Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science & Commerce, Baramati

(Empowered Autonomous)

DEPARTMENT OF CHEMISTRY

(Faculty of Science)

Three/Four Year Honours/Honours with Research B.Sc. Degree Program in Chemistry

S.Y.B.Sc. (Chemistry)
Semester III

(NEP-2.0 2024 Pattern)

Choice Based Credit System Structure and Syllabus

(As Per NEP-2020)

(To be implemented from Academic Year 2025-2026)

Title of the Programme: S.Y. B.Sc. (Chemistry)

Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus ofacross various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making educationmore holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Chemistry and related subjects, the Board of Studies in Chemistry at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the third semester of S.Y.B.Sc. Chemistry, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and the Circular issued by SPPU, Pune on 31st May 2023.

The CBCS Course curriculum of the discipline of Chemistry is well designed and very promising. A degree in Chemistry subject equips students with the knowledge and skills necessary for a diverse range of fulfilling career paths. The core course would help to enrich the subject knowledge of the students and increase their confidence level in the field of both academia and industry. Open electives (OE) make sustainable integration among the various interdisciplinary courses to fulfill the vision and mission of designing the course. The

introduction of Skill Enhancement Courses (SEC) would help to gain more powerful knowledge not only in their core Chemistry subject but also in interrelated multidisciplinary subjects both theoretically and practically. The inclusion of Skill Enhancement Course (SEC) and Vocational Skill Course (VSC) has brought an opportunity in front of students to gain knowledge on various naturally and industrially important useful materials and also helps them to familiar and expert in handling different chemistry-based software after proper training. In brief the student graduated with this type of curriculum would be able to disseminate subject knowledge along with necessary skills to suffice their capabilities for academia, research, entrepreneurship and industry. By acquiring these comprehensive skills and knowledge, graduates are well-prepared to embark on rewarding careers that contribute to a better understanding of the subject and address the challenges of our ever-changing lifestyle.

Overall, revising the Chemistry syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

Programme Specific Outcomes (PSOs)

PSO1: Comprehensive Knowledge and Understanding: Graduates will possess a profound understanding of their field of study, including foundational theories, principles, methodologies, and key concepts, within a broader multidisciplinary context.

PSO2: Practical, Professional, and Procedural Knowledge: Graduates will acquire practical skills and expertise essential for professional tasks within their field. This includes knowledge of industry standards, best practices, regulations, and ethical considerations, with the ability to apply this knowledge effectively in real-world scenarios.

PSO3: Entrepreneurial Mindset and Knowledge: Graduates will cultivate an entrepreneurial mindset, identifying opportunities, fostering innovation, and understanding business principles, market dynamics, and risk management strategies.

POS4: Specialized Skills and Competencies: Graduates will demonstrate proficiency in technical skills, analytical abilities, problem-solving, effective communication, and leadership. relevant to their field of study. They will also adapt and innovate in response to changing circumstances.

PSO5: Capacity for Application, Problem-Solving, and Analytical Reasoning: Graduates will possess the capacity to apply learned concepts in practical settings, solve complex problems, and analyze data effectively. This requires critical thinking, creativity, adaptability, and a readiness to learn and take calculated risks.

PSO6: Communication Skills and Collaboration: Graduates will effectively communicate complex information, both orally and in writing, using appropriate media and language. They will also collaborate effectively in diverse teams, demonstrating leadership qualities and facilitating cooperative efforts toward common goals.

PSO7: Research-related Skills: Graduates will demonstrate observational and inquiry skills, formulate research questions, and utilize appropriate methodologies for data collection and analysis. They will also adhere to research ethics and effectively report research findings.

PSO8: Learning How to Learn Skills: Graduates will acquire new knowledge and skills through self-directed learning, adapt to changing demands, and set and achieve goals independently.

PSO9: Digital and Technological Skills: Graduates will demonstrate proficiency in using ICT, accessing information sources, and analyzing data using appropriate software.

PSO10: Multicultural Competence, Inclusive Spirit, and Empathy: Graduates will engage effectively in multicultural settings, respecting diverse perspectives, leading diverse teams, and demonstrating empathy and understanding of others' perspectives and emotions.

PSO11: Value Inculcation and Environmental Awareness: Graduates will embrace ethical and moral values, practice responsible citizenship, recogaine and address ethical issues, and take appropriate actions to promote sustainability and environmental conservation.

PSO12: Autonomy, Responsibility, and Accountability: Graduates will apply knowledge and skills independently, manage projects effectively, and demonstrate responsibility and Accountability in work and leaming contexts

PSO13: Community Engagement and Service: Graduates will actively participate in community engaged advices and activities, promoting societal well-being

Anekant Education Society's

Tuljaram Chaturchand College, Baramati

(Empowered Autonomous)

Board of Studies (BOS) in Chemistry

From 2025-26 To 2028

Sr. No.	Name	Designation
1.	Dr. Prof. Shrikrushna T. Salunke	Chairman
2.	Mr. Bhimrao R. Torane	Member
3.	Mr. Maharudra A. Dudhe	Member
4.	Mr. Ravikiranamrut R. Gandhi	Member
5.	Dr. Vaibhav P. Landge	Member
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18.	Mrs. Kalpana Surnavar	Member
19.	Dr. Dilip Satpute	External Member VC Nominee
20.	Dr. Sidaram Pujari	External Member from other University
21.	Dr. Vijay Vader	External Member from other University
22.	Dr. Nitin Jadhav	Member Representative Alumni
23.	Mr. Dadaso Kare	Member Representative from Industry
24.	Ms. Tanishka Fadatare	UG Student Representative
25.	Ms. Disha Waghmode	PG Student Representative

Credit Distribution Structure for Three/Four Year Honours/Honours with Research Degree Programme with Multiple Entry and Exit options as per National Education Policy (2024 Pattern as per NEP-2020)

Level/ Difficulty	Sem	Subject DSC-1	Subject DSC-2	Subject DSC-3	GE/OE	SEC	IKS	AEC	VEC	CC	Total
4.5/100	I	2(T)+2(P)	2(T)+2(P)	2(T)+ 2(P)	2(T)	2 (T/P)	2(T) (Generic)	2(T)	2(T)	--	22
	II	2(T)+2(P)	2(T)+2(P)	2(T)+2(P)	2(P)	2 (T/P)	--	2(T)	2(T)	2(T)	22
Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core NSQF course/Internship OR Continue with Major and Minor **Continue option**: Student will select one subject among the (subject 1, subject 2 and subject 3) as major and other as minor and third subject will be dropped.											

Level/ Difficulty	Sem	Credits Related to Major				Minor	--	GE/OE	SEC	IKS	AEC	VEC	CC	Total
		Major Core	Major Elective	VSC	FP/OJT/CEP/RP									
5.0/200	III	4(T)+2(P)	--	2 (T/P)	2(FP)	2(T)+2(P)	--	2(T)	--	2(T)	2(T)	--	2(T)	22
	IV	4(T)+2(P)	--	2 (T/P)	2(CEP)	2(T)+2(P)	--	2(P)	2 (T/P)	--	2(T)	--	2(T)	22
Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4credits core NSQF course/Internship OR Continue with Major and Minor														
5.5/300	V	8(T)+4(P)	2(T)+2(P)	2 (T/P)	2(FP/CEP)	2(T)	--	--	--	--	--	--	--	22
	VI	8(T)+4(P)	2(T)+2(P)	2 (T/P)	4 (OJT)	--	--	--	--	--	--	--	--	22
Total 3Years		**44**	**8**	**8**	**10**	**18**	**8**	**8**	**6**	**4**	**8**	**4**	**6**	**132**
Exit option: Award of **UG Degree in Major** with 132 credits OR Continue with Major and Minor														
6.0/400	VII	6(T)+4(P)	2(T)+2 (T/P)	--	4(RP)	4(RM)(T)	--	--	--	--	--	--	--	22
	VIII	6(T)+4(P)	2(T)+2 (T/P)	--	6(RP)	--	--	--	--	--	--	--	--	22
Total 4Years		**64**	**16**	**8**	**22**	**22**	**8**	8	**6**	**4**	**8**	**4**	**6**	**176**
Four Year **UG Honours with Research Degree** in Major and Minor with 176 credits														
6.0/400	VII	10(T)+4(P)	2(T)+2 (T/P)	--	--	4(RM) (T)	--	--	--	--	--	--	--	22
	VIII	10(T)+4(P)	2(T)+2 (T/P)	--	4 (OJT)	--	--	--	--	--	--	--	--	22
Total 4Years		**72**	**16**	**8**	**14**	**22**	**8**	8	**6**	**4**	**8**	**4**	**6**	**176**
Four Year **UG Honours Degree** in Major and Minor with176 credits														

T = Theory **P** = Practical **DSC** = Discipline Specific Course **OE** = Open Elective **SEC** = Skill Enhancement Course **IKS** = Indian Knowledge System
AEC = Ability Enhancement Course **VEC** = Value Education Course **CC** = Co-curricular Course **VSC**= Vocational Skill Course
OJT= On Job Training **CEP**= Community Engagement Project **FP**= Field Project **RP**= Research Project

Course and Credit Distribution Structure for B.Sc. (Chemistry)-2024-2025

Level/ Difficulty	Sem	Credits Related to Major				Minor	--	GE/OE	SEC	IKS	AEC	VEC	CC	Total
		Major Core	Major Elective	VSC	FP/OJT/CEP/RP									
5.0/200	III	4(T)+2(P)	--	2 (T/P)	2(FP)	2(T)+2(P)	--	2(T)	--	2(T)	2(T)	--	2(T)	**22**
	IV	4(T)+2(P)	--	2 (T/P)	2(CEP)	2(T)+2(P)	--	2(P)	2 (T/P)	--	2(T)	--	2(T)	**22**
												Total Credits		**44**

*** T = Theory**
Discipline Specific Course

*** P = Practical**

*** DSC =**

*** OE = Open Elective**

*** SEC = Skill Enhancement Course**

*** IKS = Indian Knowledge System**

*** AEC = Ability Enhancement Course**

*** VEC = Value Education Course**

*** CC = Cocurricular Courses**

Course Structure for S.Y.B.Sc. Chemistry (2024 Pattern)

