



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. (Applied Chemistry) Semester-I

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2T01NCACH01	Transition Metal Chemistry and Organometallics	4-0-1	120	04

• Course Learning Outcomes (CLOs)

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

CLO1: Critically analyse the fundamental principles of Crystal Field Theory (CFT), Ligand Field Theory (LFT), and Molecular Orbital Theory (MOT), and apply these concepts to interpret and analyse the splitting patterns of d-orbitals in coordination compounds with different geometries.

CLO2: Analyse and determine electronic states, term symbols, and microstates for transition metal complexes and simple electronic configurations, and interpret their significance in chemical bonding and spectroscopy.

CLO3: Interpret and critically analyse the electronic spectra of transition metal complexes using Orgel and Tanabe–Sugano diagrams, and evaluate ligand field parameters such as Dq, Racah parameter (B), and nephelauxetic ratio (β).

CLO4: Analyse the structure, bonding, and classification of organometallic compounds of main group and transition elements, and evaluate their catalytic applications in modern chemical processes.

CLO5: Evaluate reaction mechanisms in coordination chemistry, including substitution reactions and electron transfer processes (inner-sphere and outer-sphere), and apply mechanistic concepts to predict reaction outcomes.

Unit	Course Content	Learning Pedagogies*	CO(s)
I	Chemistry of Transition Elements – I Concept of crystal field theory (CFT), ligand field theory (LFT) and molecular orbital theory (MOT), splitting of d-orbitals in various stereochemistry, Jahn Teller effect: tetragonal distortion in octahedral complexes; spectrochemical series, nephelauxetic series, Electronic states and term symbols; term symbols for diatomic molecule, microstates; derivation of terms for closed subshell; derivation of terms for p ² and d ² configurations.	Classroom lecture, Seminar, Problem-Based Learning	CLO1, CLO2
II	Chemistry of Transition Elements – II Correlation diagrams; Orgel diagram; Tanabe-Sugano diagram; selection rule; determination of Dq and electronic parameters; Interpretation of electronic spectra of 3d metal complexes.	Classroom lecture, Seminar, Problem-Based Learning	CLO3



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III	Organometallic Compounds Introduction, classifications and general characteristics of organometallic compounds, Organometallic compounds of main group elements; organometallic compounds of transition metals– σ -bonded and Π -bonded organometallics, Catalytic processes involving transition metal organometallic compounds as homogeneous catalysts hydrogenation, hydroformylation, oxidation, isomerization, dimerization and polymerization of alkenes and alkenes metathesis, Catalytic applications of main group organometallic compounds	Classroom lecture, Seminar, Problem-Based Learning, Collaborative Learning	CLO4
IV	Reaction Mechanism The nature of substitution reaction, Theoretical approach to substitution mechanism, Nucleophilic reactivity, Nature of central atom, Kinetic application of crystal field theory, Replacement of coordinated metal, Acid analysis, Molecular rearrangement complexes, Reactions of geometrical and optical isomers, Outer sphere electron transfer reactions, Inner sphere electron transfer reactions, Two electron transfer.	Classroom lecture, Seminar	CLO5

- **(*) Learning Pedagogies/Methods**

- (a) Classroom lecture
- (b) Seminars (Student-led and Faculty-moderated)
- (c) Case-Based Learning (CBL)
- (d) Micro-Projects/Mini Research Tasks
- (e) Industrial Visit/Field Visit/Institutional Visit
- (f) Problem-Based Learning (PBL)
- (g) Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
- (h) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- (i) Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- (j) Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- (k) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- (l) Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
- (m) Inquiry-Based Learning
- (n) Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

- (A) **Internal Assessment**

- a. **Internal Formative assessment (30 Marks)**

- (a) Quiz
- (b) Seminar
- (c) Assignment



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(d) Group Task

(e) Attendance

b. Internal Summative Assessment (20 Marks)

Mid-term test

(B) Weightage of Learning Efforts for External

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Analyse & above (A)	
I	CLO 1, CLO 2	30	1	3	6	10
II	CLO 3	30	2	3	7	12
III	CLO 4	30	1	4	10	15
IV	CLO 5	30	1	5	7	13
		120	05	15	30	50

Sr.No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity, and Group tasks	50%
2	End-Semester Examination	Written Exam	50%

• CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	3	1	2	3	1	1	1	2	-	-	2	-
CLO2	3	1	2	3	2	1	-	2	-	-	2	-
CLO3	3	2	3	3	2	1	-	2	-	-	2	-
CLO4	3	2	3	3	1	2	1	2	1	2	2	2
CLO5	3	3	3	3	2	2	1	2	1	1	2	1

Values to 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	-



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M.Sc. (Applied Chemistry) Semester-I

• Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Advanced Inorganic Chemistry	F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann	6 th Edition 1999	John Wiley & Sons (Wiley)
2	Mechanism of Inorganic Reactions	Fred Basolo, Ronald G. Pearson	2 nd Edition 1967	John Wiley & Sons (Wiley)
3	Fundamental Principles of Inorganic Chemistry	D. Banerjee	1 st Edition 1993	Sultan Chand & Sons
4	Organometallic Chemistry	R. C. Mehrotra, Anirudh Singh	Revised Edition 2006	New Age International (P) Limited Publishers
5	Electronic Absorption Spectroscopy and Related Techniques	D. N. Sathyanarayana	1 st Edition 2001	Universities Press (India) Ltd.

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	NPTEL (Transition Metal Organometallic Chemistry, Co-ordination Chemistry)	http://www.nptel.ac.in
2	SWAYAM (Inorganic Chemistry)	http://www.swayam.gov.in
3	e-PG Pathshala (Inorganic Chemistry-I, Inorganic Chemistry-II, Inorganic Chemistry-III)	http://www.epgp.inflibnet.ac.in
4	National Digital Library (Advanced Inorganic Chemistry by F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann)	http://www.ndl.iitkgp.ac.in



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M.Sc. (Applied Chemistry) Semester-I

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2T01NCACH02	Organic Reactions and Stereochemistry	4-0-1	120	04

• Course Learning Outcomes (CLOs)

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

CLO1: Apply and evaluate stereochemical principles to determine molecular chirality, interpret optical activity, and assign absolute configurations (*R/S*) in organic compounds.

CLO2: Analyze and predict organic reaction mechanisms using thermodynamic and kinetic principles, including transition states, intermediates, and experimental evidence.

CLO3: Critically examine and justify the structure, stability, and reactivity of reactive intermediates such as carbocations, carbanions, free radicals, carbenes, and nitrenes in organic reactions.

CLO4: Differentiate and rationalize various types of organic reactions (addition, elimination, substitution) and predict their mechanistic pathways and stereochemical outcomes.

CLO5: Evaluate and optimize the role of stereochemistry and mechanistic pathways in controlling product formation, selectivity, and reaction efficiency in organic transformations.

Unit	Course Content	Learning Pedagogies*	CO(s)
I	Stereochemistry Elements of symmetry, chirality, different projections and their interconversion, CIP Nomenclature, Molecules with more than one Chiral centre, Total number of Stereoisomer, Enantiomeric and Diastereomeric Relationship, Chirogenicity and Stereogenecity, Pseudochirality, Topicity and Prostereoisomerism, chirality due to chiral axis, plane, and helical shape, Determination of Topic relationship between Homomorphic ligands in Intact Molecules, Concept of stereoselective and stereospecific reactions, Optical Purity.	Classroom Lecture, Collaborative Learning, Reflective Practices, Self-Directed Learning.	CLO1
II	Resolution Techniques and Conformational Analysis Methods of resolution, conformational analysis of acyclic compounds (ethane, n-butane, haloalkanes, vicinal dihydroxy, etc.), Conformational analysis of cycloalkanes, Mono and disubstituted cyclohexane, decalins, effect of conformation on reactivity	Classroom Lecture, Seminars, Problem-Based Learning, Research-Oriented Learning	CLO2
III	Reactive intermediates in organic chemistry Carbocation: Structure, geometry and generation of carbocations, Carbocation stability, Reactions involving non-classical carbocations Carbanions: Structure, geometry and generation of	Classroom Lecture, Problem-Based Learning, Research-Oriented Learning, Self-	CLO3



