SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. Chemistry Semester II

Course Type	Course Code	Course Title	Teaching-Learning Scheme L-P-T	Total Notional Hours	Course credits
DSC	**P2S02NCCHE01**	Inorganic Chemistry-II	4-0-1	**120**	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Apply and analyze fundamental principles of quantum chemistry, including operator formalism, commutation relations, and model systems (particle in a box, harmonic oscillator, rigid rotor, hydrogen atom) to interpret energy levels and wave functions.

CLO2: Evaluate and predict chemical bonding and molecular properties using quantum mechanical approaches such as angular momentum theory and molecular orbital theory.

CLO3: Analyze and interpret mechanisms of inorganic reactions, including ligand substitution, electron transfer (inner and outer sphere), and photochemical processes, along with factors influencing reactivity and stability.

CLO4: Apply concepts of organometallic chemistry to explain the structure, bonding, stability, and catalytic roles of complexes involving π-bonded ligands and transition metals.

CLO5: Explain and evaluate the structure, bonding, and reactivity of non-transition element compounds and cage systems (boranes, carboranes, metal clusters, noble gas compounds) using modern bonding theories.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	**Quantum Chemistry** Commutation Relations: Angular Momentum Operators and their commutation relations; Ladder Operators and their commutation relations; Eigen Functions of the position Operator and Dirac Delta function; Eigenvalues of L2 and Lz, Projection operators; Eigenvalue equation; Particle in a One-Dimensional Box: Energy eigenvalues and wave functions, Transition energies; Harmonic Oscillator: Energy levels and zero-point energy, Angular Momentum & Rigid Rotor: Quantization of angular momentum, Rigid rotor energy levels, Degeneracy; Approximation method: Perturbation theory (First order and nondegenerate), application to hydrogen and helium atoms; Variation method and application to hydrogen atom; The Concept of tunnelling, Shape of the Barriers of tunneling	Classroom Lectures Seminars Problem-Based Learning Self-Directed Learning ICT-Enabled Learning (Digital Resources)	CLO1 CLO2
II	**Inorganic Reactions and Reaction Mechanisms** Ligand substitution reactions, Mechanism of Ligand substitution reactions, Ligand substitution in square-planar complexes, Ligand substitution in octahedral complexes, Factors affecting Ligand substitution reactions, Stereochemistry in Ligand substitution reactions, Acid and base catalyzed hydrolysis of complexes, Isomerisation and racemization of octahedral	Classroom Lectures Seminars Problem-Based	CLO3

M.Sc. Chemistry Semester II

Unit	Course Content	Learning Pedagogies*	CLO(s)
	complexes, Reactions on coordinated ligands, Methods for Determining Stability Constants of Coordination Compounds, Redox reactions, Classification of redox reactions, Reaction mechanism, Outer sphere electron transfer reactions, Inner sphere electron transfer reactions, Marcus theory, Two electron transfer reactions, Complementary and Noncomplementary reactions, Inorganic photochemical reactions, Adamson's rules, Oxidation and reduction of carbonyls.	Learning Self-Directed Learning ICT-Enabled Learning (Digital Resources)	
III	**Organometallic compounds, and Ancient Indian Metallurgy** Introduction, Classification of organometallic compounds, Main group organometallic compounds, Transition metal organometallic compounds, π-bonded organometallic compounds, Hapticity, Electron-deficient organometallic compounds, Structure of organometallic compounds, General methods of synthesis of organometallic compounds, General characteristics of organometallic compounds, Uses of organometallic compounds. Ancient Indian Metallurgy for the extraction and purification of gold, copper, iron, and zinc; traditional methods of alloy preparation (for bronze, brass, and panchaloha); and corrosion-inhibition techniques.	Classroom Lectures Seminars Problem-Based Learning Self-Directed Learning ICT-Enabled Learning (Digital Resources)	CLO4
IV	**Chemistry of non-transition elements, cage compounds** Sulfur nitrogen compounds, Binary neutral S-N compounds, SxNy compounds, S-N cations and anions Noble gas compounds: The chemistry of xenon (xenon fluorides, compounds with Xe-O bonds, xenon compounds with other elements), Cage Compounds of Non-Metal Elements, Transition Metal Clusters, Metal carbonyl and halide clusters Boranes: Boron-hydrogen compounds, preparation of neutral boron hydrides, Preparation of polyhedral borane anions, structures and bonding, properties of boranes Carboranes: Closo-carboranes, Nido- and Arachno- carboranes Carbides: salt-like carbides, Metallic carbides, covalent carbides, preparation	Classroom Lectures Seminars Problem-Based Learning Self-Directed Learning ICT-Enabled Learning (Digital Resources)	CLO5

