATP synthesis and role of cytochrome in oxygen activation.[3L]	**15**
4	**Biomolecules-IV**	
	4.1 Carbohydrates: Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and lactic acid fermentation, Krebs cycle. [8L] 4.2 Lipids: Biological importance of triglycerids and phosphoglycerides and cholesterol: Lipid membrane, Liposomes and their biological functions and underlying applications. [7L]	**15**

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Semester III: Practicals

Course code: PSC3TOP

Course Outcomes

COS.	After successful completion of this course Students will be able to..,	Bloom Taxonomy Level (BTL)
CO1	Identify the chemical type of components present the in ternary mixture oforganic compounds.	Apply
CO2	Apply skills in detection, identification and separation of organiccompounds of ternary mixtures by microscale technique.	Apply

Separation of a ternary mixture of organic compounds using micro-scale technique (minimum 8 experiments)

1. 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.

Course code: PSC3SOP

Course Outcomes

COS.	After successful completion of this course Students will be able to..,	Bloom Taxonomy Level (BTL)
CO1	Identify the chemical type of components present the in ternary mixture oforganic compounds.	Apply
CO2	Demonstrate the practical aspects in the preparation of the organiccompounds and their derivatives	Understand

Identification of any unknown organic compound with preparation, purification and determination of physical constant of its derivatives.

Course code: PSC3NPP & (PSC3MBP or PSC3BIP)

Course Outcomes

COS.	After successful completion of this 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 vacuumdistillation for purification of the organic compounds	Apply
CO3	Identify the prepared organic compounds by Thin Layer Chromatography	Apply

Single step organic preparation (1.0 g scale) involving purification by Steam distillation / Vacuum distillation or Column chromatography (Minimum 8 experiments)

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)
13. Preparation of cinnamic acid from benzaldehyde. (purification by column chromatography)

Note:

1. Students are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and **safety aspects including MSDS** (ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.
2. Students are expected to purify the product by Steam distillation / Vacuum distillation or Column chromatography, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

References for Practicals:

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2. Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd
3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
5. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
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.
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11. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
12. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

Important Note:

1. The candidate is expected to submit a journal and project certified by the Head of the Department /institution at the time of the practical examination.
2. 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.
3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

Semester IV

Course Code - PSC4TOC
Paper I- Theoretical Organic Chemistry-II

Course Outcomes

COS.	After successful completion of this 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**	
	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]** Uses of Hammett equation, deviations from Hammett equation. Dual parameter correlations, Inductive substituent constants, Calculation of k values, Taft equation, Solvent effects, Grunwald-	**15**

	Winstein equation, General tools for mechanistically studies of organic reactions, e.g. crossover experiments (intramolecular or intermolecular reaction) and isotope labelling experiments **[6L]**	
2	**Supramolecular chemistry**	
	Principles of molecular associations and organizations as exemplified in biological macromolecules like nucleic acids, proteins and enzymes. **[2L]**	**15**
	Synthetic molecular receptors: receptors with molecular cleft, molecular, tweezers, receptors with multiple hydrogen sites. **[3L]**	
	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]**	
	Molecular recognition, Molecular interactions and catalysis, molecular self-assembly. Supramolecular Polymers, Gelsand Fibers. **[4L]**	
3	**Stereochemistry- II**	
	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]** 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]**	**15**

	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]**	
	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]**	
4	**Asymmetric synthesis**	
	Principles of asymmetric synthesis: Introduction, the chiral pool in Nature, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions. **[2L]**	**15**
	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]**	

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2. A guide to mechanism in Organic Chemistry, 6th 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.
15. Pericyclic Reactions, S. Sankararaman, Wiley VCH, 2005.
16. Advanced organic chemistry, Jagdamba Singh L. D. S. Yadav, Pragati Prakashan, 2011
17. Pericyclic reactions, Ian Fleming, Oxford University press, 1999.
18. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.
19. Organic chemistry, 8th edition, John McMurry
20. Modern methods of Organic Synthesis, 4th Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004
21. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books,2006
22. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman
23. Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A john Wiley and Sons, Ltd., Publication)
24. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd.
25. Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley-India edit
26. Stereochemistry, P. S. Kalsi, 4th edition, New Age International Ltd
27. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005
28. Bioorganic, Bioinorganic and Supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers

29.Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH.
30Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992.
31Large ring compounds, J.A. Semlyen, Wiley-VCH, 1997.
32.Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wiley-Eastern
33.Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
34.Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
35.Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill
36.Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
37.Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.