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M.Sc. (Applied Chemistry) Semester-I

	carbanions, Stability, and reactions of carbanions Free Radicals: Structure and generation of free radicals, Stability, and reactions of free radicals Carbenes: Structure, geometry, and generation of carbenes, Reactions of carbenes Nitrenes: Structure, reactivity, and generation of nitrenes, Reactions of nitrenes Benzynes: Structure, reactivity, generation, and reactions of benzyne	Directed Learning	
IV	Addition, Elimination and Substitution reactions Orientation of Addition reactions, reactivity and mechanism, Markovnikov and anti-Markovnikov addition reactions, Addition reactions (hydro-halo, hydro-hydroxy, and hydro-alkoxy), Elimination mechanism and orientation, E1-E2-E1cB, mechanistic spectrum, various factors affecting elimination reactions, Pyrolytic Eliminations, Aliphatic substitution, S _N 1, S _N 2, S _N i mechanism, Neighbouring-Group participation, Aromatic Substitution, S _N Ar, Ipso substitution	Classroom Lecture, Problem-Based Learning, Research-Oriented Learning, Collaborative Learning, Self-Directed Learning	CLO4, CLO5

- (*) Learning Pedagogies/Methods**

- (o) Classroom Lecture (CL)
- (p) Seminars (Student-led and Faculty-moderated)
- (q) Case-Based Learning (CBL)
- (r) Micro-Projects/Mini Research Tasks
- (s) Industrial Visit/Field Visit/Institutional Visit
- (t) Problem-Based Learning (PBL)
- (u) Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
- (v) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- (w) Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- (x) Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- (y) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- (z) Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
- (aa) Inquiry-Based Learning
- (bb) Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- Assessment Methodologies/Tools**

- (C) Formative assessment (Assessment for Learning)**

- a. Internal Formative assessment (30 Marks)**

- (f) Quiz
- (g) Seminar
- (h) Assignment
- (i) Group Task
- (j) Attendance



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M.Sc. (Applied Chemistry) Semester-I

b. Internal Summative Assessment (20 Marks)

Mid-term test

(D) Weightage of Learning Efforts for External Assessment

Unit	Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
			Remember (R)	Understanding (U)	Analyse & above (A)	
I	CLO 1 CLO 2	30	1	3	6	10
II	CLO 3	30	1	3	8	12
III	CLO 4	30	2	4	9	15
IV	CLO 5	30	1	5	7	13
		120	5	15	30	50

• Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity, and Group task	50
2	End-Semester Examination	Written Exam	50

(E) CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	3	-	2	2	1	-	-	1	-	1	2	-
CLO2	3	1	3	2	2	1	-	1	-	2	1	-
CLO3	3	1	3	3	2	1	-	-	-	2	1	1
CLO4	3	2	3	3	2	2	1	1	-	3	1	1
CLO5	3	2	3	3	3	2	1	1	1	3	2	2

Values to 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	Textbook of Organic Chemistry (Vol. I & II)	I. L. Finar	6 th Edition, 2022	Pearson Education India
2	Organic Chemistry	R. T. Morrison, R. N. Boyd	7 th Edition, 2011	Pearson Publication



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3	Organic Chemistry	J. Clayden, N. Greeves, S. Warren	2 nd Edition, 2012	Oxford University Press
4	Organic Reactions, Stereochemistry and Mechanism	P. S. Kalsi	4 th Edition, 2007	Cambridge University Press
5	Modern Methods of Organic Synthesis	W. Carruthers	4 th Edition, 2004	Cambridge University Press

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	NPTEL: Stereochemistry	https://nptel.ac.in/courses/104105086
2	SWAYAM: Symmetry, Stereochemistry and Applications	https://onlinecourses.nptel.ac.in/noc22_cy18/preview
3	NPTEL: Reactive Intermediates Carbene And Nitrene	https://nptel.ac.in/courses/104105104
4	NPTEL: Symmetry, Stereochemistry and Applications	http://www.digimat.in/nptel/courses/video/104106127/L34.html



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M.Sc. (Applied Chemistry) Semester-I

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2T01NCACH03	Fundamentals of Physical Chemistry	4-0-1	120	04

• Course Learning Outcomes (CLOs)

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

CLO1: Apply the laws of thermodynamics to analyse chemical systems, including concepts of free energy, entropy, and chemical potential.

CLO2: Interpret thermodynamic relationships such as Maxwell relations, Gibbs-Duhem equation, and their applications in evaluating partial molar properties.

CLO3: Critically examine the principles of statistical thermodynamics, including distribution laws, partition functions, and their role in determining thermodynamic properties and the contribution of Indian scientist S. N. Bose in statistical thermodynamics.

CLO4: Analyse phase equilibria and chemical equilibria in one-, two-, and three-component systems, including ideal and non-ideal behaviour.

