



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 IV

(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 of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more 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 fourth 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), NCeF, 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 become 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.

PSO4: 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, recognize 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 learning 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
6.	Dr. Yogesh N. Indulkar	Member
7.	Dr. Deepali S. Pakhare	Member
8.	Mrs. Supriya S. Deokate	Member
9.	Mrs. Jyoti T. Waghmode	Member
10.	Ms. Geetanjali S. Bhunje	Member
11.	Mrs. Reshma T. Gadadare	Member
12.	Mrs. Swati A. Deokate	Member
13.	Ms. Sakshi S. Navale	Member
14.	Ms. Pratiksha P. Tak	Member
15.	Ms. Anjali N. Bhong	Member
16.	Dr. Pravinkumar B. Patil	Member
17.	Mrs. Kalpana Surnavar	Member
18.	Ms. Pratiksha R. Bankar	Member
19.	Mrs. Chaitrali A. Bunage	Member
20.	Dr. Dilip Satpute	External Member VC Nominee
21.	Dr. Sidaram Pujari	External Member from other University
22.	Dr. Vijay Vader	External Member from other University

23.	Dr. Nitin Jadhav	Member Representative Alumni
24.	Mr. Dadaso Kare	Member Representative from Industry
25.	Ms. Tanishka Phadatare	UG Student Representative
26.	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/CE P/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 BSc (Chemistry)-2024-2025

Level	Semester	Sub. DSC-I Languages	Sub. DSC-II Social Science-I	Sub. DSC-III Social Science-II	OE	SEC	IKS	AEC	VEC	CC	Degree/Cum.Cr.
4.5	I	2 T + 2 T / P	2 T + 2 T / P	2 T + 2 T / P	2 T (from other faculty)	2 T / P	2 T (Generic)	2 T (C. Eng.)	2 T	--	22
	I	2 T + 2 T / P	2 T + 2 T / P	2 T + 2 T / P	2 T / P (from other faculty)	2 T / P	--	2 T (C. Eng.)	2 T	2 T YOG/PES/ CUL/NSS/ NCC	22
Total Credits											44

* 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 = 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
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Major Mandatory Theory
Course Name	: Physical and Inorganic Chemistry-II
Course Code	: CHE-251-MRM
No. of Lectures	: 30
No. of Lectures	: 2 credits

Course Objectives:

1. Develop a strong conceptual understanding of liquid-liquid solutions, their ideal and non-ideal behavior, and related physical parameters.
2. Introduce the principles and applications of the laws of thermodynamics to chemical systems.
3. Explain the concepts of entropy, free energy, and spontaneity of chemical reactions with numerical illustrations.
4. Establish the relationship between free energy and chemical equilibrium, and analyze equilibrium behavior under varying conditions.
5. Familiarize students with the molecular orbital theory and its application to homonuclear and heteronuclear diatomic molecules.
6. Enhance analytical, numerical, and problem-solving skills through calculations and data interpretation in thermodynamics and equilibrium.
7. Encourage self-learning, scientific reasoning, and effective communication of physical chemistry concepts.

Course Outcomes:

After successful completion of this course, the learner will be able to:

- CO1. Explain the types and properties of liquid–liquid solutions, including ideal and non - ideal behavior, vapour pressure relations, azeotropes, and distillation processes.
- CO2. Apply the laws of thermodynamics to interpret energy transformations, entropy changes, and the spontaneity of chemical and physical processes.
- CO3. Calculate and analyze entropy and free energy changes for reversible and irreversible systems under different thermodynamic conditions.
- CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.
- CO5. Illustrate and interpret molecular orbital diagrams for homonuclear and heteronuclear diatomic molecules to explain bond order, magnetism, and molecular stability.
- CO6. Solve numerical and theoretical problems related to thermodynamics, equilibrium, and phase

behavior using appropriate analytical and computational approaches.

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

Topics and Learning Points

Unit I: Solutions of Liquids in Liquids

[8 L]

Types of solutions, vapour pressure of ideal and non-ideal solutions, boiling point diagram of miscible binary mixtures, distillation of binary miscible solutions, azeotropes. Partial miscibility of liquids, vapour pressure and distillation of immiscible liquids, determination of molecular weight by steam distillation.

Unit II: Chemical Thermodynamics

[6 L]

Second Law of Thermodynamics: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change (ΔS) for reversible and irreversible processes under different conditions. Numerical problems.