Course Code- PSC4SOC
Paper II- Synthetic Organic Chemistry-II

Course Outcomes

COS.	After successful completion of this course Students will be able to..,	Bloom Taxonomy Level (BTL)
CO1	Explain the concepts of retrosynthesis, protecting groups, syntheticplanning and selective transformations in organic synthesis.	Understand
CO2	Apply disconnection approach, FGI, FGA, FGR and recognize startingcompounds 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	**15**

	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]**	
2	**Designing Organic Synthesis-II** **2.2** One group C-C Disconnections: Alcohols (including stereoslectivity), carbonyls (including regioselectivity), Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. **[7L]** **2.3** 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]** **2.4 Application of the above in the synthesis of some complex:** Camphore, Longifolene, Cortisone, Vitamin D, Aphidicolin. **(5L)**	
3	**Electro-organic chemistry and Selected methods of Organic synthesis**	

	3.1 Electro-organic chemistry: 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. **[7L]** **3.2 Selected Methods of Organic synthesis** Applications of the following in organic synthesis: 3.2.1 Crown ethers, cryptands, micelles, cyclodextrins, catenanes. 3.2.2 Pd catalysed cycloaddition reactions: Stille reaction, Saeguse-Ito oxidation	**15**
	to enones, Negishi coupling. **[4L]** **3.3** Epoxidation: mCPBA, BuOOH, H_2O_2, Dimethyldioxirane, Potassium peroxomonosulphate and aziridination. **(4L)**	
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]** **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]**	15

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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.
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5. Modern Organic Synthesis: An Introduction, G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, (2007).
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8. Organic Chemistry, 7th Edn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
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10. Advanced Organic Chemistry: Reactions & Mechanisms, 2nd Edn., B. Miller & R. Prasad, Pearson
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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 Code- PSC4NPHS
Paper III- Natural products Heterocyclic chemistry and Spectroscopy

Course Outcomes

COS.	After successful completion of this course Students will be able to..,	Bloom Taxonomy Level (BTL)
CO1	Explain occurrence, classification, structural and stereochemical featuresof 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 requiredfor heterocyclic compounds in research and industry and explain the names of	Apply
	heterocycliccompounds by IUPAC nomenclature and replacement nomenclature.	
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 Product-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,	15

	grandisol from 2- methyl-1, 3-butadiene**.** Pheromones-production, and their use in pest surveillance and management of pests. Merits and demerits in using 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 Product-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 esterof 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)	

3	**Heterocyclic Chemistry-II** 4.1 : 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) 4.2 : Structure, reactivity, synthesis and reactions of quinoline, indole, coumarines, benzimidazoles, benzthiazoles, quinoxaline, benzofuran, benzothiophene. (10L) Structure elucidation of quinoline and isoquinoline.(2L)	**15**
4	**Advanced Spectroscopic Techniques-II** 3.1 : 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) 3.2 : Spectral problems based on UV, IR, 1HNMR, 13CNMR (Including 2D technique) and Mass spectroscopy. (5L)	**15**

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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.
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16. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.
17. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.

18. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the mericas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
19. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers, 1998.
20. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers, 1998.
21. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.
22. Comprehensive Organic Chemistry by Barton and Olis, Pergamon Press, Oxford, 1979.
23. Medicinal Natural Products, a Biosynthetic Approach, Derick Paul, John Wiley and Sons, 2002.
24. Biosynthesis of Natural Products, Mannitto Paolo, Ellis Horwoocl Limited, 1981.
25. Selected Organic synthesis, Ian Fleming, John Wiley and Sons, 1973.

Course Code- PSC4IPR
Paper IV- Intellectual Property Rights & Cheminformatics

Course Outcomes

COS.	After successful completion of this 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
CO3	Summarise the various models of cheminformatics.	Understand
CO4	Apply the knowledge of cheminformatics to predict the properties of compounds, structures and drug designing.	Apply

Unit	Course Description	Hrs
1	**Introduction to Intellectual Property-I**	
	1.1 Introduction to Intellectual Property: 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 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 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 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	**15**

	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)	
3	**Introduction to Cheminformatics**	
	3.1 History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation. (5L) 3.2 Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.(5) 3.3 Searching Chemical Structures: Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.(5L)	**15**
4	**Applications of Cheminformatics**	
	Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand based and Structure based Drug design, Application of Cheminformatics in Drug Design. (15L)	**15**

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2. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley–VCH
3. Gupta, S. P. *QSAR and Molecular Modeling.* Springer-Anamaya Pub.: New Delhi.