CLO5: Evaluate electrochemical systems using concepts such as Debye-Hückel theory, activity coefficients, and interionic interactions in electrolyte solutions.

Unit	Course Content	Learning Pedagogies*	CLO(s)
I	Chemical Thermodynamics Introduction, revision of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Extensive and intensive properties, Gibbs-Duhem equation and its application to study the partial molar quantities and their significance. Maxwell relations, thermodynamic equation of state, variation of chemical potential with temperature and pressure	Classroom Lecture, Seminars, Problem-Based Learning, Research-Oriented Learning, Collaborative Learning, Reflective Practices, Self-Directed Learning	CLO1, CLO2
II	Statistical Thermodynamics Limitation of classical thermodynamics, statistical thermodynamics, Contribution of Indian scientist S. N. Bose in statistical thermodynamics, Energy states and energy levels, macrostate and microstate, thermodynamic probability, the Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac distributions, Bose-Einstein Condensation, Molecular partition function and their significance, thermodynamics properties in terms of partition function, Rotational, translational, vibrational and electronic partition function, the statistical interpretation of entropy, Sackur-Tetrode equation, comparison of distribution function for indistinguishable particles	Classroom Lecture, Seminars, Problem-Based Learning, Reflective Practices, Self-Directed Learning	CLO3



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III	Phase Equilibria and Chemical Equilibria Elementary description of phase transitions, phase equilibria and phase rule, One-component, two-component, and three-component systems. Thermodynamics of ideal and non-ideal gases and solutions	Classroom Lecture, Seminars, Problem-Based Learning, Research-Oriented Learning, Self-Directed Learning	CLO4
IV	Electrochemistry Electrochemistry of solutions, conductivity of solutions, law of Faraday, Debye-Hückel theory of inter-ionic attraction, atmosphere, time of relaxation, relaxation and electro-phoretic effects, Debye-Hückel-Onsager equation and its validity for dilute solutions and at appreciable concentrated solutions. Activity coefficients: forms of activity coefficients and their interrelationship. Debye-Hückel limiting law for osmotic and activity coefficients of dilute electrolyte solutions and its application to concentrated solutions. Debye-Hückel-Bornsted equations, Industrial applications of Electrochemistry	Classroom Lecture, Seminars, Problem-Based Learning, Research-Oriented Learning, Collaborative Learning,	CLO5

• (*) Learning Pedagogies/Methods

- (cc) Classroom Lecture (CL)
- (dd) Seminars (Student-led and Faculty-moderated)
- (ee) Case-Based Learning (CBL)
- (ff) Micro-Projects/Mini Research Tasks
- (gg) Industrial Visit/Field Visit/Institutional Visit
- (hh) Problem-Based Learning (PBL)
- (ii) Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
- (jj) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- (kk) Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- (ll) Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- (mm) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- (nn) Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
- (oo) Inquiry-Based Learning
- (pp) Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

• Assessment Methodologies

(F) Internal Assessment

a. Internal Formative assessment (30 Marks)

- (k) Quiz
- (l) Seminar
- (m) Assignment
- (n) Group Task
- (o) Attendance



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M.Sc. (Applied Chemistry) Semester-I

b. Internal Summative Assessment (20 Marks)

Mid-term tests

(G) Weightage of Learning Efforts for External Assessment

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	1	4	8	13
II	CLO3	30	1	3	7	11
III	CLO4	30	2	3	6	11
IV	CLO5	30	1	5	9	15
		120	05	15	30	50

• Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity, and Group tasks	50
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(H) CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	3	-	1	3	-	-	2	3	1	1	-	1
CLO2	3	-	1	3	-	-	2	3	1	1	-	1
CLO3	3	-	1	3	-	-	2	3	1	1	-	1
CLO4	3	1	1	3	-	-	2	3	2	2	-	1
CLO5	3	2	2	3	1	-	2	3	2	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	-



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M.Sc. (Applied Chemistry) Semester-I

• Suggested Learning Materials Books:

Sr. No.	Title	Author(s)	Edition/Year	Publisher
1	Elements of Physical Chemistry	Peter Atkins, Julio De Paula, James Keeler	11 th edition, 2018	Oxford University Press
2	Physical Chemistry	Ira N. Levine	6 th edition, 2009	McGraw-Hill Publishing House
3	Modern Electrochemistry (Vol. I & II)	J. O. M. Bockris, A. K. N. Reddy	2 nd edition, 2004	Kluwer Academic Publishers
4	An Introduction to Electrochemistry	S. Glasstone	4 th reprint, 2006	Affiliated East-West Press Pvt. Ltd.
5	Electrolytic Solutions	R. A. Robinson, R. H. Stokes	2 nd edition, 2002	Dover Publication