SEM	Course Type	Course Code	Course Title	Theory / Practical	Credits
III	Major Mandatory	CHE-201-MRM	Physical and Inorganic Chemistry-I	Theory	02
	Major Mandatory	CHE- 202-MRM	Organic and Inorganic Chemistry -I	Theory	02
	Major Mandatory	CHE -203-MRM	Chemistry Practical - III	Practical	02
	Vocational Skill Course (VSC)	CHE -204-VSC	Practicals on Titrimetric analysis	Practical	02
	Field Project (FP)	CHE-205-FP	Field Project	Practical	02
	Minor	CHE-206-MN	Advanced Chemistry - I	Theory	02
	Minor	CHE-207-MN	Advanced Chemistry Practical - I	Practical	02
	Open Elective	CHE-208-OE	Introduction to Dairy Chemistry	Theory	02
	Subject Specific Indian Knowledge System (IKS)	CEM-209-IKS	Indian Heritage of Chemistry	Theory	02
	Ability Enhancement Project (AEC)	MAR-210-AEC/ HIN-210- AEC/SAN-210-AEC	-	Theory (Any One)	02
	Co-curricular Course (CC)	YOG/PES/CUL/NSS/NCC- 211-CC	To be continued from the Semester - II		02
				Total Credit	**22**
IV	Major Mandatory	CHE-251-MRM	Physical and Inorganic Chemistry-II	Theory	02
	Major Mandatory	CHE- 252-MRM	Organic and Inorganic Chemistry -II	Theory	02
	Major Mandatory	CHE -253-MRM	Chemistry Practical -IV	Practical	02
	Vocational Skill Course (VSC)	CHE -254-VSC	Introduction to Analytical Chemistry	Theory	02
	Community Engagement Project (CEP)	CHE -255-CEP	Community Engagement Project	Practical	02
	Minor	CHE-256-MN	Advanced Chemistry- II	Theory	02
	Minor	CHE-257-MN	Practicals on Advanced Chemistry Practical - II	Practical	02
	Open Elective (OE)	CHE-258-OE	Practicals on Dairy Chemistry	Practicals	02
	Skill Enhancement Course (SEC)	CEM-259-SEC	Practicals on Instrumental Analysis	Practicals	02
	Ability Enhancement Project (AEC)	MAR-260-AEC/ HIN-260-AEC/SAN-260-AEC	-	Theory (Any One)	02
	Co-curricular Course (CC)	YOG/PES/CUL/NSS/NCC- 289-CC	To be continued from the Semester- III		02
				Total Credit	**22**
				Cumulative Credits Semester III + Semester IV	**44**

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of the Programme : B.Sc. Chemistry
Program Code : CHE
Class : S.Y.B.Sc
Semester : III
Course Type : Major Mandatory Theory
Course Name : Physical and Inorganic Chemistry-I
Course Code : CHE-201-MRM
No. of Lectures : 30
No. of Credits : 2 credits

Course Objectives:

1. To understand fundamental thermodynamic terms, including system, surroundings, boundaries, and types of systems.
2. Explain intensive and extensive properties, state functions, and path functions, and differentiate between them.
3. Understand the concepts of ionic equilibria, including the ionization of weak acids and bases, pH scale, and common ion effect.
4. Apply the principles of chemical bonding and structure, including different types of overlaps and the formation of sigma and pi bonds.
5. Analyze bonding theories such as Valence Bond Theory, Heitler-London Theory, and Pauling-Slater Theory.
6. Demonstrate knowledge of hybridization, including its definition, need, and types involving s, p, and d orbitals.
7. Apply the first law of thermodynamics to calculate heat, work, internal energy, and enthalpy in chemical processes.

Course Outcome:

After completion of this course students will be able to..

CO1. Know the concept of reaction rate, order of reaction, activation energies & rate theories.
CO2. Understand second law of thermodynamics, entropy calculation.
CO3. Understand chemical thermodynamics & its laws.
CO4. Know hybridization, including its definition, need, and types involving s, p, and d orbitals.
CO5. Understand bonding theories such as Valence Bond Theory, etc.
CO6. Understand the concepts of ionic equilibria, including the pH scale, and common ion effect.
CO7. Calculates heat, work, internal energy, and enthalpy in chemical processes.

Topics and Learning Points

Unit 1: Chemical Thermodynamics (08 L)

Thermodynamic terms; System, surrounding, boundaries, types of system, Intensive and Extensive properties, State functions and path functions, Thermodynamic processes.

First law of thermodynamics: Concept of heat (q), work (w), internal energy (U), enthalpy, heat capacity, relation between heat capacities, sign conventions, calculations of heat, work, internal energy and enthalpy (H).

Thermochemistry: Heat of reactions, standard states, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculations of bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equation

(Numerical problems expected wherever necessary)

Unit 2: Chemical Kinetics (07 L)

Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, Integrated rate equation of first order and Second order reactions (with equal initial concentration of reactants) Determination of order of reaction by a) Integration method b) Graphical method c) Ostwald's isolation method d) Half time method, Effect of temperature on the rate of reaction, Concept of activation energy and its calculation from Arrhenius equation (derivation not expected).

(Numerical problems expected wherever necessary).

Unit 3: Ionic Equilibria (05 L)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, dissociation constants of mono- and diprotic acids.

(Numerical problems expected, wherever necessary)

Unit 4: Chemical bonding and Structure (04 L)

Recapitulation: Ionic, Covalent, Coordinate and Metallic bonds, Types of overlaps: s-s, s-p, p-p, p- d, d-d with examples, Formation of sigma and pi bond, Theories of bonding: Valance bond theory, Heitler-London theory, Pauling Slater theory.

Unit 5: Concept of Hybridization (06 L)

Definition and need of Hybridization, steps involved in hybridization, explanation of covalancy of atoms in the molecules based on hybridization, types of hybridization involving in s, p and d orbital.

References:

1) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai
2) Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001)
3) Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011)
4) Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003)
5) Halpern, A. M. &McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co. New York (2003)

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: S.Y.B.Sc. (SEM-III)

Subject: Chemistry

Course: Physical & Inorganic Chemistry-I **Course Code:** CHE-201-MRM

Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

	Pogramme Outcomes (POs)												
Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**
CO1	3	2	1	3	3	1	2	2	1	2	2	2	1
CO2	3	2	1	2	2	1	1	2	1	2	2	2	1
CO3	3	3	1	3	2	1	1	2	1	2	3	2	1
CO4	3	2	1	2	1	1	1	2	1	2	1	2	1
CO5	3	2	1	2	1	1	1	2	1	2	1	2	1
CO6	3	3	1	3	2	2	2	2	1	2	2	2	2
CO7	3	3	1	3	3	1	1	2	1	2	2	2	1

Justification for Mapping

Comprehensive Knowledge and Understanding (PO1):

CO1: Gain an in-depth understanding of reaction kinetics, including reaction rate, order, activation energy, and rate theories, within a broader physical chemistry context.

CO2: Understand and apply the second law of thermodynamics and entropy, developing conceptual clarity on thermodynamic processes.

CO3: Comprehend chemical thermodynamics and its fundamental laws, reinforcing interdisciplinary knowledge in chemistry and physics.

CO4: Grasp the concept and application of hybridization involving s, p, and d orbitals, linking atomic structure to bonding.

CO5: Understand bonding theories like Valence Bond Theory, strengthening foundational knowledge in structural chemistry.

CO6: Develop conceptual clarity in ionic equilibria and pH, reinforcing acid-base behavior and analytical techniques.

CO7: Acquire knowledge of energy changes in chemical processes through calculation of heat, work, and enthalpy.

Practical, Professional, and Procedural Knowledge (PO2):

CO1: Apply rate laws and kinetic models in laboratory and industrial chemical processes, demonstrating alignment with standard procedures.

CO2: Use thermodynamic principles to assess feasibility and direction of chemical processes, essential for industrial applications.

CO3: Apply laws of thermodynamics to calculate thermodynamic parameters in real-life scenarios, aligning with chemical industry practices.

CO4: Understand hybridization in coordination and organic compounds, forming the basis for molecular design.
CO5: Apply bonding theories to interpret molecular geometry and reactivity patterns relevant to professional chemistry tasks.
CO6: Use ionic equilibrium concepts in buffer preparation and pH determination, essential for chemical analysis.
CO7: Perform heat and work calculations in calorimetric and other thermal experiments, adhering to laboratory best practices.

Entrepreneurial Mindset and Knowledge (PO3):
CO1: Recognize opportunities to apply kinetic models in product design or process optimization.
CO2: Develop innovative approaches to energy management based on entropy and efficiency principles.
CO3: Explore entrepreneurial applications of thermodynamic systems in green chemistry and energy systems.
CO4: Utilize hybridization knowledge in material design and development of new molecular entities.
CO5: Apply bonding principles in conceptualizing new molecules and chemical products.
CO6: Use pH and equilibrium concepts for formulation of consumer products like pharmaceuticals or cleaning agents.
CO7: Develop energy-efficient reaction setups through understanding enthalpic changes in chemical processes.

Specialized Skills and Competencies (PO4):
CO1: Analyze reaction mechanisms and interpret kinetic data using mathematical modeling and graphs.
CO2: Solve problems involving entropy and spontaneity through theoretical and numerical methods.
CO3: Calculate thermodynamic variables from experimental or theoretical data, improving analytical precision.
CO4: Interpret molecular shapes using hybridization models, enhancing structural problem-solving skills.
CO5: Use bonding theories to explain reactivity and stability of compounds.
CO6: Analyze acid-base behavior and equilibria using appropriate scientific techniques.
CO7: Develop thermochemical profiles and interpret energy flow in chemical processes.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO1: Solve complex rate equations and determine reaction mechanisms using logical and mathematical reasoning.
CO2: Predict spontaneity and equilibrium of processes through entropy-based problem solving.
CO3: Resolve problems involving enthalpy, free energy, and internal energy in multistep chemical processes.
CO4: Apply hybridization rules to deduce geometry and bonding patterns in unknown molecules.
CO5: Evaluate molecular properties using different bonding models to identify the most accurate theory.
CO6: Solve problems on ionic equilibrium using appropriate constants and approximations.
CO7: Analyze thermodynamic data and interpret the energy balance in chemical experiments.

Communication Skills and Collaboration (PO6):
CO1: Communicate kinetic data and interpretations in reports and presentations.

CO2: Explain thermodynamic principles clearly during academic discussions and team-based activities.
CO3: Present energy and entropy analysis effectively, demonstrating clarity and depth.
CO4: Collaborate on molecular structure prediction tasks using hybridization.
CO5: Discuss bonding theories within peer groups to evaluate chemical models critically.
CO6: Work collaboratively on ionic equilibria calculations and lab tasks involving pH.
CO7: Participate in group experiments and discussions involving heat and work measurements.

Research-related Skills (PO7):
CO1: Conduct experiments to determine rate laws and activation energy, developing inquiry-based learning.
CO2: Collect and analyze thermodynamic data with accuracy and scientific integrity.
CO3: Formulate hypotheses related to chemical energetics and test them through experiments.
CO6: Design buffer solutions and explore equilibrium in research projects.
CO7: Analyze experimental data involving energy transformations, contributing to meaningful conclusions.