(A) Assessment Methodologies/Tools

(A) Internal Assessment

(a) Formative assessment (30 Marks)

(a) Quiz
(b) Assignment, Self-learning, and Term work
(c) Seminar/Presentation
(d) Regularity

(b) Summative Assessment (20 Marks)

- Mid Term Examination: 20 Marks

(B) External Assessment

- Term End Examination: 50 Marks

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyze & above (A)	
I	CLO1 CLO2	30	0	1	12	13
II	CLO3	32	1	1	10	12
III	CLO4	28	1	1	10	12
IV	CLO5	30	0	1	12	13
		120	**02**	**04**	**44**	**50**

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity,	60
2	End-Semester Examination	Written Exam/Practical Exam Project Evaluation (Report, Presentation, Viva)	40

(B) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	**3**	**1**	**2**	**–**	**–**	**2**	**–**	**2**	**2**	**–**
CLO2	**3**	**2**	**3**	**1**	**–**	**2**	**–**	**2**	**2**	**–**
CLO3	**3**	**2**	**3**	**1**	**–**	**1**	**2**	**2**	**2**	**1**
CLO4	**3**	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**2**	**1**
CLO5	**3**	**1**	**2**	**1**	**–**	**1**	**2**	**2**	**2**	**2**

M.Sc. Chemistry Semester II

Values to the **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Quantum Chemistry	R. K. Prasad	1985	New Age International (P) Limited, Publishers, New Delhi
2	Quantum Chemistry through problems and solutions	R. K. Prasad	1997	New Age International (P) Limited, Publishers, New Delhi
3	Shriver & Atkins' Inorganic Chemistry	P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong	Fifth Edition/2010	Oxford University Press
4	Inorganic Chemistry	C.E. Housecroft, Alan G. Sharpe	Fourth Edition/2012	Pearson Pub.
5	Organometallic Chemistry	R.C. Mehrotra & Anirudh Singh	Second Edition/2000	New Age International (P) Limited, Publishers, New Delhi
6	Concise Inorganic Chemistry	J.D. Lee	Fifth Edition/1996	Blackwell Science Ltd.
7	Advanced Inorganic Chemistry	F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann	Sixth Edition/1999	John-Wiley & Sons, New York
8	A History of Hindu Chemistry: from the Earliest Times to the Middle of the Sixteenth Century A.D	Prafulla Chandra Ray	Volume I: 1902 Volume II: 1909	Williams and Norgate, London & Chuckervertty, Chatterjee & Co., Ltd., Calcutta
9	Rasaratna Samucchaya of Vagbhattacharya (Hindi)	Indra Dev Tripathi	2019	Chaukhambhas Sanskrit Sansthan

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Web link
1	Chemistry in India, by B. N. Sharma, Source: Academia.edu	https://www.academia.edu/49089007/Chemistry_in_India

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NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. Chemistry Semester II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	**P2S02NCCHE02**	Organic Chemistry - II	4-0-1	**120**	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Analyze the mechanisms, scope, and limitations of important organic name reactions, including Robinson annulation, Wittig and modified olefinations, Shapiro reaction, Bamford–Stevens reaction, and Julia olefination.

CLO2: Design multistep synthetic routes for alkenes and complex organic molecules using appropriate name reactions and reagents with justification based on chemo- and regio-selectivity.

CLO3: Evaluate the role of transition-metal catalysts in C–C and C–N bond-forming reactions such as Suzuki, Sonogashira, and Buchwald–Hartwig coupling reactions, including their mechanisms and synthetic applications.

CLO4: Analyze the reactivity and applications of reagents such as Grignard reagents, organolithiums, Gilman reagents, the Wilkinson catalyst, NBS, DCC, and phase-transfer catalysts in organic synthesis.

CLO5: Solve reaction mechanism and synthetic strategy-related problems using scientific conventions, and appreciate the importance of ethical practices, laboratory safety, environmentally responsible use of reagents, and Traditional Chemical Transformations involving bio-based and waste-derived materials and ancient catalytic systems from Indian Knowledge Systems.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	**Organic Name Reactions I and their applications:** Robinson ring annulation, Wittig reaction and its modifications; Peterson olefination, Dakin reaction, Pummerer Rearrangement, Shapiro reaction, Bamford Steven's reaction, Julia olefination	Interactive Lectures, Problem-Based Learning, ICT-Enabled Learning, Seminar	CLO1 CLO2 CLO5
II	**Organic Name Reactions-II and their applications:** Stork Enamine reaction, Buchwald–Hartwig amination, Suzuki coupling, Sonogashira coupling, Brown's hydroboration reactions, Vilsmeier-Haack reaction, Darzen condensation.	Interactive Lectures, Tutorial, Experiential Learning	CLO2 CLO3 CLO5
III	**Oxidizing and Reducing Reagents in Organic Synthesis:** 3.1 Oxidizing Reagents: CrO_3, SeO_2, MnO_2, Fetizon reagent, $Pb(OAc)_4$, HIO_4, DMSO, $K_3Fe(CN)_6$, DDQ, Dess-Martin periodinane, Peracid. 3.2 Reducing Reagents:	Interactive Lectures, Experiential Learning, Industrial Visit	CLO2 CLO4 CLO5