Course Code- PSC4RMT
Paper IV- Research Methodology

Course Outcomes

COS.	After successful completion of this course Students will be able to..,	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,	

	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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Semester IV: Practicals

Course code: PSC4TOP & PSC4SOP

Course Outcomes

COS.	After successful completion of this 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

Two steps preparations (Minimum 8 experiments)

1	Acetophenone → Acetophenone phenyl hydrazine → 2-phenyl indole.
2	2-naphthol → 1-phenyl azo-2-naphthol → 1-amino-2-naphthol.
3	Cyclohexanone → Cyclohexanone oxime → Caprolactum.
4	Hydroquinone → hydroquinone diacetate → 2,5-dihydroxyacetophenone.
5	4-nitrotoluene → 4-nitrobenzoic acid → 4-aminobenzoic acid.
6	*o*-nitroaniline → *o*-phenylene diamine → Benzimidazole.
7	Benzophenone → benzophenone oxime → benzanilide.
8	*o*-chlorobenzoic acid → N-phenyl anthranilic acid → acridone.
9	Benzoin → benzil → benzilic acid.
10	Phthalic acid → phthalimide → anthranilic acid.
11	Resorcinol → 4-methyl-7-hydroxy coumarin → 4-methyl-7-acetoxy Coumarin.
12	Anthracene → anthraquinone → anthrone.
13	Acetophenone-→Oxime-→ Acetanilide.
14	Acetanilide -→ pBromoacetanilide-→ pBromoaniline.
15	Chlorobenzene-→ 2,4-dinitrochlorobenzene-→ 2,4-dinitrophenol.

Note:

1. Students are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and **safety aspects including MSDS** ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.
2. Students are expected to purify the product by recryllization, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

Session-I:

Course code: PSC4NPP & (PSC4IPP or PSC4RMP)

Course Outcomes

COS.	After successful completion of this course Students will be able to..,	Bloom Taxonomy Level (BTL)
CO1	Interpret spectral data like FT-IR, ^{13}C NMR, $^{1}HNMR$, UV-Visible spectrum and Mass spectrum for structure elucidation of organic compound	Evaluate

CO2	Analyze the print and digital resources critically to formulate the research problem, argue and justify the statements	Analyse
CO3	Apply the existing methodologies or develop a new methodology to address the research problem	Apply
CO4	Interpret the results and structures it to communicate via dissertation, and oral presentation by following ethical guidelines	Evaluate

Combined spectral identification: Interpretation of spectral data of organic compounds (UV, IR, PMR, CMR and Mass spectra).

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. **(**Minimum 8 spectral analysis)

Session-II: Project evaluation OR Internship

References for Practicals:

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 Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
5. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
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.
11. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
12. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

Important Note:

1. The candidate is expected to submit a journal and project certified by the Head of the Department /institution at the time of the practical examination.
2. 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.
3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

Janardan Bhagat Shikshan Prasarak Sanstha's

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

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

Program: Post-Graduate Diploma in Analytical Instrumentation
Total Credits: 20

SYLLABUS

(Approved in the Academic council meeting held on--------)

Post-Graduate Diploma in Analytical Instrumentation

as per
Choice Based Credit & Grading System (60:40)
w. e. f. Academic Year 2022-23

Preface

Post Graduate Diploma in Advanced Analytical Instrumentation Programme is offered by Changu Kana Thakur Arts, Commerce and Science College, New Panvel is the initiative towards the "Skill India" and "Make in India" campaign by Hon. Prime Minister Narendra Modi. This programme is designed to cater the needs of the qualified trained analytical personnel working in Industries, laboratories, R & D centres and academic institutions. Specifically, it is useful for all the science graduates of our institute and the other institutes aspiring to get employment in industries and pursuing research as well. The chemists working in the industry need to be academically revitalised for total quality management, good laboratory practices and modern analytical instrumentation. The course will bridge the gaps and differences between industry and academic institutions. As the course is based on practical aspects of analysis including handling of highly sophisticated analytical instruments it would be able to accomplish all these targets envisaged.

The participants of this course will have knowledge sample testing, laboratory management, analysis methods, record keeping, technical writing and related activities. They will have job opportunities in Quality control, Quality assurance and R & D, Analytical Development departments / sections in the industries and onsite labs. Those who are already working in these areas will be benefitted by the programme in terms of career enhancement and growth within the organisation or at the time of switching their organisations.