Learning How to Learn Skills (PO8):
CO1: Independently explore advanced rate theories and their applications through guided learning.
CO2: Engage in self-learning on entropy and its relevance in modern scientific contexts.
CO3: Update knowledge on thermodynamics through independent review of current literature.
CO4: Learn and apply advanced hybridization models through self-paced modules.
CO5: Explore advanced bonding models using digital tools and simulation software.
CO6: Adapt to different problem-solving strategies in ionic equilibrium.
CO7: Enhance learning through practice in thermodynamic calculations and laboratory tasks.

Digital and Technological Skills (PO9):
CO1: Use simulation tools to model chemical kinetics and visualize reaction progress.
CO2: Utilize software to calculate entropy and other thermodynamic properties.
CO3: Apply digital spreadsheets and calculators for thermodynamic data analysis.
CO4: Use molecular visualization software to understand hybridization.
CO5: Employ digital models to explore and present bonding theories.
CO6: Use pH meters and digital titration tools in laboratory experiments.
CO7: Record and analyze calorimetric data using lab-based software

Multicultural Competence, Inclusive Spirit, and Empathy (PO10):
CO1–CO7: Engage with diverse student groups in labs and discussions, respecting varied viewpoints and encouraging inclusive teamwork during collaborative problem-solving activities in chemistry.

Value Inculcation and Environmental Awareness (PO11):
CO1: Appreciate the role of kinetics in designing environmentally friendly reaction pathways.
CO2: Understand entropy and energy efficiency in sustainable chemical processes.
CO3: Apply thermodynamic principles in evaluating energy conservation.
CO6: Use ionic equilibrium knowledge in environmental monitoring and pollution control.
CO7: Consider energy implications of chemical reactions for sustainable development.
Autonomy, Responsibility, and Accountability (PO12):
CO1–CO7: Conduct individual experiments and problem-solving exercises with responsibility and minimal supervision, showing accountability in data reporting and time management.

Community Engagement and Service (PO13):
CO1: Share knowledge on reaction rates relevant to chemical hazards and safety with the community.
CO2: Promote awareness of thermodynamics in energy conservation at local levels.
CO3: Help develop and demonstrate simple thermal experiments for schools or science outreach.
CO6: Participate in community water testing projects using pH and equilibrium concepts.

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of the Programme : B.Sc. Chemistry
Program Code : CHE
Class : S.Y.B.Sc.
Semester : III
Course Type : Theory
Course Name : Organic and Inorganic Chemistry -I
Course Code : CHE- 202-MRM
No. of Lectures : 30
No. of Credits : 2 credits

Course Objectives:

1. Develop a thorough understanding of stereochemistry, explore various forms of isomerism, including conformational, geometrical, and optical isomerism, learn to represent organic molecules using different projection formulas.
2. Understand the chemistry of alcohols and phenols; study their nomenclature, physical properties, methods of preparation, and chemical reactions.
3. Explore the chemistry of carboxylic acids, gain insights into their nomenclature, physical properties, synthesis methods, and reactivity.
4. Investigate the properties of p-block elements; focus on the chemistry of boron compounds, silicon, and the nitrogen family.
5. Analyze electron-deficient compounds, examine compounds like BH_3, BF_3, and BCl_3 concerning their Lewis acidity and applications.
6. Study the structure and bonding of boranes understand the preparation and structural aspects of diborane and tetraborane, emphasizing 3-center 2-electron bonds.
7. Examine the chemical reactivity trends in the nitrogen family, focus on the formation and structures of hydrides, halides, and oxides, particularly oxides of nitrogen.

Course Outcome:

After completion of this course students will be able to..

CO1. Interpret and represent stereochemical configurations, apply knowledge of isomerism to determine and depict the spatial arrangement of atoms in organic molecules.

CO2. Predict and explain the behavior of alcohols and phenols, utilize understanding of their properties and reactions in various chemical contexts.

CO3. Demonstrate proficiency in synthesizing carboxylic acids, apply general methods of preparation and predict reaction outcomes.

CO4. Analyze the characteristics of p-block elements; explain the chemistry and applications of boron, silicon, and nitrogen family compounds.

CO5. Evaluate the acidity and applications of electron-deficient compounds; assess the Lewis acidity of compounds like BH_3, BF_3, and BCl_3 and their practical uses.

CO6. Elucidate the structure and bonding in boranes, describe the preparation, structure, and bonding mechanisms in diborane and tetraborane.

CO7. Understand the formation and structures of nitrogen oxides, explain the preparation methods and structural features of NO, NO_2, N_2O, and N_2O_4.

Topics and Learning Points

Unit 1: Stereochemistry **[8L]**

Concept of isomerism, representation of organic molecules, conformational isomerism in alkane (Ethane, Propane and n-Butane) with energy profile diagram. Geometrical isomerism- Conditions for geometrical isomers, E / Z nomenclature of geometrical isomers. Optical isomers- Chirality, specific rotation, enantiomers, R/S nomenclature of one chiral carbon.
Ref. 2

Unit 2: **Chemistry of Alcohols and Phenols** **[7L]**

Introduction, nomenclature, physical properties, general methods of preparations, chemical reactions.
Ref. 1

Unit 3: **Chemistry of Carboxylic acid** **[5L]**

Introduction, nomenclature, physical properties, general methods of preparations, chemical reactions.
Ref. 1

Unit 4: **P-block elements** **[10L]**

Chemistry of Boron compounds

Electron deficient compounds, BH_3, BF_3 and BCl_3 with respect to Lewis acidity and applications. Preparations of simple boranes like diborane and tetra borane. Structure and bonding in diborane and tetra borane ($2e^-$ - 3C bonds). Synthesis of borax.

Chemistry of Silicon

Silicon compounds, occurrence, structure and inertness of SiO_2. Preparation of structure of $SiCl_4$.

Chemistry of Nitrogen family

Trends in chemical reactivity-formation of hydrides, halides, oxides with special reference to oxides of nitrogen. Oxides of nitrogen with respect to preparation and structure of NO, NO_2, N_2O, and N_2O_4.
Ref. 5,6

References:

1. Organic Chemistry Morrison and Boyd, 6th Ed Prentice Hall, New Delhi- 2001.
2. Stereochemistry of carbon compounds, E.L. Eliel
3. Reactions, rearrangement sand reagents, S. N. Sanyal
4. Organic Chemistry- Clayden, Oxford Uni. Press.
5. Inorganic Chemistry -Vogel, 6th edition
6. Inorganic Chemistry- Gary Wulsberg 1st edition 2002

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: S.Y.B.Sc. (SEM-III) **Subject:** Chemistry

Course: Organic & Inorganic Chemistry-I **Course Code:** CHE-202-MRM

Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	0	3	3	1	0	2	2	0	0	2	0
CO2	3	3	0	2	3	1	1	2	2	0	1	2	0
CO3	3	3	1	3	3	1	1	2	3	0	1	2	0
CO4	3	2	1	2	3	1	2	2	3	1	2	2	1
CO5	3	3	1	3	3	1	1	2	2	0	2	2	1
CO6	3	2	0	3	3	1	2	2	2	0	1	2	1
CO7	3	2	1	3	3	1	2	2	2	1	2	2	1

Justification for Mapping

Comprehensive Knowledge and Understanding (PO1):

CO1: Gain in-depth understanding of stereochemistry and isomerism, interpreting molecular configurations relevant to organic chemistry.

CO2: Develop theoretical and conceptual clarity about alcohols and phenols, including their physical and chemical behaviors.

CO3: Acquire core knowledge on methods of synthesizing carboxylic acids and predicting their reactivity.

CO4: Comprehend the unique characteristics and chemical behavior of p-block elements such as boron, silicon, and nitrogen families.

CO5: Understand the acidity and reactivity of electron-deficient compounds, including BH_3 and BF_3, and their relevance in modern chemistry.

CO6: Learn about boranes, including structure, bonding, and their preparation mechanisms.

CO7: Develop foundational knowledge of nitrogen oxides, their structures, and preparation methods within the framework of inorganic chemistry.

Practical, Professional, and Procedural Knowledge (PO2):

CO1: Apply stereochemical principles in identifying and drawing chiral molecules and isomers in lab and professional contexts.

CO2: Use reactivity patterns of alcohols and phenols in organic syntheses or analytical reactions.

CO3: Follow standard preparation methods of carboxylic acids in laboratory settings, demonstrating chemical precision.

CO4: Analyze chemical behavior and practical applications of p-block elements through experimentation and observation.

CO5: Evaluate and apply Lewis acidity of compounds in synthesis and catalysis.

CO6: Use knowledge of borane chemistry in laboratory demonstrations or industrial applications involving electron-deficient compounds.

CO7: Apply structural understanding of nitrogen oxides in environmental and industrial chemical assessments.

Entrepreneurial Mindset and Knowledge (PO3):
CO3: Identify the role of carboxylic acids in pharmaceutical and polymer industries, fostering product innovation.
CO4: Explore industrial and technological applications of p-block element chemistry, encouraging entrepreneurship in material and agrochemical sectors.
CO5: Recognize the commercial value of electron-deficient compounds in catalysts and sensors.
CO7: Analyze how understanding nitrogen oxides supports innovation in green chemistry and emission reduction technologies.

Specialized Skills and Competencies (PO4):
CO1: Demonstrate analytical and visual skills in determining stereochemical configurations of organic compounds.
CO2: Predict reaction outcomes for alcohols and phenols, applying knowledge to complex organic transformations.
CO3: Synthesize carboxylic acids using general methods and assess reaction mechanisms critically.
CO4: Evaluate bonding and reactivity trends across p-block elements, applying them to chemical problem-solving.
CO5: Analyze acidity and reactivity of Lewis acids like BF_3 and their influence on organic transformations.
CO6: Describe borane structures and mechanisms with precision, enhancing conceptual and analytical chemistry skills.
CO7: Compare and contrast the structures of nitrogen oxides using bonding theories and structural diagrams.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO1: Apply knowledge of stereochemistry in solving configuration and conformation-related questions.
CO2: Predict the chemical behavior of alcohols and phenols in various chemical environments.
CO3: Solve synthetic problems by applying carboxylic acid preparation strategies.
CO4: Evaluate chemical reactions involving p-block compounds through analytical reasoning.
CO5: Assess electron-deficient species and interpret their behavior in complex reactions.
CO6: Solve problems related to structure and bonding in boranes using multi-step reasoning.
CO7: Analyze bonding in nitrogen oxides using formal charge, resonance, and molecular orbital theory.
Communication Skills and Collaboration (PO6):
CO1: Present stereochemical models and isomerism diagrams clearly in group activities and assignments.
CO2: Communicate reaction mechanisms of alcohols and phenols effectively in team projects**.**
CO3: Share synthesis techniques and results related to carboxylic acids during lab collaboration.
CO4: Discuss chemical behavior of p-block elements in group settings, enhancing peer learning.
CO5–CO7: Explain concepts of bonding, structure, and reactivity for boranes and nitrogen oxides through collaborative presentations and peer discussion.