	$Al(O\text{-}^tBu)_3$, $Al(O\text{-}^iPr)_3$, Na/NH_3, Zn/HCl, N_2H_4/OH^-, complex metal hydrides, TBTH.		
IV	**Organic Chemical Transformation:** Chemical Reagents in Organic Synthesis: Trimethylsilylhalide, LDA, Wilkinson catalyst, alkyl lithium, Grignard reagent, Gilman reagent, PTC, NBS, DCC, Sulfur-ylide. Traditional Chemical Transformations: Bio-based and waste-derived chemical materials, Ancient catalytic and reactive systems.	Interactive Lectures, Problem-Based Learning, Micro-Projects, Seminar	CLO2 CLO4 CLO5

- **Weightage of Learning Efforts for External Assessment**

Unit	Aligned CLOs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Analyze & above (A)	
I	CLO1, CLO2, CLO5	32	1	2	10	13
II	CLO2, CLO3, CLO5	28	1	1	10	12
III	CLO2, CLO4, CLO5	32	1	2	10	13
IV	CLO2, CLO4, CLO5	28	1	1	10	12
		120	04	06	40	50

Assessment Methodologies/Tools

(A) Internal Assessment

(a) Formative assessment (30 Marks)

- Quiz
- Assignment, Self-learning, and Term work
- Seminar/Presentation
- Regularity

(b) Summative Assessment (20 Marks)

- Mid Term Examination: 20 Marks

(B) External Assessment

- Term End Examination: 50 Marks

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity,	50
2	End-Semester Examination	Written Exam/Practical Exam, Project Evaluation, (Report, Presentation, Viva)	50

M.Sc. Chemistry Semester II

- **CLOs – PLOs Matrix**

CLO	PLO									
	PLO1	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	3	2	3	1	-	1	-	3	1	-
CLO2	3	3	3	1	-	1	-	3	1	-
CLO3	3	3	3	1	1	2	-	3	1	-
CLO4	3	2	3	1	-	2	1	3	1	-
CLO5	3	2	3	3	1	2	3	3	2	1

Values to the CLO-PLO matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Principles of Organic Synthesis	R.O.C Norman and J. M. Coxon	3rd Ed., 1993	ELBS
2	Mechanism in Organic Chemistry	Peter Sykes	6th Ed., 1999	Orient Longman
3	Modern Methods of Organic Synthesis	W. Carruthers & Iain Coldham	4th Ed., 2004	Cambridge University Press
4	Organic Reaction Mechanism	V. K. Ahluwalia & R. K. Parashar	4th Ed., 2010	Narosa Publishing House
5	Organic Chemistry	Jonathan Clayden, Nick Greeves & Stuart Warren	2nd Ed., 2012	Oxford University Press
6	Organic Reactions and Their Mechanism	P. S. Kalsi	6th Ed., 2025	New Age International Publishers

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Advanced Organic Chemistry — NPTEL (IIT)	https://nptel.ac.in/courses/104/101/104101138/
2	Advanced Organic Chemistry II — NPTEL	https://nptel.ac.in/courses/104/101/104101137/
3	LibreTexts – Organic Chemistry (Oxidation & Reduction)	https://chem.libretexts.org/Bookshelves/Organic_Chemistry
4	Organic Chemistry Portal – Reactions by Type	https://www.organic-chemistry.org/reactions/

M.Sc. Chemistry Semester II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	**P2S02NCCHE03**	Physical Chemistry-II	4-0-1	**120**	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Analyze reaction kinetics by applying rate laws, collision theory, activated complex theory, Arrhenius equation, and different reaction mechanisms, including chain, photochemical, and oscillatory reactions.

CLO2: Evaluate complex reaction systems involving ionic reactions, kinetic salt effects, steady-state approximation, and distinguish between kinetic and thermodynamic control of reactions.

CLO3: Explain solid-state concepts, including crystal structures, Miller indices, X-ray diffraction techniques, polymorphism, and classification of solids using band theory.