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	Elementary Electrochemistry, IISER Mohali Prof. Angshuman Roy Choudhury	https://nptel.ac.in/courses/104106137
2	Basic thermodynamics: Classical and Statistical Approaches, IISER Pune Prof. Arnab Mukherjee	https://nptel.ac.in/courses/104106107
3	Physical_and_Theoretical_Chemistry online content	https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps
4	classical/ macroscopic and statistical thermodynamics and kinetics	https://nptel.ac.in/courses/104106089



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M.Sc. (Applied Chemistry) Semester-I

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2T01NCACH04	Quantitative and Qualitative Practical	0-8-0	120	04

• Course Learning Outcomes (CLOs)

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

Course Learning Outcomes (CLOs)

CLO1: Execute quantitative analysis of metal ions (Cu^{2+} , Ni^{2+} , Ca^{2+} , Mg^{2+} , Fe^{3+}) using direct, indirect, back, and replacement titration techniques with accuracy.

CLO2: Determine calcium content through indirect titration methods and perform related calculations with proper interpretation of results.

CLO3: Synthesize inorganic compounds including double salts and coordination complexes, and estimate their composition using gravimetric methods.

CLO4: Develop practical proficiency in the preparation and characterization of coordination compounds such as chrome alum and various ammine and oxalato complexes.

CLO5: Separate and identify components of binary organic mixtures using systematic chemical tests and physical methods.

CLO6: Estimate functional groups and perform organic synthesis reactions, including acid-catalyzed (acetal formation) and base-catalyzed (Knoevenagel condensation) processes.

Unit	Course Content	Learning Pedagogies*	CO(s)
	Inorganic Chemistry Quantitative Analysis: Direct Titration (Cu^{+2} , Ni^{+2} , Ca^{+2} , Mg^{+2} and Fe^{+3}) Synthesis of metal complexes, double salts and estimation by gravimetry. ➤ Chrome alum K_2SO_4, $\text{Cr}_2(\text{SO}_4)_3 \cdot 24\text{H}_2\text{O}$ ➤ Ferrous ammonium sulphate $\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ ➤ Tris ethylene diamine Ni(II) sulphate ➤ Tetrammine Cu(II) sulphate ➤ Sodium trioxalato ferrate trihydrate ➤ Potassium trioxalatochromate (III) ➤ Hexa-ammine nickel (II) chloride Organic Chemistry ➤ Separation and identification of the three-component mixtures using Chemical and physical methods. ➤ Estimation of reducing sugars, phenols, and aniline.	Mini Research Tasks, Industrial Visit, Problem-Based Learning, Research-Oriented Learning, Experiential Learning, Reflective Practices	CLO1 to CLO6



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M.Sc. (Applied Chemistry) Semester-I

• (*) Learning Pedagogies/Methods

- (qq) Classroom lectures
- (rr) Seminars (Student-led and Faculty-moderated)
- (ss) Case-Based Learning (CBL)
- (tt) Micro-Projects/Mini Research Tasks
- (uu) Industrial Visit/Field Visit/Institutional Visit
- (vv) Problem-Based Learning (PBL)
- (ww) Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
- (xx) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- (yy) Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- (zz) Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- (aaa) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- (bbb) Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
- (ccc) Inquiry-Based Learning
- (ddd) Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

• Assessment Methodologies

(I) Internal Assessment

a. Internal Formative Assessment (30 Marks)

- (p) Journal Evaluation
- (q) Method of workings
- (r) Attendance

b. Internal Summative Assessment (20 Marks)

- (a) Mid-Term Examination
- (b) Viva-voce

(J) Weightage of Learning Efforts for External Assessment

Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
		Remember (R)	Understanding (U)	Analyse & above (A)	
CLO1 to CLO6	120	5	10	35	50
	120	5	10	35	50

• Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Journal Evaluation, Method of workings, Attendance, Mid-Term Examination, Viva-voce	50%
2	End-Semester Examination	Practical Exam	50%