Research-related Skills (PO7):
CO2: Design and conduct experiments to explore reactions of alcohols and phenols, demonstrating curiosity and scientific rigor.
CO3: Formulate research problems involving synthesis and characterization of carboxylic acids.
CO4: Investigate properties and uses of p-block elements through literature review and small-scale research.
CO5–CO7: Develop inquiry skills by exploring structure–function relationships in boranes and nitrogen oxides through academic or independent research projects.

Learning How to Learn Skills (PO8):
CO1–CO7: Continuously acquire new knowledge and skills related to organic and inorganic chemistry through self-directed learning strategies, tutorials, scientific literature, and digital platforms.

Digital and Technological Skills (PO9):
CO1: Use digital tools to model stereochemistry and isomerism with visualization software.
CO2: Access online databases to predict reactivity trends of alcohols and phenols.
CO3: Use reaction simulation tools to design synthesis pathways for carboxylic acids.
CO4–CO7: Apply digital platforms and drawing tools to visualize molecular structures and bonding patterns in p-block and nitrogen oxide compounds.

Multicultural Competence, Inclusive Spirit, and Empathy (PO10):
CO4: Participate in discussions on global environmental impacts of nitrogen oxides and boron compounds, fostering diverse scientific perspectives.
CO7: Collaborate across disciplines and cultures to understand pollution, climate change, and mitigation strategies involving nitrogen compounds.

Value Inculcation and Environmental Awareness (PO11):
CO2: Appreciate the ecological importance of managing alcohol-based pollutants and phenolic compounds.
CO4: Recognize the environmental impact of p-block elements and promote responsible usage.
CO5: Evaluate ethical concerns regarding the use of electron-deficient compounds in synthetic chemistry.
CO7: Understand the toxicological and atmospheric significance of nitrogen oxides, promoting environmental consciousness.

Autonomy, Responsibility, and Accountability (PO12):
CO1–CO7: Demonstrate accountability in conducting individual experiments, completing assignments independently, and managing time effectively in practical and theoretical chemistry work.

Community Engagement and Service (PO13):
CO4–CO7: Share scientific knowledge on air pollution, nitrogen oxides, and environmentally relevant p-block compounds through community outreach or educational programs.

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of the Programme	**:** B.Sc. Chemistry
Program Code	**:** CHE
Class	**:** S.Y.B.Sc
Semester	**:** III
Course Type	**:** Major Mandatory, MRM
Course Name	**:** Chemistry Practical-III
Course Code	**:** CHE-203-MRM
No. of Contact Hours	**:** 60
No. of Credits	**:** 2 credits

Course Objectives:

1. To introduce chemical and laboratory safety.
2. To learn basic of chemistry practical from all the discipline of chemistry.
3. To determine the order and rate of the reaction to understand the chemical kinetics.
4. To determine the solubility of Benzoic acid at different temperature and learn thermodynamics.
5. To determine the type of given organic compound and characterize it by doing full analysis.
6. To learn the estimation of compounds.
7. To know the synthesis of inorganic complexes.
8. To learn the volumetric analysis

Course Outcomes:

CO1. Student will able to understand the theoretical aspects and scientific principles of selected experiments through demonstrations which help in developing the subject interest.

CO2. Student will able to develop experimental and operational skills through hands on training showcasing accident-free working, critical thinking and numerical solving ability in laboratory.

CO3. Student will able to prepare the standard solutions required in chemical synthesis/analysis with qualitative/ quantitative approach.

CO4. Student will able to perform good laboratory practices through pre-setting of experiments by utilizing their scientific temper with interdisciplinary manner.

CO5. Student will able to carry out the analysis of given organic compound in terms of its type, functional group, elements detection and melting points.

CO6. Student will able to learn the processes involved in synthesis of inorganic complexes.

CO7. Student will able to apply the knowledge about various chemical methods of analysis to solve various social/ scientific problems. It can be useful in the research with many interdisciplinary subjects such as microbiology, nanoscience and engineering.

Topics and Learning Points

Section I: Physical Chemistry Practical (Any five experiments)

1. Determination of rate constant of a reaction between potassium persulphate and potassium iodide for equal initial concentration of the reactants. .
2. Determination of solubility of Benzoic acid at different temperature and calculate ΔHof solution.
3. To determine the first order rate constant of acid catalyzed ester hydrolysis.
4. To determine the rate constant of base catalyzed ester hydrolysis.
5. Determination of the relative strength of HCl and H_2SO_4 by studying the kinetics of hydrolysis of ester.
6. To study the kinetics of iodination of acetone and hence determine the order of reaction.

Section II: Organic Chemistry Practical (Six Single compounds)

1. Organic Qualitative Analysis Identification of organic compounds through –

a) Type determination b) Preliminary tests
c) Detection of elements (Sodium fusion tests) d) Detection of functional groups
e) Melting point / Boiling point

i) Acid: benzoic, salicylic, phthalic, cinnamic, oxalic, salicylic acid
ii) Phenol: *α*-naphthol, *β*-naphthol, resorcinol, *o*-nitrophenol, *p*-nitrophenol
iii) Base: Aniline, *p*-toludine, diphenylamine, *N*, *N*-dimethylaniline, *o*-nitroaniline, *m*-nitroaniline, *p*-nitroaniline
iv) Neutral: benzaldehyde, glucose, fructose, acetone, ethyl methyl ketone, acetophenone, methyl acetate, ethyl acetate, naphthalene, anthracene, nitrobenzene, *m*-dinitrobenzene, acetamide, urea, acetanilide, chloroform, carbon tetrachloride, thiourea.

Section III: Inorganic Chemistry Practical (Any Four experiments)

1. Synthesis of coordination compounds

a) $[Mn(acac)_3]$
b) $K3[Fe(OX)_3]$
c) $[Ni(en)3]Cl_2$
d) $[Co(NH3)5Cl]Cl_2$
e) $[Co(NO_2)_3(NH_3)_3]$
f) [Cu(acac)2]

References:

1. Senior Practical Physical Chemistry, Khosla, Garg & Gulati, R, Chand & Co
2. Practical Physical Chemistry, A M. Jemes, F. E. Prichard, 3rd edn, Longman.
3. Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing house
4. Organic Qualitative Analysis – A. I. Vogel
5. Vogel's Qualitative Inorganic Analysis, Svehla G. Pearson Education, 2012
6. Vogel's Quantitative Inorganic Analysis, Mendham J.2012

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: B.Sc. (SEM III) **Subject:** Chemistry
Course: Chemistry Practical-III **Course Code**: CHE-203-MRM
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PO 13
CO1	3	2	1	2	2	1	1	3	2	1	2	2	1
CO2	2	3	1	3	3	2	1	2	3	1	2	3	1
CO3	2	3	1	3	3	1	2	2	2	1	2	3	1
CO4	3	3	1	2	2	2	2	2	2	1	3	3	2
CO5	2	3	1	2	3	1	1	2	2	1	2	2	1
CO6	2	3	1	2	2	1	1	1	1	1	2	2	1
CO7	3	2	2	2	3	2	3	3	2	2	3	3	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):

CO1: Understand the theoretical basis of physical and chemical experiments through guided demonstrations, fostering a foundational knowledge of chemistry.
CO2: Build conceptual clarity through hands-on lab experiences, connecting theory with practical laboratory work.
CO3: Acquire core knowledge in solution preparation techniques, enhancing foundational understanding of titration and molarity-based chemistry.
CO4: Internalize laboratory protocols and safety principles through exposure to interdisciplinary experimental setups.
CO5: Recognize the theoretical framework of organic qualitative analysis, including detection of elements and functional groups.
CO6: Understand the structural and bonding principles in inorganic synthesis, focusing on complex formation.
CO7: Apply theoretical chemistry knowledge in real-world problem-solving, demonstrating the relevance of experimental chemistry in broader scientific domains.

Practical, Professional, and Procedural Knowledge (PO2):

CO1: Observe and analyze demonstration-based experiments to understand the procedural flow of chemical analysis.
CO2: Gain hands-on experience in handling apparatus and chemicals, practicing safety, precision, and reliability in lab work.
CO3: Follow standardized procedures to prepare accurate solutions, reflecting procedural expertise.
CO4: Demonstrate adherence to good laboratory practices (GLP), including setup, calibration, and record-keeping.
CO5: Apply correct techniques for organic compound analysis using procedural accuracy.
CO6: Execute synthesis protocols for inorganic complexes by following stepwise chemical operations.
CO7: Utilize standardized chemical methods for analysis and problem-solving in diverse scientific settings.

Entrepreneurial Mindset and Knowledge (PO3):

CO1: Recognize opportunities for learning and innovation through experimental demonstrations.
CO2–CO3: Showcase initiative in solving lab-based problems and working independently, which are essential entrepreneurial traits.
CO5: Connect organic compound analysis to applications in pharmaceutical and forensic industries.
CO6: Understand the practical use of inorganic complexes in industries like catalysis and materials science.
CO7: Develop the mindset to address social and industrial issues using chemical analysis tools.

Specialized Skills and Competencies (PO4):
CO1: Interpret experiment-based findings and develop an analytical approach to chemical procedures.
CO2: Demonstrate precision in measuring, mixing, and executing procedures with critical thinking.
CO3: Show technical skill in standard solution preparation and analytical calculations.
CO4: Pre-set experiments accurately, aligning with best laboratory practices.
CO5: Analyze organic compounds through functional group identification and melting point measurement.
CO6: Construct and synthesize inorganic compounds, interpreting bonding and composition.
CO7: Employ various techniques for scientific analysis applicable to emerging fields like nanoscience and biotechnology.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO1: Analyze outcomes from demonstration experiments and draw conclusions from theoretical reasoning.
CO2: Solve problems during experimentation by applying logical steps and chemical principles.
CO3: Predict outcomes during solution preparation and modify approaches to achieve accurate results.
CO4: Apply interdisciplinary knowledge to understand experiment design and purpose.
CO5: Classify and identify organic substances using scientific reasoning.
CO6: Apply analytical reasoning to the synthesis and interpretation of inorganic complexes.
CO7: Solve scientific and social problems using knowledge of chemical analysis methods.