CLO4: Differentiate electrical properties of materials by understanding band structure, intrinsic and extrinsic semiconductors, and applications of organic semiconductors.

CLO5: Examine principles of catalysis, including homogeneous and heterogeneous catalysis, catalytic kinetics, catalyst preparation, characterization techniques, and their applications in traditional and modern systems.

CLO6: Apply group theory concepts such as symmetry elements, point groups, matrix representations, and character tables to determine molecular properties, while relating symmetry to traditional Indian architecture and art forms.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	Chemical Dynamics: Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation, and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions. Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions), and oscillatory reactions (Belousov-Zhabotinsky reaction).	Classroom Lecture(CL), ICT-Enabled Learning(ICT), Problem-Based Learning(PBL), Seminar(S)	CLO1 CLO2
II	Solid State Chemistry: Crystal structures, Miller Indices, Bragg equation, Laue Method, Debye-Scherrer method of X-ray diffraction, Polymorphism and Its Structural Characterization Using X-Ray Diffraction Techniques, Classifications of solids: conductor, semiconductor and insulator, Band theory, Band structure of solids, Concept of Valence band, Energy gap, Intrinsic semiconductors, Extrinsic semiconductors, p-type and n-type semiconductors, organic semiconductors. **Crystalline Materials in Ancient Architecture, Magnetic Materials in Ancient India**	Classroom Lecture(CL), ICT-Enabled Learning(ICT), Problem-Based Learning(PBL), Seminar(S)	CLO3 CLO4

III	Catalysis: Types of catalysis -Homogeneous and heterogeneous, Heterogeneous catalysis and catalytic kinetics: concepts of Langmuir - Hinshelwood, Preparation and characterization of catalysts: General methods for preparation of catalysts: precipitation, sol-gel hydrothermal, impregnation, hydrolysis, vapor deposition, Activation of catalysts: size determination, etc., turnover number. **Natural Catalysts in Ayurveda, Enzyme Catalysis in Fermentation, Catalysis in Rasashastra (Ancient Indian Alchemy)**	Classroom Lecture(CL), ICT-Enabled Learning(ICT), Problem-Based Learning(PBL), Seminar(S)	CLO5
IV	Group theory: Concepts of symmetry in molecules, Symmetry elements: Proper and improper axes, mirror planes, center of inversion and identity, examples of groups, subgroups and classes, Molecular point groups: Identification and classification, Schonflies notation of point groups, matrix notations for symmetry elements: E, Cn, i, σ, Sn. Matrix representation of symmetry operations, Matrix representation point groups: product and square rule, inverse rule, matrices for C3V, C4V, etc., Construction of character tables: rules, reducible and irreducible representations, Great Orthogonality Theorem (GOT). Applications of group theory: Determination of Molecular vibrations of molecules, hybridization of molecules. **Symmetry in Indian Temple Architecture, Symmetry in Traditional Indian Arts and Rangoli, Crystallography and Symmetry in Ancient Knowledge**	Classroom Lecture(CL), ICT-Enabled Learning(ICT), Problem-Based Learning(PBL), Seminar(S)	CLO6

- **Assessment Methodologies/Tools**

(A) Internal Assessment

(a) Formative assessment (30 Marks)

- Quiz
- Assignment, Self-learning, and Term work
- Seminar/Presentation
- Regularity

(b) Summative Assessment (20 Marks)

- Mid Term Examination: 20 Marks

(B) External Assessment

- Term End Examination: 50 Marks

Unit	Aligned Cos	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/ Analyse & above (A)	
I	CLO1, CLO2	30	3	7	4	14
II	CLO3, CLO4	32	3	3	4	10
III	CLO5	28	2	7	3	12
IV	CLO6	30	2	8	4	14
		120	**10**	**25**	**15**	**50**

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity, written Internal Exam	50
2	End-Semester Examination	Written Exam/Practical Exam Project Evaluation (Report, Presentation, Viva)	50

(A) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	3	2	3	1	1	1	1	3	2	1
CLO2	3	2	3	1	1	1	1	3	2	1
CLO3	3	3	2	1	1	3	1	2	2	2
CLO4	3	2	3	1	1	2	1	3	2	2
CLO5	3	3	2	1	2	2	2	3	2	3
CLO6	3	2	3	1	1	2	1	3	2	2

Values to the **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	An Introduction to Chemical Thermodynamics	R. P. Rastogi and P. R. Misra	1995	Vikas Publishing House Pvt.Ltd.
2	Elements of Physical Chemistry	Peter Atkins, Julio De Paula, David Smith,	8th edition, 2006	Oxford University Press,
3	Physical Chemistry	Ira N. Levine	5th edition, 2002	Tata McGraw-Hill Publishing Company, New Delhi, .