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• CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO10	PLO11	PLO12
CLO1	2	3	3	3	2	2	1	2	1	1	2	-
CLO2	2	3	3	3	3	2	1	2	1	1	2	-
CLO3	3	3	3	3	2	3	1	2	1	2	2	2
CLO4	3	3	2	3	2	2	1	2	1	2	2	2
CLO5	3	3	3	3	2	2	1	2	1	1	2	-
CLO6	3	3	3	3	2	2	1	2	1	2	2	2

Values to 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	Qualitative Chemical semi micro analysis	V. N. Alexeyev	2 nd Ed. 1979	Mir Publishers Moscow
2	Vogel's Qualitative Inorganic Analysis	G. Svehla	7 th Ed. 1996	Orent Longman
3	Vogel's Textbook of Quantitative Chemical Analysis	G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney	5 th Ed. 1989	ELBS Publication
4	A Textbook of Practical Organic Chemistry	A. I. Vogel	5 th Ed. 1989	Pearson edu.
5	Elementary Practical Organic Chemistry – Part 3 Quantitative Organic Analysis	A. I. Vogel	2 nd Ed. 1978	Pearson edu.

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	LibreTexts (Coordination compounds lab, Organic chemistry lab)	https://chem.libretexts.org
2	NPTEL (Analytical chemistry course/Direct titration)	https://nptel.ac.in



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Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2T01NCACH05	Physical and Analytical Instrumental Practical	0-8-0	120	04

• Course Learning Outcomes (CLOs)

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

CLO1: Perform precise potentiometric measurements to determine the normality and composition of various halide and electrolyte solutions.

CLO2: Analyze solubility and calculate the solubility product of silver halides through established experimental methodologies.

CLO3: Utilize conductometric titrations to determine the exact composition of acid mixtures and establish the critical micelle concentration (CMC) of surfactants.

CLO4: Investigate the molecular composition of complexes and evaluate reaction kinetics using advanced analytical techniques.

CLO5: Calculate fundamental kinetic parameters, including reaction rate constants and activation energies, for chemical transformations.

Course Content	Learning Pedagogies*	CO(s)
Physical and Analytical Chemistry: 1. Determination of normality, amount of chloride/bromide/iodide using Potentiometry. 2. Determination of solubility and solubility product of silver halides. 3. Determination the composition of a mixture of acetic acid and Hydrochloric acid by Conductometric titration. 4. Determination of CMC of anionic surfactant by Conductometry. 5. Determination of mixture of acids and relative strength of weak acids using Conductometry. 6. Investigate the molecular composition of a ferric-salicylate complex by Job's method. 7. To determine the rate constant of the saponification of ethyl acetate at different temperatures and calculate the energy of activation of the reaction. 8. To study the variation of refractive index with composition of mixtures of glycol and water. 9. To find out the amount of Borax in given solution by titrating it against hydrochloric acid pH metrically. 10. Kinetics of inversion of cane sugar in presence of strong acid. 11. Determination of partial molar volume by intercept method, density measurements. 12. Determine the pK_1 and pK_2 value of phosphoric acid by pH metry.	Collaborative Learning, Research-Oriented Learning, Problem-Based Learning	CLO1 to CLO5



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13. Determine the indicator constant of given indicator by colorimetric measurements.		
14. Study of kinetics of inversion of cane sugar.		
15. To study the effect of surfactants (sodium chloride) on surface tension of given liquid.		

• (*) Learning Pedagogies/Methods

- Classroom Lecture (CL)
- Seminars (Student-led and Faculty-moderated)
- Case-Based Learning (CBL)
- Micro-Projects/Mini Research Tasks
- Industrial Visit/Field Visit/Institutional Visit
- Problem-Based Learning (PBL)
- Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
- Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
- Inquiry-Based Learning
- Self-Directed Learning (Guided Reading, Concept Exploration Tasks)

• Assessment Methodologies

(K) Internal Assessment

a. Internal Formative assessment (30 Marks)

- Journal Evolution
- Method of Working
- Attendance

b. Internal Summative Assessment (20 Marks)

- Mid-term test
- Viva-voce

(L) Weightage of Learning Efforts for External Assessment

Aligned COs	Total Learning Hours	Approximate weightage (Marks) to Learning levels (BT)			Total Marks
		Remember (R)	Understanding (U)	Analyse & above (A)	
CLO1 to CLO5	120	5	10	35	50
	120	5	10	35	50



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Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Journal Evolution, Method of Working, Attendance, Mid-term exam, and Viva-voce	50
2	End-Semester Examination	Practical Exam and Viva-voce	50

CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO10	PLO11	PLO12
CLO 1	3	2	2	3	2	2	2	2	2	1	1	–
CLO 2	3	3	2	3	2	2	2	2	2	1	1	–
CLO 3	3	3	2	3	3	2	2	2	2	2	1	–
CLO 4	3	3	3	3	2	2	2	2	2	2	1	1
CLO 5	3	3	3	3	2	2	2	2	2	2	1	1

Values to 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	Experiments in Physical Chemistry	J. M. Wilson, R. J. Newcombe, A. R. Denaro, R. M. W. Rickett	2 nd revised and enlarged ed. 2013	Pergamon Press, Oxford.
2	Advanced Physico-Chemical Experiments: A Textbook of Practical Physical Chemistry and Calculations.	James Spicer Rose	1 st ed. 1964	Sir Isaac Pitman & Sons Ltd., London



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3	Experimental Physical Chemistry,	R. C. Das, B. Behera,	1 st ed. 1983	Tata McGraw-Hill Publishing Company Ltd., New Delhi.
4	A Laboratory Manual of Experiments in Physical Chemistry	D. Brennan, C. F. H. Tipper	1 st ed. 1967	McGraw-Hill Publishing Company Ltd., London.
5	Practical Physical Chemistry	Renu Gupta	1 st ed. 2017	New Age International Private Limited

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	NPTEL: Virtual labs simulation of physical chemistry practical concept	https://chemcollective.org/vlabs
2	SWAYAM: Physical chemistry practical video	https://chemagic.org/home/Index.html
3	e-PG Pathshala (INFLIBNET)	http://www.epgp.inflibnet.ac.in
4	Libretexts Physical chemistry practical concepts	https://commons.libretexts.org/book/chem-332621



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M.Sc. (Applied Chemistry) Semester-I

Course Type	Course Code	Course Title	Teaching-Learning Scheme	Total Notional Hours	Course credits
			L-P-T		
DSC	P2T01NCACH06	Spectroscopy	2-0-1	60	02

• Course Learning Outcomes (CLOs)

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

CLO1: Analyze the fundamental principles of spectroscopy, including regions of electromagnetic radiation, interaction of radiation with matter, and different types of spectroscopy with reference to rotational, vibrational, and electronic energy levels.

CLO2: Apply the principles of UV-Visible and IR spectroscopy, including Beer-Lambert's law, electronic transitions, chromophores, auxochromes, vibrational modes, and selection rules, to interpret spectral data and analyze molecular structure.

CLO3: Evaluate and explain the principles and instrumentation of Nuclear Magnetic Resonance (NMR) spectroscopy, including magnetic properties of nuclei, chemical shift, spin-spin coupling, and relaxation processes.

CLO4: Critically analyze NMR spectral data using concepts such as shielding/deshielding, coupling constants, integration, anisotropic effects, and Nuclear Overhauser Effect (NOE) for structural elucidation of organic compounds.

CLO5: Formulate and apply the principles of mass spectrometry, including ionization methods, fragmentation patterns, molecular ion peak identification, nitrogen rule, and apply these concepts for molecular weight determination and structure elucidation.

Unit	Course Content	Learning Pedagogies*	CO(s)
I	UV-Visible and Infra-red (IR) Visible Spectroscopy Introduction of Spectroscopy, region of electromagnetic radiations, Interactions of radiation with matter, rotational, vibrational, electronic energy levels, types of spectroscopy methods. UV-Vis: Introduction, Beer-Lambert's law, instrumentation, fundamental of electronic transitions, chromophores and auxochromes, Woodward-Fieser rules, Effect of conjugation. IR Spectroscopy: Introduction, Principle of IR spectroscopy, Instrumentation, fundamental modes of vibrations, types of vibrations, condition for IR absorption, selection rules, condition for IR absorption.	Classroom Lecture, Research-Oriented Learning, Problem-Based Learning, Collaborative Learning	CLO1, CLO2
II	Nuclear Magnetic Resonance (NMR) Introduction, principles, magnetic and nonmagnetic nuclei, precessional motion, Larmor frequency, absorption of radio frequency, instrumentation, Shielding and de-shielding effects, chemical shift,	Classroom Lecture, Seminars, Problem-Based Learning, Research-Oriented Learning, Problem-	CLO3, CLO4, CLO5



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M.Sc. (Applied Chemistry) Semester-I