Communication Skills and Collaboration (PO6):
CO1: Communicate observations and theoretical conclusions effectively during demonstrations.
CO2: Collaborate in team-based experiments while sharing lab responsibilities.
CO3: Report findings and calculations related to titrations clearly in lab records and presentations.
CO4: Work cooperatively in interdisciplinary setups and pre-lab discussions.
CO5–CO6: Communicate results from qualitative and synthesis-based work through organized documentation.
CO7: Participate in interdisciplinary scientific discussions linking chemistry with microbiology, nanotech and engineering.

Research-related Skills (PO7):
CO1: Develop a scientific mindset through observation and inquiry during demonstrations.
CO3: Design approaches to improve accuracy in chemical preparations through repeated trials and analysis.
CO4: Investigate the rationale behind experimental procedures across disciplines.
CO5: Explore structure-activity relationships of organic compounds during analysis.
CO7: Formulate research questions based on chemical analysis methods and their broader applications

Learning How to Learn Skills (PO8):
CO1: Foster curiosity about chemical phenomena and retain conceptual understanding through demonstrations.
CO2–CO4: Practice self-directed learning by preparing, executing, and refining experimental techniques.
CO5–CO7: Independently explore analytical methods and their applications beyond curriculum content.

Digital and Technological Skills (PO9):
CO1: Use video demonstrations and simulations for better understanding of complex experiments.
CO2: Operate digital instruments like pH meters or colorimeters in hands-on sessions.
CO3: Apply software tools for titration data logging or stoichiometric calculations.
CO4–CO7: Use ICT tools for research, data analysis, and visualization of experimental results.

Multicultural Competence, Inclusive Spirit, and Empathy (PO10):
CO1–CO7: Collaborate in a multicultural classroom setting, promoting inclusive lab practices and respecting diverse perspectives in team-based experiments.

Value Inculcation and Environmental Awareness (PO11):
CO1: Learn to conduct experiments responsibly and sustainably.
CO2–CO3: Minimize chemical waste and follow eco-friendly practices during solution preparation.
CO5: Understand the environmental implications of organic compound disposal.

CO7: Link chemical analysis with real-world environmental issues and sustainable research.

Autonomy, Responsibility, and Accountability (PO12):
CO1–CO6: Show self-discipline and independent execution of experiments while ensuring safety, accuracy, and reliability in lab work.
CO7: Demonstrate ownership in solving real-world problems through chemistry.

Community Engagement and Service (PO13):
CO4: Promote community awareness on the importance of safe and efficient laboratory practices.
CO5–CO7: Engage in outreach or academic events highlighting chemical analysis' role in health, safety, and sustainable development.

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of Programme	: B.Sc. Chemistry
Programme Code	: CHE
Class	: S.Y.B.Sc.
Semester	: III
Course Type	: Vocational Skill Course (VSC)
Course Name	: Practicals on Titrimetric Analysis
Course Code	: CHE-204-VSC
No. of Contact Hours	: 60
No. of Credit	: 2 Credit

Course Objectives:

1. Develop fundamental analytical skills for precise chemical quantification using titrimetric methods.
2. Understand the principles and techniques of various titration methods, including acid-base, complexometric, Iodometric, precipitation, and instrumental titrations.
3. Enhance practical laboratory skills by standardizing solutions and determining unknown concentrations with accuracy.
4. Foster critical thinking and problem-solving abilities in the analysis and interpretation of titration data.
5. Introduce the use of instrumental techniques like potentiometry, conductometry, and pH-metry for endpoint determination.
6. Promote safety awareness and ethical laboratory practices in handling chemicals and reporting results.
7. Prepare students for industrial and research applications, including pharmaceuticals, environmental analysis, and quality control laboratories.

Course Outcomes:

CO1. Accurately perform titrimetric analyses, including acid-base, complexometric, iodometric, precipitation, and instrumental titrations.

CO2. Standardize solutions and determine the concentration of unknown samples in different chemical and pharmaceutical applications.

CO3. Apply complexometric titration methods to estimate metal ions like calcium, magnesium, zinc, nickel, and aluminum.

CO4. Utilize precipitation titration techniques to determine chloride, sulfate, and silver Content using Mohr's, Volhard's, and Fajan's methods.

CO5. Operate instrumental titration methods (pH-metry, conductometry, potentiometry) for enhanced precision in endpoint detection

CO6. Analyze and interpret titration data, ensuring accuracy, reproducibility, and proper documentation of results.

CO7. Implement titrimetric techniques in real-world applications, such as pharmaceutical analysis, environmental testing, and quality control.

Topics and Learning Points

i. Acid-Base Titrations (Standardization & Applications)

1. Standardization of HCl using sodium carbonate (Na_2CO_3).
2. Standardization of NaOH using oxalic acid.
3. Determination of acetic acid content in vinegar.
4. Determination of carbonate and bicarbonate in a mixture.
5. Determination of aspirin content in a tablet using NaOH.
6.

ii. Complexometric Titrations (EDTA & Metal Ion Estimations)

a. Standardization of EDTA using $MgCO_3$•/ Ca CO_3 solution.
b. Determination of Ca, Mg From dolomite ore/tablet using EDTA.
c. Estimation of zinc in zinc sulfate solution using EDTA.
d. Determination of Nickel in a given sample by complexometric titration.
e. Determination of aluminum using EDTA.

iii. Iodometric & Iodimetric Titrations

a. Standardization of sodium thiosulfate using potassium dichromate ($K_2Cr_2O_7$).
b. Determination of copper in brass using iodometric titration.
c. Estimation of chlorine in bleaching powder using iodometry.
d. Determination of vitamin C content in fruit juice using iodine solution.
e. Estimation of hydrogen peroxide using potassium permanganate ($KMnO_4$).
f. Estimation of Aniline/Actone.

iv. Precipitation Titrations (Mohr's, Volhard's, Fagan's Methods)

a. Determination of chloride in a water sample using Mohr's method ($AgNO_3$).
b. Determination of chloride in a sample using Volhard's method.
c. Estimation of sulfate by $BaSO_4$ precipitation titration.
d. Determination of silver content using Fajan's adsorption indicator method.

References:

1. Vogel's Textbook of Quantitative chemical analysis.

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: B.Sc. (SEM III) **Subject:** Chemistry
Course: Practical's on Titrimetric Analysis **Course Code:** CHE-204-VSC
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	3	1	3	3	1	1	2	2	1	2	3	1
CO2	3	3	1	2	3	1	1	2	2	1	2	3	2
CO3	2	3	1	2	3	1	1	2	2	1	2	2	2
CO4	2	3	1	2	2	1	1	2	2	1	2	2	2
CO5	3	3	1	3	3	1	2	2	3	1	2	3	2
CO6	3	3	1	3	3	2	2	2	2	1	3	3	2
CO7	3	3	2	2	3	2	3	3	2	2	3	3	3

Justification for Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Gain thorough understanding of titrimetric analysis methods such as acid-base, iodometric, complexometric, and precipitation titrations.
CO2: Acquire conceptual clarity on standardization techniques and the principles behind quantitative analysis.
CO3: Understand coordination chemistry principles used in estimating metal ions through complexometric titrations.
CO4: Comprehend the fundamentals of precipitation reactions and titration mechanisms used in chloride and sulfate estimation.
CO5: Learn the theoretical background of instrumental titrations and their role in accurate endpoint detection.
CO6: Interpret titration data to assess the accuracy and reproducibility of experiments.
CO7: Relate theoretical titrimetric principles to practical use cases in various applied fields.

Practical, Professional, and Procedural Knowledge (PO2):
CO1: Demonstrate procedural accuracy in performing various types of titrations using standard laboratory practices.
CO2: Standardize solutions with precision, reflecting good lab practices and industry-aligned techniques.
CO3: Apply standardized methods in complexometric titrations to achieve consistent and accurate results.
CO4: Execute Mohr's, Volhard's, and Fajan's methods following established analytical protocols.
CO5: Utilize instruments such as pH meters and potentiometers correctly for titrimetric analysis.
CO6: Ensure correct documentation and data interpretation aligned with best lab practices.
CO7: Apply professional standards to perform titrimetric techniques in fields such as pharma and environmental chemistry.

Entrepreneurial Mindset and Knowledge (PO3):
CO1: Understand titrimetric techniques relevant to quality control, encouraging innovative thinking in product analysis.
CO2: Recognize the entrepreneurial potential in standardization processes used in formulation and

drug analysis.
CO3–CO4: Apply chemical estimation techniques that support small-scale industries and startups.
CO5: Identify novel applications of instrumental titration in tech-based chemical analysis.
CO6–CO7: Connect chemical data interpretation and real-world analysis to entrepreneurship in industrial testing and consultancy.

Specialized Skills and Competencies (PO4):
CO1: Develop precision and accuracy in laboratory skills through hands-on titrimetric operations.
CO2: Demonstrate competency in preparing and analyzing solutions across diverse applications.
CO3–CO4: Cultivate analytical skills by estimating metal ions and salts with accuracy.
CO5: Operate titration instruments with precision, showing competency in endpoint determination.
CO6: Analyze experimental data and reflect on reproducibility and accuracy through effective lab practices.
CO7: Use analytical techniques to solve practical problems in environmental and pharmaceutical contexts.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO1: Apply titration principles to analyze unknown solutions accurately.
CO2: Solve analytical problems by applying titration-based standardization in pharmaceutical formulations.
CO3–CO4: Predict and resolve experimental challenges while estimating ions or salts through various titration techniques.
CO5–CO6: Analyze data critically to determine correct titration endpoints.
CO7: Utilize titrimetric methods to solve scientific and industrial problems effectively.

Communication Skills and Collaboration (PO6):
CO1–CO2: Record and communicate findings clearly through lab reports and verbal discussions.
CO3–CO6: Present titration data effectively using standard documentation practices.
CO7: Collaborate with team members to perform titrimetric analysis in research and industrial settings.

Research-related Skills (PO7):
CO1–CO2: Observe and inquire about reaction behavior and titration curves during practical work.
CO5: Explore research-based applications of instrumental titration techniques.
CO6: Draw conclusions based on reproducibility and titration data patterns.
CO7: Conduct titrimetric research relevant to industry, environmental studies, and interdisciplinary applications.

Learning How to Learn Skills (PO8):
CO1–CO2: Learn titration techniques through repetition, observation, and reflection.
CO3–CO6: Demonstrate independent learning by refining titration techniques and improving accuracy over time.
CO7: Extend learning to new contexts by applying titrimetric analysis in diverse interdisciplinary scenarios.

Digital and Technological Skills (PO9):
CO1–CO2: Operate and calibrate digital burettes and titration instruments.
CO5: Use digital devices like pH meters, conductometers, and potentiometers to enhance analytical precision.
CO6: Analyze titration results using spreadsheet software or graphical tools for improved accuracy.
CO7: Utilize technology in real-world analysis to solve industry-relevant problems.
Multicultural Competence, Inclusive Spirit, and Empathy (PO10):

CO1–CO7: Collaborate in diverse groups during laboratory work, respecting varied opinions and roles while ensuring inclusive practice in shared lab spaces.