4	Micelles, Theoretical and Applied Aspects	V. Moroi	1992	Plenum Press
5	Thermodynamics	P. C. Rakshit	1983	The New Book Stall, Calcutta
6	Fundamentals of Chemical Thermodynamics	M. L. Lakhanpal	1998	Tata McGraw-Hill Publishing Company, New Delhi
7	Modern Electrochemistry	J. O. M. Bockris and A. K. N. Reddy	1998	Plenum press
8	Chemical Kinetics	K. J. Laidler	1987	Mc-Graw Hill Publisher

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	**Video lectures,**	**www.swayam.gov.in,**
2	**Specially prepared reading material that**	**www.epgp.inflibnet.ac.in,**
3	**can be downloaded/printed.**	**www.ndl.iitkgp.ac.in,**
4	**Self-assessment tests through tests and quizzes.** **An online discussion forum for clearing doubts**	**www.nptel.ac.in,**

M.Sc. Chemistry Semester II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
SKILL	**P2S02NSCHE01**	Analytical Chemistry	2-0-0	**60**	02

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Critically analyze and evaluate the fundamental principles of analytical chemistry, and compare the applicability, advantages, and limitations of major analytical methods in solving complex chemical problems.

CLO2: Evaluate and design appropriate sampling strategies and analytical procedures for real-world samples, assess risks associated with chemical experiments, and critically interpret analytical data to draw scientifically valid conclusions.

CLO3: Analyze and evaluate the fundamental principles of chromatography, including mechanisms of retention and classification based on mobile phase, stationary phase, and configuration.

CLO4: Apply and interpret separation efficiency concepts using plate theory and the Van Deemter equation to optimize chromatographic performance.

CLO5: Design and critically assess chromatographic methods using Thin Layer Chromatography (TLC), Gas Chromatography (GC), and High Performance Liquid Chromatography (HPLC) for real-world analytical applications.

Unit	Course Content	Learning Pedagogies*	CO(s)
I	**Fundamental of Analytical Chemistry:** Definitions, classification of analytical techniques and importance, Classical and Instrumental methods, Factors affecting choice of analytical methods. **Verification and validation in chemical analysis:** Introduction, Fundamental definitions. Categories of validation. Quality Management System, Good laboratory practices. **SI units, validation parameters:** Accuracy, precision, mean and standard deviation, calibration, classification of errors, minimization of errors,	Classroom Lecture ICT-Enabled Learning Problem-Based Learning	CLO1, CLO2
II	**Indigenous separation methods for** Dyes and Food **Separation Methods:** Principles of chromatography, classification of chromatographic techniques based on mechanism of retention, configuration, mobile and stationary phase, Principles and applications of thin layer chromatography (TLC) and high performance thin layer chromatography (HPTLC) **Gas Chromatography, HPLC:** Principle, Introduction, instrumentation, Efficiency of separation- plate theory (theoretical plate concept) and rate theory (Van Deemter equation)	Classroom Lecture (CL) ICT-Enabled Learning	CLO3, CLO4 CLO5

M.Sc. Chemistry Semester II

- **Weightage of Learning Efforts for Assessment**

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Analyze & above (A)	
I	**CLO1, CLO2**	15	4	4	5	13
II	**CLO3, CLO4, CLO5**	15	4	4	4	12
		30	**08**	**08**	**9**	**25**

- **Assessment Methodologies/Tools**

(A) Internal Assessment

(a) Formative assessment (15 Marks)

- Quiz
- Assignment, Self-learning, and Term work
- Seminar/Presentation
- Regularity

(b) Summative Assessment (10 Marks)

- Mid Term Examination: 10 Marks

(B) External Assessment

- Term End Examination: 25 Marks

- **CLOs – PLOs Matrix**

CLO	PLO								PSLO	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PSLO1	PSLO2
CLO1	**3**	**1**	**2**	**1**	**-**	**1**	**-**	**1**	**2**	**-**
CLO2	**2**	**3**	**2**	**2**	**1**	**1**	**2**	**2**	**2**	**2**
CLO3	**3**	**2**	**3**	**1**	**-**	**1**	**-**	**2**	**3**	**2**
CLO4	**3**	**2**	**3**	**1**	**-**	**2**	**-**		**3**	**3**
CLO5	**2**	**3**	**3**	**2**	**1**	**2**	**2**	**3**	**3**	**3**

Values to the CLO-PLO matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

M.Sc. Chemistry Semester II

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity,	50
2	End-Semester Examination	Written Exam/Practical Exam Project Evaluation (Report, Presentation, Viva)	50