Course Details

- **Course type** : P G Diploma course

- **Course Title** : Post Graduate Diploma in Advanced Analytical Instrumentation

- **Course Objectives**:
  - To Provide thorough knowledge and hands- on experience of highly sophisticated analytical instruments and laboratory techniques
  - To familiarize the students with Quality control processes, GMP, GLP etc.
  - To provide Practice based learning and improvements.
  - To train the students with skills, that can meet the requirements of industry.

- **Course Outcomes**
  After completing the program, students will be able to
  - Prepare solutions of various strength, reagents used for Instrumental analysis.
  - Analyze real sample on sophisticated analytical instruments using SOPs.
  - Demonstrate handling of troubleshooting abilities on the instruments during actual analysis.
  - Interpret chromatographic and spectroscopic analytical data.

- **Eligibility**: B.Sc. in the discipline of Chemistry; Microbiology; Biotechnology, Candidates appearing for the final year of Bachelor's degree or awaiting their results, are also eligible.

- **Intake capacity:** 20

- **Duration**: 1 Y

- **Fees:** Rs. 20000/-

- **Course coordinator**:
  Email:

- **Career opportunities:** Quality control, Quality assurance and R&D/Analytical Devlopement departments/sections of food, pharma API/Formulation Mfg, chemical industries and onsite labs. Those who are already working in these areas will be benefitted by the programme in terms of career enhancement and growth within the organisation or at the time of switching their organisations.

- COURSE STRUCTURE:

SEMESTER I					
Course	**Course Name**	**Contact hrs.**	**Marks allotted**		**Credits allotted**
			CIE	**final**	
Course1	Fundamentals of Chemical and Pharmaceutical analysis	30	40	60	02
Course 2	Advanced Spectroscopic Techniques	30	40	60	02
Laboratory 1	Practical in Spectroscopic techniques	30	50		02
Laboratory 2	Spectral analysis and Interpretation of data	30	50		02
Project	Dissertation	30	50		02
		Total	**350**		**10**

SEMESTER II					
Course	**Course Name**	**Contact hrs.**	**Marks allotted**		**Credits allocated**
			CIA	**Final**	
Course1	Quality Management system, sample management and safety in industry	30	40	60	02
Course 2	Advanced Chromatographic techniques	30	40	60	02
Laboratory 1	Practical in chromatographic techniques	30	50		02
Laboratory 2	Practical in method development and method validation	30	50		02
Industrial Training (1 to 3 months) (Report)		30	50		02
		Total	**350**		**10**

SYLLABUS

SEMESTER I

Course I : Basic Understanding of Chemical and Pharmaceutical analysis

Course No. I	**Course name Basic Understanding of Chemical and Pharmaceutical analysis**	**Course code PDAI1BCP**
Module	**Description**	**Teaching hours**
• The foundation module is designed to provide a background in analytical techniques and introduce new concepts in Quality Control and Statistics. • A crucial component of the foundation module is the introduction of Industrial Ethics and Law, which prepares students for dealing with Industrial Regulatory issues and compliance.		
1.1	Basic Understanding of Chemical and Pharmaceutical analysis	03
1.2	Evaluation of Method of Analysis, Pharmacopoeias Monographs, Routine Testing, and Verification studies, Method Development and Method Validation. - ICH guidelines for Analytical Method Validation Q2A	08
1.3	- Specialized Analytical Techniques: Karl Fischer Titrator, digital M.P./B.P. meter, Kjeldahl apparatus.	04

Course II : Advanced Spectroscopic Techniques

Course No. II	**Course name Advanced Spectroscopic techniques**	**Course code PDAI1AST**
Module	description	Teaching hours
.		
2.1	**Spectroscopic Methods**	
	- UV-VIS spectroscopy, - FTIR spectroscopy,	15

	- Flame photometry - Atomic absorption spectroscopy - Mass Spectroscopy	
	- Principle behind Spectroscopy. - Operation, Cleaning and Calibration of Spectroscopy Instruments. - Safety Measurements - Maintenance of instruments	