Value Inculcation and Environmental Awareness (PO11):
CO1–CO6: Conduct titrations responsibly, minimizing chemical waste and practicing environmentally conscious lab work.
CO7: Apply titrimetric methods for analyzing pollutants and contaminants, contributing to environmental awareness.

Autonomy, Responsibility, and Accountability (PO12):
CO1–CO2: Perform experiments independently, showcasing accountability in handling apparatus and chemicals.
CO3–CO7: Take ownership of data accuracy and maintain ethical conduct during analytical procedures.

Community Engagement and Service (PO13):
CO2–CO4: Apply titration methods in community-oriented contexts like water testing or drug analysis camps.
CO6–CO7: Contribute to societal well-being through chemical analysis used in health, safety, and quality control domains.

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of the Programme	**:** B.Sc. Chemistry
Program Code	**:** CHE
Class	**:** S.Y.B.Sc.
Semester	**:** III
Course Type	**:** Theory
Course Name	**:** Advanced Chemistry-I
Course Code	**:** CHE- 206-MN
No. of Lectures	**:** 30
No. of Credits	**:** 2 credits

Course Objectives:

1. Understand the basic concepts of chemical kinetics and the significance of rate laws and rate constants.
2. Analyze the methods for determining the order of chemical reactions using experimental and graphical techniques.
3. Learn the effect of temperature on reaction rates and evaluate activation energy using the Arrhenius equation.
4. Explore ionic and covalent bonding through the concepts of radius ratio, Born-Haber cycle, and valence bond theory.
5. Develop a conceptual understanding of hybridization and molecular structure in both homo- nuclear and polyatomic molecules.
6. Gain foundational knowledge of the physical and chemical properties of alcohols and carboxylic acid
7. Examine the general methods of preparation and chemical reactions of key organic functional groups.

Course Outcomes:

CO1. Define and interpret reaction rate laws, rate constants, and apply integrated rate equations to chemical kinetics, enhancing reaction mechanism analysis.

CO2. Apply different methods such as graphical, integration, isolation, and half-life methods to determine the order of reactions.

CO3. Calculate and interpret the effect of temperature on reaction rates using Arrhenius equation and activation energy concepts.

CO4. Explain the formation of ionic compounds using radius ratio rules, lattice energy, and Born-Haber cycle.

CO5. Describe covalent bonding using valence bond theory and evaluate molecular shapes using various types of hybridization.

CO6. Illustrate the nomenclature, physical properties, and methods of preparation of alcohols and carboxylic acids.

CO7. Predict and explain chemical reactions of alcohols and carboxylic acids including their acidic behavior and functional group transformations.

Topics and Learning Points

Unit 1: Chemical Kinetics [10 L]

Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, Integrated rate equation of first order and Second order reactions (with equal initial concentration of reactants) Determination of order of reaction by a) Integration method b) Graphical method c) Ostwald's isolation method d) Half time method, Effect of temperature on the rate of reaction, Concept of activation energy and its calculation from Arrhenius equation (derivation not expected). (Numerical problems expected wherever necessary).

Unit-2 Chemical Bonding [4 L]

Non-Directional Bonding

Ionic Bond: Conditions for the formation of ionic bond, Types of ionic crystals, radius Ratio Rules, Born Haber Cycle and its Application.

Directional Bonding: Orbital Approach[6 L]

Covalent bonding, The Valence Bond Theory – introduction and basic tenets, Interaction between two hydrogen atoms and the potential energy diagram of the system, Correction applied to the system of two hydrogen atoms – Formation of H_2, Definition, Concept of Homonuclear diatomic molecules only for He_2 and Ne_2 molecules, Resonance and the concept of Formal Charge; Rules for Resonance or Canonical structures, Bonding in polyatomic Species: The role of Hybridization. And types of Hybridisations sp, sp^2, sp^3, sp^3d, sp^2d^2, sp^2d, sp^3d^2, Equivalent and Non-equivalent hybrid orbitals.

Unit-3: Chemistry of functional groups [10L]

Alcohol:

Introduction, nomenclature, physical properties, general methods of preparations, chemical reactions.

Carboxylic acid

Introduction, nomenclature, physical properties, general methods of preparations, chemical reactions.

References:

1. Organic Chemistry. Morrison and Boyd, 6th Ed Prentice Hall, New Delhi-2001.
2. Organic Chemistry- Clayden, Oxford Uni. Press
3. Inorganic Chemistry by Vogel 6th edition
4. Concise inorganic Chemistry by J. D. Lee 5th edition

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: S.Y.B.Sc. (SEM-III) **Subject:** Chemistry
Course: Advanced Chemistry-I **Course Code:** CHE-206-MN
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	1	3	3	1	1	2	2	1	2	2	1
CO2	3	2	1	3	3	1	1	2	2	1	2	2	1
CO3	3	2	1	2	3	1	1	2	2	1	2	2	1
CO4	3	2	1	2	2	1	1	2	1	1	2	2	1
CO5	3	2	1	3	2	1	1	2	1	1	2	2	1
CO6	2	2	1	2	2	1	2	2	1	1	2	2	2
CO7	3	2	1	2	3	1	2	2	1	1	2	2	3

Justification for Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1–CO3: Build a deep theoretical understanding of chemical kinetics including rate laws, integrated rate equations, temperature dependence, and energy profiles.
CO4–CO5: Understand the principles behind ionic and covalent bonding, including the Born-Haber cycle, VSEPR, hybridization, and molecular structure.
CO6–CO7: Gain comprehensive knowledge about the structure, physical properties, nomenclature, and chemical behavior of alcohols and carboxylic acids.

Practical, Professional, and Procedural Knowledge (PO2):
CO1–CO3: Apply appropriate mathematical and logical procedures in determining reaction kinetics, rate constants, and energy parameters.
CO4–CO5: Use theoretical bonding models to predict compound behavior and structures, essentialin professional chemical analysis.
CO6–CO7: Apply procedural knowledge in identifying, synthesizing, and understanding reactivity of functional organic groups.

Entrepreneurial Mindset and Knowledge (PO3):
CO1–CO3: Foster an entrepreneurial mindset through quantitative problem-solving in kinetics and application in product formulation.
CO4–CO5: Encourage innovation in materials and molecular design using bonding theories.
CO6–CO7: Inspire small-scale synthesis ideas through organic reaction understanding relevant to food, fragrance, or pharma sectors.

Specialized Skills and Competencies (PO4):
CO1–CO3: Develop precise kinetic analysis and calculation skills used in research and development.
CO4–CO5: Build molecular modeling skills through hybridization and bonding predictions.
CO6–CO7: Cultivate organic synthetic technique and mechanism prediction relevant to labs and industry.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO1–CO3: Analyze and solve reaction-based numerical problems and predict reaction pathways and rates.
CO4–CO5: Use bonding concepts to rationalize the properties of ionic/covalent compounds.
CO6–CO7: Solve synthetic and reaction prediction problems related to alcohols and acids.

Communication Skills and Collaboration (PO6):
CO1–CO3: Clearly communicate kinetic data and interpret graphs/tables in written and oral formats.
CO4–CO7: Effectively express chemical structures and mechanisms using standard notations and reaction schemes.

Research-related Skills (PO7):
CO1–CO3: Enhance observation and inquiry through kinetic experiment design and mechanism exploration.
CO4–CO5: Link theoretical bonding concepts to real-world materials and structures.
CO6–CO7: Generate research ideas in synthesis and reactivity studies in organic chemistry.

Learning How to Learn Skills (PO8):
CO1–CO3: Apply kinetic methods and bonding theories to new systems independently**.**
CO4–CO7: Continuously improve synthetic understanding and reaction applications through exploratory learning.

Digital and Technological Skills (PO9):
CO1–CO3: Utilize digital tools (e.g., Excel, ChemDraw, kinetics software) for reaction data analysis and modeling.
CO4–CO5: Create molecular structure representations using digital tools.
CO6–CO7: Document, share, and analyze synthesis pathways digitally.

Multicultural Competence, Inclusive Spirit, and Empathy (PO10):
CO1–CO7: Collaborate in diverse learning groups, respecting differing viewpoints in problem-solving and experimental tasks.

Value Inculcation and Environmental Awareness (PO11):
CO1–CO3: Understand environmentally responsible reaction conditions and green chemistry in kinetics.
CO4–CO7: Evaluate bonding and synthesis with a perspective toward non-toxic, eco-friendly chemical alternatives.

Autonomy, Responsibility, and Accountability (PO12):
CO1–CO7: Demonstrate accountability in theoretical understanding and problem-solving; take initiative in synthesis and mechanism prediction tasks.

Community Engagement and Service (PO13):
CO6–CO7: Apply organic synthesis knowledge to societal needs such as pharmaceuticals, food chemistry, and eco-friendly products.

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of Programme	: B.Sc. Chemistry
Programme Code	: CHE
Class	: S.Y.B.Sc.
Semester	III
Course Type	: Minor
Course Name	: Applied Chemistry Practical-I
Course Code	: CHE-207-MN
No. of Contact Hours	60
No. of Credit	: 2 Credit

Course Objectives:

:

1. Develop an understanding of physical chemistry concepts by determining solubility, enthalpy, and thermodynamic parameters in chemical reactions.
2. Enhance proficiency in inorganic chemistry techniques, including the preparation and estimation of metal ions in various samples.
3. Introduce complexometric, iodometric, and titrimetric analysis methods for the determination of metal ions and pharmaceutical compounds.
4. Foster skills in organic qualitative analysis by identifying organic compounds using type determination, functional group tests, and melting/boiling point measurements.
5. Introduce chromatographic and spectroscopic techniques for compound separation and analysis.
6. Develop hands-on experience in water quality assessment, focusing on pH, total dissolved solids (TDS), and hardness determination.
7. Strengthen analytical and instrumental skills for accurate quantitative and qualitative chemical analysis.

Course Outcomes:

CO1. Apply principles of physical chemistry by determining solubility, enthalpy of dissolution, and thermodynamic parameters for chemical reactions.

CO2. Synthesize and estimate inorganic compounds, such as Mohr's salt, and determine metal content (Ca, Zn, Ni, Cu) using various titrimetric methods.

CO3. Perform iodometric and complexometric titrations for the estimation of metals like copper, nickel, and zinc in different samples.

CO4. Analyze pharmaceutical compounds, including the estimation of aspirin in tablets using titration techniques.

CO5. Identify organic compounds through qualitative analysis, including element detection, functional group determination, and physical property measurements.