- **Suggested Learning Materials Books:**

Sr.No.	Title	Author(s)	Edition/Year	Publisher
1	Quantitative Chemical Analysis	Daniel C. Harris	7th Edition/2007	W.H. Freeman and Company, New York
2	Analytical Chemistry	Gary D. Christian, Purnendu K. (Sandy) Dasgupta and Kevin A. Schug	7th Edition/2014	John Wiley and Sons Inc. New Jersey
3	Fundamental of Analytical Chemistry	Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch	8th Edition/2004	Thomson, Brookes/Cole
4	Modern Analytical Chemistry	David Harvey	2001	McGraw Hill, New York
5	Quantitative analysis	R. A. Day, Jr , A. L. Underwood	2006	Prentice -Hall of India Private Limited, New Delhi.
6.	Validation and qualification in analytical laboratories"	L. Huber	2nd Edition, 2007	CRC Press, Taylor & Francis group
7	Instrumental Methods of Analysis	B. Sivasankar	2012	Oxford University Press

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Analytical Chemistry	**https://edu.rsc.org/teacher-pd/in-person/analytical-chemistry/classroom-resources**
2	Analytical Separations	**https://youtu.be/Nk9DLP1rffg?si=KR569sI6FsrFA2KH**
3	Novel Separation Processes	**https://nptel.ac.in/courses/103105060**

M.Sc. Chemistry Semester II

Course Type	Course Code	Course Title	Teaching-Learning Scheme L-P-T	Total Notional Hours	Course credits
DSC	**P2S02NCCHE02**	Chemistry Practical-III	0-8-0	**120**	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO 1: Formulate and execute a logical analytical scheme for the separation of complex mixtures, including interfering radicals and rare earth elements (e.g., Ce, Th, V, Zr), while accounting for matrix effects and coordination chemistry.

CLO 2: Systematically identify cations and anions using advanced group separation methods, ensuring precision in confirmatory tests for both common and transition metal species.

CLO 3: Demonstrate mastery in laboratory practices, encompassing the synthesis of observations, logical inference, and the safe, ethical handling of hazardous reagents in an inorganic context.

CLO 4: Design and optimize quantitative estimation protocols for functional groups—including hydroxyl, phenol/aniline, and unsaturation—and binary systems using redox, acid-base, and back-titration methodologies.

CLO 5: Critically validate experimental observations and stoichiometric data, performing comprehensive error analysis to ensure the accuracy, precision, and reproducibility of organic quantitative estimations.

CLO 6: Master organic transformations and separation techniques, including nitration, polymerization, and column chromatography, while characterizing products through spectral interpretation (IR, UV-Vis).

CLO 7: Appraise and uphold laboratory safety, ethical documentation, and environmental responsibility, demonstrating the ability to independently manage and report complex chemical analyses and estimations.

CLO 8: Analyze and interpret the kinetics of acid-catalyzed iodination of acetone and saponification of ethyl acetate, evaluating the influence of temperature and activation energy on reaction dynamics.

CLO 9: Investigate the molecular weight of volatile liquids via steam distillation and predict the partitioning behavior of solutes between immiscible phases using distribution laws and Nernst equations.

CLO 10: Evaluate surface tension data to determine Critical Micelle Concentration (CMC) and interpret the thermodynamic surface-active parameters of surfactants at liquid interfaces.

Unit	Course Content	Learning Pedagogies*	CLO(s)
In Org-IIII	Qualitative Analysis (6 + 1 Radicals) 6 – Cation, Anion variable 1 – Rare earth elements form the following: Th, Ce, Li, Mo, Se, Te, V, Ti, and Zr, etc.	Experiential Learning, Seminar, Mini Research Task, Research-Oriented Learning, Collaborative Learning	CLO1 CLO2 CLO3

Org-III	1. Experiments based on protection-deportation, nitration, acetylation, suffocation, halogenation, reaction with diazonium salts, oxidation-reduction, and polymerization. 2. Spectral characterization of the compounds synthesized and related exercises. 3. Introduction and demonstration of chromatographic techniques, including column chromatography.	Inquiry-based Learning, Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)	CLO4 CLO5 CLO6 CLO7
Phy - III	1. To determine the rate of acid–catalyst iodination of acetone in the presence of excess acid and acetone at room temperature. 2. To determine the molecular weight of a given liquid by the steam distillation method. 3. To determine the Critical micelle concentrations (CMC) and surface active parameters of surfactant by the surface tension method. 4. To determine the transition temperature of Glauber's salt by the solubility method. 5. To determine the partition coefficient of ammonia between $CHCl_3$ and H_2O.	Inquiry-based Learning, Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)	CLO8 CLO9 CLO10