Origin of Chemical shift and spin-spin coupling, Fourier Transform technique, Pulse sequence, relaxation processes, peak area and proton ratio, anisotropic effect, spin-spin coupling, coupling constant, applications to simple structural problems, Nuclear Overhauser effect with examples. Mass Spectroscopy General principle and theory, Methods of ionization, different detectors, time of flight, Importance of HRMS, Rules of fragmentation, Recognition of the molecular ion peak, McLafferty rearrangements, metastable ionson peaks, the nitrogen rule, Application of Mass spectrometer in structure elucidation and molecular weight determination.	Based Learning, Collaborative Learning, Experiential Learning	
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- **(*) Learning Pedagogies/Methods**

- (eee) Classroom Lecture (CL)
- (fff) Seminars (Student-led and Faculty-moderated)
- (ggg) Case-Based Learning (CBL)
- (hhh) Micro-Projects/Mini Research Tasks
- (iii) Industrial Visit/Field Visit/Institutional Visit
- (jjj) Problem-Based Learning (PBL)
- (kkk) Research-Oriented Learning (Literature Review, Tool Construction, Data Analysis Exercises)
- (lll) Collaborative Learning (Group Tasks, Peer Discussion, Joint Presentations)
- (mmm) Experiential Learning (Community Engagement, Internship-linked Activities, Practice-based Tasks)
- (nnn) Simulation and Role-Play (Academic, Professional, or Policy-based Scenarios)
- (ooo) ICT-Enabled Learning (LMS-based Tasks, Digital Resources, Virtual Labs/Webinars)
- (ppp) Reflective Practices (Learning Journals, Reflective Notes, Concept Mapping)
- (qqq) Inquiry-Based Learning
- (rrr) Self-Directed Learning (Guided Readings, Concept Exploration Tasks)

- **Assessment Methodologies**

- (M) **Internal Assessment**

- a. **Internal Formative assessment (30 Marks)**

- (v) Quiz
 - (w) Seminar
 - (x) Assignment
 - (y) Group Task
 - (z) Attendance

- b. **Internal Summative Assessment (20 Marks)**

- Mid-term test



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(B) 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)	Analyse & above (A)	
I	CLO1, CLO2	30	1	3	7	11
II	CLO3, CLO4, CLO5	30	1	4	9	14
		60	2	7	16	25

• Assessment and Evaluation

Sr. No.	Assessment/Evaluation	Component	Weightage (%)
1	Continuous Internal Evaluation	Seminars, Assignments, Quizzes, Class Regularity and Group task	25
2	End-Semester Examination	Written Exam	25

• CLOs – PLOs Matrix

CLO	PLO											
	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12
CLO1	3	1	2	2	1	-	-	1	-	1	2	-
CLO2	3	3	3	2	2	1	-	1	-	1	2	-
CLO3	3	2	2	2	1	1	1	1	-	1	2	-
CLO4	3	2	3	3	2	1	-	2	1	-	2	-
CLO5	3	3	3	3	2	1	-	2	-	1	2	1

Values to 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	Instrumental Methods of Analysis	Willard, Merritt, Dean, Settle	7 th edition 2004	CBS Publishers & Distributors
2	Fundamentals of Analytical Chemistry	D. A. Skoog, D. M. West	9 th edition 2013	Thomson Brooks/Cole



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3	Introduction to Spectroscopy	Donald L. Pavia, Gary M. Lampman, George S. Kriz	5 th edition 2015	Thomson Brooks/Cole
4	Spectroscopic Identification of Organic Compounds	R. M. Silverstein, G. C. Bassler	8 th edition 2022	John Wiley & Sons
5	Fundamentals of Molecular Spectroscopy	C. N. Banwell, E. M. McCash	4 th edition 2017	Tata McGraw Hill Publishing

• Online Resources (Open Source)

Sr. No.	Description of Resource(s)	Weblink
1	NPTEL- Fundamentals of Spectroscopy	https://onlinecourses.nptel.ac.in/noc20_cy08/preview
2	SWAYAM- Fundamentals of Spectroscopy	https://onlinecourses.nptel.ac.in/noc23_cy09/preview
3	e-PG Pathshala (INFLIBNET)- Physical Spectroscopy	https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
4	National Digital Library (IIT Kharagpur)- Analytical Chemistry Course	https://onlinecourses.nptel.ac.in/noc23_cy59/preview