CO6. Assess water quality parameters, including pH, total dissolved solids (TDS), and hardness, using standard analytical techniques.

CO7. Utilize instrumental techniques such as chromatography and spectrophotometry for

the analysis of chemical substances.

Topics and Learning Points

Section I: Physical Chemistry Practical (Any five experiments)

1. Determination of solubility of Benzoic acid at different temperature and calculate ΔH of solution.
2. Determine enthalpy of dissolution of salt (KNO_3)/NH_4Cl.
3. Determine ΔH and ΔS of the following Chemical reaction Zinc (S) + $CuSO_4$ (aq.) Cu (s) + $ZnSO_4$ (aq.)
4. Determination of heat of neutralization strong base and strong acid.
5. Determine the enthalpy change during the interaction (hydrogen bond formation) between acetone and chloroform.
6. Determination of enthalpy of hydration of copper sulphate

Section II: Inorganic Chemistry Experiments (Any five experiments)

I. Inorganic Chemistry Experiments

1. Preparation of Mohr's salt & its estimation.
2. Determination of Ca from tablet.
3. Estimation of Zn in ZnSO4 solution using EDTA.
4. Determination Nickel in Given Sample by Complexometric.
5. Determination of aspirin Content in Tablet Using NaOH.
6. Estimation of Copper in Brass using Iodometric Titration
7. Estimation of Acetone

II: Organic Chemistry Practical

1) Organic Qualitative Analysis (Six single compounds)

Identification of organic compounds through –

a) Type determination b) preliminary tests

c) Detection of elements (Sodium fusion tests)

d) Detection of functional groups e) Physical Constant (Melting point / Boiling point)

Acid : benzoic, salicylic, phthalic, cinnamic, oxalic, salicylic acid

Phenol: *α*-naphthol, *β*-naphthol, resorcinol, *o*-nitro phenol, *p*-nitro phenol

Base : aniline, *p*-toludine, diphenylamine, *N*, *N*-dimethylaniline, *o*-nitro aniline, *m*-nitro aniline, *p*-nitro aniline

Neutral: benzaldehyde, glucose, fructose, acetone, ethyl methyl ketone, acetophenone, methyl acetate, ethyl acetate, naphthalene, anthracene, nitrobenzene, *m*-dinitrobenzene, acetamide, urea, acetanilide, chloroform, carbon tetrachloride, thiourea.

III: Analytical & Instrumental Techniques

Water quality analysis:-

Physical parameters:-Temperature, Turbidity, Colour, Total Suspended Solids (TSS), Odor and taste

Chemical Parameters:- *pH*, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Hardness, Alkalinity, Chlorides, Nitrates and Nitrites, Fluorides, Heavy metals

References:

1) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
2) Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).
3) Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
4) Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
5) Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry3rd Ed.; W.H. Freeman & Co.: New York (2003).

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: S.Y.B.Sc. (SEM-III) **Subject:** Chemistry\
Course: Advanced Chemistry Practical -I **Course Code:** CHE-207-MN
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	1	3	3	1	1	2	2	1	2	2	2
CO2	3	3	1	3	3	1	2	2	2	1	2	3	2
CO3	3	3	1	3	3	1	2	2	2	1	2	3	2
CO4	3		1	2	3	2	2	2	2	1	2	3	3
CO5	3		1	3	3	1	2	2	2	1	2	2	2
CO6	3	2	1	2	3	2	2	2	2	1	3	2	3
CO7	3	3	1	3	3	2	3	2	3	2	3	3	3

Justification for Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1–CO3: Deepen understanding of physical and inorganic chemistry concepts such as solubility, enthalpy, titrimetric analysis, and thermodynamics.
CO4–CO7: Apply this theoretical knowledge in pharmaceutical, organic, and instrumental analyses, reinforcing multidisciplinary connections.

Practical, Professional, and Procedural Knowledge (PO2):
CO1–CO7: Acquire extensive procedural skills in synthesis, qualitative and quantitative estimation, and use of analytical instrumentation, building professional competency in laboratory techniques.

Entrepreneurial Mindset and Knowledge (PO3):
CO1–CO7: Foster innovation through the preparation and analysis of pharmaceutical and environmental samples, encouraging small-scale research and product development ideas.

Specialized Skills and Competencies (PO4):
CO1–CO7: Develop expertise in conducting solubility, metal estimation, qualitative analysis, and pharmaceutical titration—skills critical for roles in research labs and quality control.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO1–CO7: Strengthen ability to analyze and interpret chemical data across diverse samples, applying scientific reasoning to real-world chemical challenges including pharmaceutical and water analysis.

Communication Skills and Collaboration (PO6):
CO1–CO7: Students learn to articulate experimental findings through report writing, group discussions, and presentations, improving both verbal and written communication in scientific contexts.

Research-related Skills (PO7):
CO1–CO7: Build research aptitude through chemical synthesis, environmental testing, and use of advanced techniques like spectrophotometry and chromatography, fostering inquiry and experimentation.

Learning How to Learn Skills (PO8):
CO1–CO7: Cultivate self-driven learning through critical thinking, method validation, and reflective analysis of experimental outcomes in varied chemical domains.

Digital and Technological Skills (PO9):
CO1–CO7: Use digital tools and instruments (e.g., spectrophotometers, pH meters, chromatographs) to gather, record, and analyze chemical data accurately.

Multicultural Competence, Inclusive Spirit, and Empathy (PO10):
CO1–CO7: Participate in cooperative lab work promoting inclusivity and teamwork; develop awareness of the societal role of chemical applications.

Value Inculcation and Environmental Awareness (PO11):
CO1, CO4, CO6, CO7: Develop environmentally responsible approaches in chemical analysis (e.g., water quality testing, pharmaceutical residue analysis), emphasizing green chemistry and safe lab practices.

Autonomy, Responsibility, and Accountability (PO12):
CO1–CO7: Demonstrate accountability in lab settings by safely conducting procedures, maintaining records, and adhering to good laboratory practices.

Community Engagement and Service (PO13):
CO4, CO6, CO7: Contribute to society by evaluating pharmaceutical and environmental samples, supporting public health and industrial quality control through chemistry.

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of Programme	: B.Sc. Chemistry
Programme Code	: CHE
Class	: S.Y.B.Sc.
Semester	: III
Course Type	: Open Elective
Course Name	: Introduction to Dairy Chemistry
Course Code	: CHE-208-OE
No. of Lectures	: 30
No. of Credit	: 2 Credit

Course Objectives:

1. Provide an understanding of dairy chemistry, including the composition and nutritional importance of milk.
2. Explore the structure, properties, and functions of milk proteins and enzymes, focusing on their role in dairy products.
3. Study the chemical nature of milk lipids and carbohydrates, emphasizing their significance in dairy nutrition and metabolism.
4. Introduce students to dairy processing techniques, including pasteurization, homogenization, and quality control measures.
5. Examine fermented and value-added dairy products, including their preparation, properties, and industrial relevance.
6. Familiarize students with food safety regulations and packaging technologies in the dairy industry.
7. Highlight the application of biotechnology in dairy chemistry, focusing on innovations and advancements in dairy science.

Course Outcomes:

CO1. Explain the composition of milk and its significance in human nutrition, considering factors affecting its quality.
CO2. Describe the properties and functions of milk proteins and enzymes, along with their role in dairy product formulation.
CO3. Analyze the chemical properties of milk lipids and carbohydrates, including their impact on health and dairy processing.
CO4. Demonstrate knowledge of dairy processing techniques, including pasteurization, sterilization, and quality control methods.
CO5. Understand the science behind fermented dairy products, ice cream, condensed milk, and traditional Indian dairy products.
CO6. Apply knowledge of food safety standards and regulations, ensuring the quality and safety of dairy products.
CO7. Evaluate technological advancements in dairy chemistry, including packaging innovations and the role of biotechnology in the dairy industry.

Topics and Learning Points

Unit 1: Introduction to Dairy Chemistry (5 L)

Definition and scope of dairy chemistry, Importance of dairy products in human nutrition, Composition of milk: Water, proteins, fats, carbohydrates, and minerals, Factors affecting the composition of milk

Unit 2: Milk Proteins and Enzymes (5 L)

Casein and whey proteins: Types, properties, and functions, Role of enzymes in milk (lipase, protease, lactase), Heat stability and denaturation of milk proteins, Milk protein-based products: Paneer, cheese, and yogurt

Unit 3: Lipids and Carbohydrates in Milk (5 L)

Milk fat: Types, structure, and properties, Factors affecting milk fat content, Lactose: Chemical properties, hydrolysis, and lactose intolerance, Dairy-based carbohydrates and their nutritional significance

Unit 4: Dairy Processing and Quality Control (5 L)

Pasteurization and sterilization of milk, Homogenization and its significance,Standardization and fortification of milk, Adulteration of milk and its detection

Unit 5: Fermented and Special Dairy Products (5 L)

Fermented dairy products: Curd, buttermilk, kefir, and probiotic drinks, Ice cream, condensed milk, and milk powder, Functional dairy products and value addition, Traditional Indian dairy products (Ghee, Khoa, Rabri, etc.)

Unit 6: Dairy Industry, Packaging, and Safety Regulations (5 L)

Overview of the dairy industry in India, Packaging of dairy products and shelf life enhancement, Food safety standards and regulations (FSSAI, BIS, Codex), Role of biotechnology in dairy chemistry

References:

1. Dairy Chemistry and Biochemistry P. F. Fox, P. L. H. Mc Sweeney
2. Fundamentals of Dairy Chemistry Robert Jenness & Stuart Patton
3. Milk and Dairy Products in Human Nutrition Young W. Park

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: B.Sc. (SEM III) **Subject:** Chemistry
Course: Introduction to Dairy Chemistry **Course Code:** CHE-208-OE
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	1	2	2	2	2	2	1	2	2	2	2
CO2	3	2	1	2	2	2	2	2	1	2	2	2	2
CO3	3	2	1	2	2	2	2	2	1	2	3	2	3
CO4	3	3	1	3	3	2	2	2	2	1	2	3	3
CO5	3	3	1	2	3	2	2	2	2	2	2	2	3
CO6	3	3	2	3	3	3	3	2	2	2	3	3	3
CO7	3	3	3	3	3	2	3	2	3	2	3	3	3

Justification for Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1–CO7: Develop fundamental and applied knowledge about milk composition, processing techniques, and dairy product formulation, essential for careers in food and dairy science.

Practical, Professional, and Procedural Knowledge (PO2):
CO1–CO7: Equip students with scientific understanding of milk chemistry, enabling them to work effectively in quality assurance, R&D, and food safety roles in the dairy industry.