(A) Assessment Methodologies/Tools

(A) Internal Assessment

(a) Formative assessment (30 Marks)

(a) Quiz
(b) Assignment, Self-learning, and Term work
(c) Seminar/Presentation
(d) Regularity

(b) Summative Assessment (20 Marks)

- Mid Term Examination: 20 Marks

(B) External Assessment

. Term End Examination: Marks 50

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Application/Analyze & above (A)	
Inorg-III	CLO1 CLO2 CLO3	40	**5**	**10**	**35**	50
Org-III	CLO4 CLO5 CLO6 CLO7	40				
Phy -III	CLO8 CLO9 CLO10	40				
		120	**5**	**10**	**50**	**50**

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Journal/record book, oral quiz, Periodic tests, Laboratory Regularity	50
2	End-Semester Examination	Practical Exam/ Project Evaluation (Report, Presentation, Viva)	50

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	3	1	1	1	1	2	1	1
CLO2	1	3	3	1	2	1	2	2	1	1
CLO3	1	2	1	3	1	1	3	1	1	1
CLO4	2	3	3	1	1	1	1	2	1	1
CLO5	1	3	1	2	1	3	1	3	1	1
CLO6	3	3	3	1	1	2	1	2	1	1
CLO7	1	1	1	3	2	1	3	1	2	3
CLO8	3	2	3	1	1	1	1	1	1	1
CLO9	2	3	2	1	1	2	1	1	1	1
CLO10	3	2	2	1	1	1	1	2	1	2

Values to the CLO-PLO matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

- **Suggested Learning Materials Books:**

Sr.No.	Title	Author(s)	Edition/Year	Publisher
1	Experimental Physical Chemistry	G. Peter Matthews	1986	Clarendon Press, Oxford, London)
2	Experimental Physical Chemistry	V. D. Athawale and Parul Mathur	1st Edition	New Age International Publishers, New Delhi)
3	Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis	A.I. Vogel Revised by G. Svehla	5th Edition, 1979	Longman Group Ltd. London

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	IGNOU eGyanKosh – Qualitative Inorganic Analysis	http://egyankosh.ac.in//handle/123456789/79535
2	IGNOU Block Resources (Cation & Anion Detection Modules)	https://egyankosh.ac.in/handle/123456789/24825?utm_source

SARDAR PATEL UNIVERSITY

Vallabh Vidyanagar

NAAC 'A' Grade (10-01-2023 To 09-01-2028)

NEP-2020 aligned Curriculum with effect from Academic Year 2026-27

M.Sc. Chemistry Semester II

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	**P2S02NCCHE01**	Chemistry Practical-IV	0-8-0	**120**	04

- **Course Learning Outcomes (CLOs)**

On completion of this course, students will be able to:

CLO1: Apply volumetric analysis techniques (direct, back, and replacement titrations) to accurately determine metal ion concentrations (Cu^{2+} , Ni^{2+} , Ca^{2+} , Mg^{2+} , Fe^{3+} , and Zn^{2+}) and evaluate given samples

CLO2: Analyze and interpret the composition and stability of complexes, including interference effects, and systematically identify different radicals and a rare earth element using advanced qualitative schemes.

CLO3: Design, execute, and optimize quantitative estimation protocols for aniline, polyhydric alcohols, halogen-containing compounds, aldehydes/ketones, and reducing as well as non-reducing sugars using appropriate analytical procedures and standard laboratory techniques.

CLO4: Analyze, interpret, and critically validate experimental observations, titration/end-point data, stoichiometric calculations, and potential sources of error to ensure accurate, precise, and reproducible estimation of diverse organic compounds.

CLO5: Appraise and uphold laboratory safety, ethical scientific practices, scientific record-keeping, and environmental responsibility while independently performing and reporting quantitative organic estimations.

CLO6: Analyze solubility data to determine the transition temperature of salts (e.g., Glauber's salt) and justify results in terms of phase behavior.

CLO7: Interpret potentiometric and Job's method data to evaluate halide strengths and molecular composition of complexes.

CLO8: Investigate polarimetric and refractive data to predict inversion of cane sugar and verify laws of refraction in liquid mixtures.

CLO 9: Analyze and interpret the kinetics of reaction dynamics, specifically the rate constant of saponification of ethyl acetate and the iodination of acetone, accounting for the effect of temperature and catalysts.

CLO 10: evaluate physical properties of chemical systems, including the determination of molecular weight by steam distillation and the investigation of chromatographic separation techniques and spectral characterization.