Laboratory1

Course No. **III**	**Course name** **Practical in Spectroscopic techniques**	**Course code** **PDAI1PST**
Module	description	Teaching hours
Practical Training will be provided in Analytical Techniques, Project based Techniques, Utilization of wide range of Lab Instrumentation including Spectroscopy and Chromatography.		
2.1	1. Determination of Paracetamol Tablet by UV-visible spectrophotometry 2. Determination of Metformin hydrochloride tablet by UV-visible Spectrophotometry 3. Recording of the UV Scan of the Ibuprofencompound by UV Spectrophotometry 4. Determination of P2O5 content in give n sample of phosphatic fertilizers. 5. Study of the FT-IR spectrum of Salicylic acid on FT-IR Spectrophotometer. 6. Study of the FT-IR spectrum of caffeine by FT-IR spectrophotometer. 7. Determination of Copper content in given water sample by AAS 8. Determination of Calcium in milk sample	30

Laboratory 2

Course No. **IV**	**Course name** **Practical in Spectral analysis and Interpretation of Data**	**Course code** **PDAI1PSI**
Module	description	Teaching hours
Practical Training will be provided in spectral analysis and interpretation of spectral data.		
2.1	1. Spectral analysis and Interpretation of Spectral Data	30

SEMESTER II

Course I : Quality Management system, sample management and safety in industry

Course No. **I**	**Course name** **Quality Management system, sample management and safety in industry**	**Course code** **PDAI2QMS**
Module	**Description**	**Teaching hours**
• **The foundation module is designed to provide a background in analytical techniques and introduce new concepts in Quality Control and Statistics.** • **A crucial component of the foundation module is the introduction of Industrial Ethics and Law, which prepares students for dealing with Industrial Regulatory issues and compliance.**		
1.1	Quality Management System- - Quality Assurance, - Documentation- SOPs, Manuals, Log Books, - Test Reporting - Graphs/ Spectra/ Chromatographs, Raw data interpretation.	
1.1	Sample Management - Guidelines for maintenance for reference standards and working standards	

	- Flow - Storage - Destruction	
1.3	Understanding Basic Safety Rules - Use of Primary Protective Equipment - Environment, Safety & Hazard - Importance of Good Laboratory Practices (GLP) while working in the Laboratory.	

Course II : Advanced Chromatographic techniques

Module	description	Teaching hours
Practical Training will be provided in Analytical Techniques, Project based Techniques, Utilization of wide range of Lab Instrumentation including Spectroscopy and Chromatography.		
2.1	**Chromatography Methods**	
	- Gas chromatography, - High performance liquid chromatography, - High Performance Thin Layer Chromatography	15
	- Principle behind Chromatography. - Operation, Cleaning and Calibration of Chromatographic Instruments. - Safety Measurements - Theoretical knowledge of IQ/OQ/PQ of Instrument - Maintenance of instruments	

Laboratory 1

Course No.	**Course name**	**Course code**
III	**Practical in chromatographic techniques**	**PDAI2PST**

Module	description	Teaching hours
Practical Training will be provided in Analytical Techniques, Project based Techniques, Utilization of wide range of Lab Instrumentation including Spectroscopy and Chromatography.		
	1. Separation of mixture of Benzene & Toluene by GC and study of chromatogram 2. Determination of percentage purity of Methyl Alcohol using GC 3. Assay of methyl paraben using HPLC 4. Determination of alcohol in beer sample by using GC 5. Estimation of nitrogen from given fertilizer by Kjeldahl method 6. Moisture content in pharmaceutical/food sample by Karl Fischer titration method 7. Calibration of Gas chromatography 8. Assay of Vitamin D3 by HPLC	30

Practical 2

Course No. **IV**	**Course name** **Method validation**	**Course code** **PDAI2PSI**
Module	description	Teaching hours
Practical Training will be provided in spectral analysis and interpretation of spectral data.		
2.1	1. Preparation of Mobile Phase for HPLC.& Preparation of Std Caffeine Sol'n 2. Determination of System Precision Test for Caffeine 3. To determine the linearity of a given solvent or mixture of solvents 4. Study to develop analytical method for determination of assay of pharmaceutical API by UV spectrophotometry 5. Determine the precision of chloroquine phosphate by using UV spectrophotometry	30

Industrial Visit: One industrial visit is mandatory (Pharma industry(API & Formulations), Speciality Chemicals/Pesticide/Fertillizers effluent treatmentplant, forensic lab.).: 6 Hrs

per visit

Industrial training: Students will send to industry for actual industrial training at least for 1 to 3 months, i.e. total 30 To 90 days.

- Students have to prepare a brief report on industrial visit with inputs from industrial personnel. The report will be assessed for internal evaluation

- **Reference Books**

1. Inorganic quantitative analysis by Vogel.
2. Practical HPLC analysis by Veronica Meyer
3. Instrumental methods of Analysis by Skoog, Holler and Nieman.