Entrepreneurial Mindset and Knowledge (PO3):
CO1–CO7: Encourage development of innovative dairy products and entrepreneurial ventures by integrating knowledge of dairy chemistry with consumer needs and regulatory trends.

Specialized Skills and Competencies (PO4):
CO1–CO7: Train students in specialized dairy processing techniques, such as pasteurization, sterilization, and fermentation, to prepare them for technical roles in dairy technology.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO1–CO7: Foster analytical skills for assessing milk components, detecting adulteration, and improving nutritional quality, directly addressing industry problems and health standards.

Communication Skills and Collaboration (PO6):
CO1–CO7: Develop the ability to effectively communicate scientific findings, safety protocols, and technological updates within a team and in reports relevant to the food industry.

Research-related Skills (PO7):
CO1–CO7: Strengthen research capacity through the analysis of milk components, quality assurance, biotechnology applications, and testing of processed dairy products.

Learning How to Learn Skills (PO8):
CO1–CO7: Promote lifelong learning by encouraging students to stay current with evolving technologies, food regulations, and innovations in dairy packaging and processing**.**

Digital and Technological Skills (PO9):
CO1–CO7: Train students in using analytical instruments and software for quality control, chemical testing, and production monitoring in dairy plants.

Multicultural Competence, Inclusive Spirit, and Empathy (PO10):
CO1–CO7: Engage students in understanding regional and cultural diversity of dairy consumption and traditional Indian dairy products, fostering inclusivity and appreciation of food heritage.

Value Inculcation and Environmental Awareness (PO11):
CO1–CO7: Encourage environmentally responsible dairy practices, hygiene, waste management, and the production of health-oriented dairy products.

Autonomy, Responsibility, and Accountability (PO12):
CO1–CO7: Install a sense of professional ethics and accountability in food safety, compliance with FSSAI norms, and maintaining consumer health standards.

Community Engagement and Service (PO13):
CO3–CO7: Promote dairy-based outreach programs, nutrition awareness, and adoption of sustainable, safe, and affordable dairy practices in the community.

CBCS Syllabus as per NEP 2020 (NEP 2.0) for S.Y.B.Sc Chemistry (2024 Pattern)

Name of Programme	: B.Sc. Chemistry
Programme Code	: CHE
Class	: S.Y.B.Sc.
Semester	: III
Course Type	: Subject Specific Indian Knowledge System (IKS)
Course Name	: Indian Heritage of Chemistry
Course Code	: CEM-209-IKS
No. of Lectures	: 30
No. of Credit	: 2 Credit

Course Objectives:

1. Introduce students to India's contributions to chemistry, including concepts from Vedic and ancient texts such as Rasashastra and Ayurveda.
2. Explore traditional metallurgical and material sciences, including the extraction and processing of metals, corrosion resistance, and alloy technology.
3. Understand Indian alchemy and pharmaceutical chemistry, focusing on early chemical techniques, herbal formulations, and the role of traditional medicine.
4. Examine environmental and agricultural chemistry, including natural water purification, organic farming, and sustainable practices.
5. Study traditional textile chemistry and perfumery, with an emphasis on natural dyes, eco- friendly textile processing, and essential oil extraction.
6. Analyze the relevance of Indian chemical knowledge in modern scientific advancements, including patents, research, and industrial applications.
7. Encourage interdisciplinary learning, integrating ancient Indian chemical practices with contemporary science and technology.

Course Outcomes:

CO1. Explain India's historical contributions to chemistry, including philosophical foundations such as the Panchamahabhutas.

CO2. Analyze traditional metallurgical practices, including Wootz steel, the Iron Pillar of Delhi, and ancient glass, ceramic, and dye technologies.

CO3. Describe key chemical processes in Indian alchemy and Ayurveda, such as distillation, sublimation, and herbal formulations.

CO4. Understand ancient environmental and agricultural chemistry, including biofertilizers, natural water purification, and sustainable practices.

CO5. Apply knowledge of traditional dyes and perfumery in modern industries for sustainable and eco-friendly solutions.

CO6. Evaluate the impact of ancient chemical knowledge on modern research, patents, and industrial applications.

CO7. Develop a research-oriented approach by integrating traditional chemical wisdom with contemporary scientific advancements.

Topics and Learning Points

Unit 1: Introduction to Indian Knowledge System in Chemistry (4 L)

Overview of Indian contributions to science and chemistry, Vedic and ancient Indian texts related to chemistry (Rasashastra, Ayurveda, Charaka Samhita, etc.), Philosophical foundations: Panchamahabhutas and their chemical significance

Unit 2: Ancient Indian Metallurgy and Materials Science (6 L)

Traditional extraction and purification of metals (gold, silver, iron, copper, zinc, etc.), The Iron Pillar of Delhi - corrosion resistance and scientific insights, Wootz steel and its influence on modern metallurgy, Glass, ceramics, and dye technology in ancient India

Unit 3: Indian Alchemy and Pharmaceutical Chemistry (6 L)

Rasashastra: Concept of mercury and its compounds, Early chemical processes: Distillation, sublimation, calcination, and alloying, Ayurveda and chemistry: Bhasmas, herbal formulations, and fermentation processes, Role of traditional medicine in pharmaceutical chemistry

Unit 4: Traditional Indian Environmental and Agricultural Chemistry (6 L)

Natural water purification techniques in ancient India, Organic farming and use of biofertilizers (Panchagavya, Jeevamrut, etc.), Traditional methods of soil testing and crop protection, Sustainable chemistry practices in ancient India

Unit 5: Indian Textile Chemistry and Perfumery (4 L)

Natural dyes: Indigo, madder, turmeric, and their chemical properties, Traditional textile processing and eco-friendly dyeing techniques, Ancient Indian perfumery and essential oils extraction

Unit 6: Relevance of IKS in Modern Chemistry (4 L)

Integration of traditional knowledge with modern scientific advancements, Research and patents inspired by ancient Indian practices, Case studies on traditional chemical knowledge applied today.

References:

1. भारतीय पारंपररक रसायनशास्त्र आणि आयुर्वेद

- **"Rasaratna Samuchchaya"** – Nagarjuna
- **"Charaka Samhita"** – Charaka (For Ayurvedic Chemistry)
- **"Sushruta Samhita"** – Sushruta (Medicinal Chemistry and Metals)

2. पारंपररक धातूशास्त्र आणि रसायनशास्त्र

- **"History of Chemistry in Ancient and Medieval India"** – Prafulla Chandra Ray
- **"Indian Alchemy: Soma in the Veda"** – David Gordon White
- **"Ayurvedic Pharmaceutics"** – Dr. S. D. Mishra

3. आधुननक दृष्टीकोनातून IKS आणि रसायनशास्त्र

- **"Science and Technology in Ancient India"** – Debiprasad Chattopadhyaya
- **"Traditional Knowledge System of India"** – Basanta Kumar Mohanta & Pradip Kumar Mohanta
- **"Metallurgy in India: Ancient and Medieval"** – Balasubramaniam R.

4. भारतीय संकल्पना आणि प्रयोगात्मक दृष्टकोन

- **"Indian Knowledge Systems"** – Kapil Kapoor
- **"Vedic Science and Modern Science"** – Dr. T. L. Devaraj
- **"Alchemy and Metallic Medicines in Ayurveda"** – Vaidya Bhagwan Dash

5. योग, पयाार्वरि आणि ननसगाशास्त्र

- **"Environmental Chemistry and Traditional Indian Practices"** – P. C. Jain
- **"Chemistry and Ayurveda: A Scientific Approach"** – M.S. Valiathan

Choice Based Credit System Syllabus (2023 Pattern)

(As per NEP 2020)

Class: B.Sc. (SEM III) **Subject**: Chemistry
Course: Indian Heritage of Chemistry **Course Code**: CEM-209-IKS
Weightage: 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	1	2	2	1	2	3	1	3	3	2	3
CO2	3	2	1	3	2	1	2	2	1	3	2	2	3
CO3	3	2	1	2	2	2	3	2	1	3	3	2	3
CO4	3	2	2	3	3	2	2	3	2	2	3	2	3
CO5	2	2	3	2	3	2	2	2	3	2	3	2	3
CO6	3	3	3	3	3	2	3	3	3	2	3	3	3
CO7	3	3	3	3	3	2	3	3	3	3	3	3	3

Justification for Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1–CO7: Offer deep insights into India's historic and philosophical contributions to chemistry, fostering appreciation of indigenous scientific thought and cultural heritage.

Practical, Professional, and Procedural Knowledge (PO2):
CO1–CO7: Help students understand practical applications of traditional chemistry from metallurgy to medicinal formulations—that influenced global knowledge systems.

Entrepreneurial Mindset and Knowledge (PO3):
CO5–CO7: Encourage entrepreneurial approaches by exploring traditional techniques (e.g., dyeing, perfumery, herbal medicine) with relevance in today's sustainable product markets.

Specialized Skills and Competencies (PO4):
CO2–CO7: Strengthen students' abilities to relate ancient processes (like distillation, smelting, and purification) with modern chemical techniques, contributing to skill-based learning.

Capacity for Application, Problem-Solving, and Analytical Reasoning (PO5):
CO2–CO7: Train students to analyze and reinterpret ancient practices to address modern challenges in green chemistry, sustainability, and resource optimization.

Communication Skills and Collaboration (PO6):
CO1–CO7: Improve communication skills by encouraging research presentations, project work, and discussion of cross-cultural scientific developments.

Research-related Skills (PO7):
CO3–CO7: Nurture research thinking by integrating ancient techniques with modern scientific tools, encouraging innovation and revival of traditional knowledge.

Learning How to Learn Skills (PO8):
CO1–CO7: Install lifelong curiosity by connecting historical chemical knowledge with present-day science, technology, and societal applications.

Digital and Technological Skills (PO9):
CO5–CO7: Develop ability to digitize traditional knowledge, utilize databases, and apply modern analytical tools to validate and reinterpret ancient chemistry practices.

Multicultural Competence, Inclusive Spirit, and Empathy (PO10):
CO1–CO7: Promote awareness of India's multicultural legacy in science, fostering pride, inclusivity, and global appreciation for heritage science.

Value Inculcation and Environmental Awareness (PO11):
CO1–CO7: Emphasize sustainability and ethical values through traditional chemical practices like natural dyeing, eco-friendly agriculture, and pollution-free metallurgy.

Autonomy, Responsibility, and Accountability (PO12):
CO1–CO7: Reinforce a sense of responsibility in preserving, reviving, and responsibly applying traditional scientific knowledge in modern contexts.

Community Engagement and Service (PO13):
CO1–CO7: Encourage community-based projects and awareness programs that integrate ancient knowledge systems in areas like organic farming, health, and rural development.