Unit	Course Content	Learning Pedagogies*	CLO(s)
Inorganic-IV	Quantitative Analysis: 1. Direct titration (Cu^{+2}, Ni^{+2}, Ca^{+2}, Mg^{+2}, Zn^{+2} and Fe^{+3}) 2. Back titration 3. Replacement titration	Hands-on laboratory work to understand	CLO1 CLO2

	4. Determination of the composition of complex and interference study. 5. Water analysis	titration techniques. Emphasis on accuracy, data analysis, and applications like water analysis.	
Org-IV	Estimations: 1. Estimation of Aniline. 2. Polyhydric alcohol estimation. 3. Percentage halogen estimation by modified Stepanow's method. 4. Estimation of aldehydes/ketones. 5. Sugar estimation [Reducing and Non-reducing].	Experiential Learning, Seminar, Mini Research Tasks, Industrial Visit, Problem-Based Learning, Research-Oriented Learning	CLO3 CLO4 CLO5
Physical-IV	1. Determination of strengths of halides in a mixture potentiometrically 2. To determine the rate constant of the saponification of ethyl acetate at different temperatures 3. To verify the law of refraction for a given glycol + water mixture 4. To determine the molecular composition of ferric – salicylate complex by Job's method. 5. To study the inversion of cane sugar by a polarimeter.	Experiential Learning, Mini Research Task, Research-Oriented Learning, Collaborative Learning	CLO6 CLO7 CLO8 CLO9 CLO10

- **Weightage of Learning Efforts for External Assessment**

Subject	**Aligned CLOs**	**Total Learning Hours**	**Approximate weightage (Marks) to Learning levels (BT)**			**Total Marks**
			Remember (R)	**Understanding (U)**	**Application/ Analyze & above (A)**	
Inorg-IV	CLO1 CLO2	40	5	10	35	50
Org-IV	CLO3 CLO4 CLO5	40				
Phy-IV	CLO6 CLO7 CLO8 CLO9	40				

	CLO10					
		120	5	10	35	50

- **Assessment Methodologies**

(A) Internal Assessment

(a) Formative assessment (20 Marks)

(a) Method of Working
(b) Viva
(c) Regularity
(d) Journal Writing

(b) Summative Assessment (30 Marks)

- Mid Term Practical Examination: 30 Marks

(B) External Assessment

- Term End Practical Examination: 50 Marks

- **Assessment and Evaluation**

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Journal/record book, oral quiz, Periodic tests, Laboratory Regularity	50
2	End-Semester Examination	Practical Exam/ Project Evaluation (Report, Presentation, Viva)	50

(A) CLOs – PLOs Matrix

CLO	PLO									
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	2	3	3	1	1	1	2	2	1	2
CLO2	3	3	3	1	1	1	1	2	1	1
CLO3	2	3	3	1	1	1	1	2	1	1
CLO4	1	3	2	2	1	3	1	3	1	1
CLO5	1	1	1	3	2	1	3	1	2	3
CLO6	3	2	2	1	1	1	1	1	1	1
CLO7	3	3	3	1	1	2	1	2	1	1
CLO8	3	3	2	1	1	1	1	2	1	1
CLO9	3	3	3	1	1	1	1	1	1	1
CLO10	2	3	2	2	1	2	1	2	1	1

M.Sc. Chemistry Semester II

Values to the **CLO-PLO** matrix are assigned **by judging the importance of the particular CLO** in relation to the **PLOs**.

CLO – PLO correlation	Value
Strong	3
Moderate	2
Low	1
No correlation	-

- **Suggested Learning Materials Books:**

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Elementary Practical Organic Chemistry Part 3	A. I. Vogel	2nd Edition	Pearson
2	Practical Organic Chemistry	F.G. Mann and B.C. Saunders	4th Edition	Pearson
3	Experimental Physical Chemistry	R. C. Das & B. Behera	1983	Tata McGraw-Hill Publishing Company Ltd., New Delhi
4	Experiments in Physical Chemistry	D. P. Shoemaker, C. W. Garland and J. W. Nibler	8th Edition	McGraw-Hill International Edition, London
5	Vogel's Textbook of Quantitative Chemical Analysis	G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney	5th Edition, 1989	Longman Group Ltd. London

- **Online Resources (Open Source)**

Sr. No.	Description of Resource(s)	Weblink
1	Complete Quantitative Analysis Lab Manual	https://studylib.net/doc/27536607/lab-manual-2023-24-1-?utm_source
2	IGNOU eGyanKosh – Inorganic Quantitative Analysis	https://egyankosh.ac.in/bitstream/123456789/28474/1/Unit-1.pdf?utm_source