Third Law of Thermodynamics: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Unit III: Free energy and Chemical Equilibrium

[6 L]

Introduction, Helmholtz free energy, variation of it with volume and temperature, Gibbs free energy, variation of it with pressure and temperature, Gibbs free energy change for chemical reaction, Free energy change for an ideal gas. Free Energy and equilibrium - Concept, Definition and significance, Exergonic and endergonic reaction. The perfect gas equilibrium, the general case of equilibrium, the relation between equilibrium constants, molecular interpretation of equilibrium constant. The response of equilibria to conditions- response to pressure, response to temperature, VantHaff equation, Value of K at different temperature, Problems

Unit IV: Molecular Orbital Theory of Covalent Bonding

[10 L]

Introduction to Molecular Orbital Method (MOT) and postulates of MO theory, LCAO approximation, s-s combination of orbitals, s-p combination of orbitals, p-p combination of orbitals, p-d combination of orbitals, d-d combination of orbitals, nonbonding combination of orbitals, Rules for linear combination of atomic orbitals, example of molecular orbital treatment for homonuclear diatomic molecules: Explain following molecules with respect to MO energy level diagram, bond order and magnetism, H_2 molecule, He_2 molecule, Li_2 molecule, Be_2 molecule, B_2 molecule, C_2 molecule, N_2 molecule, O_2 molecule, O^{2-} and O^{2+} ion, F_2 molecule, Heteronuclear diatomic molecules: NO, CO.

References

1. Principles of Physical Chemistry, S. H. Marron and C. F. Pruton, 6th edn.
2. Essentials of Physical Chemistry, Bahl, Tuli, Revised multicolour edn. 2009
3. Physical Chemistry, G. M. Barrow, Tata McGraw-Hill (2007)
4. University Chemistry, B. H. Mahan, 3rd edn. Narosa (1998)
5. Chemical Thermodynamics, R. P. Rastogi and R.P. Misera
6. Atkin's Physical Chemistry, Peter Atkins, Julio De Paula, Oxford publication. 8th ed.
7. Elements of Physical Chemistry, Peter Atkins, Julio De Paula, Oxford publication, 5th ed.
8. Concise Inorganic Chemistry J.D.Lee 7th edition.
9. Principles of Inorganic Chemistry, B.K.Sharma
10. Modern Inorganic Chemistry, Dr.R.D.Brown

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Physical and Inorganic Chemistry-II **Course Code** : CHE-251-MRM**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1=weak or low relation, 2=moderate or partial relation, 3=strong or direct relation**Mapping of COs with POs**

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

Justification for the mapping**PO1 Comprehensive Knowledge and Understanding**

- CO1. Explain the types and properties of liquid–liquid solutions, including ideal and non-ideal behavior, vapour pressure relations, azeotropes, and distillation processes.
- CO2. Apply the laws of thermodynamics to interpret energy transformations, entropy changes, and the spontaneity of chemical and physical processes.
- CO3. Calculate and analyze entropy and free energy changes for reversible and irreversible systems under different thermodynamic conditions.
- CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.
- CO5. Illustrate and interpret molecular orbital diagrams for homonuclear and heteronuclear diatomic molecules to explain bond order, magnetism, and molecular stability.

PO2 Practical, Professional, and Procedural Knowledge

- CO1. Explain the types and properties of liquid–liquid solutions, including ideal and non-ideal behavior, vapour pressure relations, azeotropes, and distillation processes.
- CO2. Apply the laws of thermodynamics to interpret energy transformations, entropy changes, and the spontaneity of chemical and physical processes.
- CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.
- CO6. Solve numerical and theoretical problems related to thermodynamics, equilibrium, and phase behavior using appropriate analytical and computational approaches.

PO3 Entrepreneurial Mindset and Knowledge

- CO1. Explain the types and properties of liquid–liquid solutions, including ideal and non-ideal behavior, vapour pressure relations, azeotropes, and distillation processes.
- CO2. Apply the laws of thermodynamics to interpret energy transformations, entropy changes, and the spontaneity of chemical and physical processes.

CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.

PO4 Specialized Skills and Competencies

CO3. Calculate and analyze entropy and free energy changes for reversible and irreversible systems under different thermodynamic conditions.

CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.

CO5. Illustrate and interpret molecular orbital diagrams for homonuclear and heteronuclear diatomic molecules to explain bond order, magnetism, and molecular stability.

CO6. Solve numerical and theoretical problems related to thermodynamics, equilibrium, and phase behavior using appropriate analytical and computational approaches.

PO5. Capacity for Application, Problem-Solving, and Analytical Reasoning

CO2. Apply the laws of thermodynamics to interpret energy transformations, entropy changes, and the spontaneity of chemical and physical processes.

CO3. Calculate and analyze entropy and free energy changes for reversible and irreversible systems under different thermodynamic conditions.

CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.

CO5. Illustrate and interpret molecular orbital diagrams for homonuclear and heteronuclear diatomic molecules to explain bond order, magnetism, and molecular stability.

CO6. Solve numerical and theoretical problems related to thermodynamics, equilibrium, and phase behavior using appropriate analytical and computational approaches.

PO6 Communication Skills and Collaboration

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

PO7 Research-Related Skills

CO2. Apply the laws of thermodynamics to interpret energy transformations, entropy changes, and the spontaneity of chemical and physical processes.

CO3. Calculate and analyze entropy and free energy changes for reversible and irreversible systems under different thermodynamic conditions.

CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

PO8 Learning How to Learn Skills

CO6. Solve numerical and theoretical problems related to thermodynamics, equilibrium, and phase behavior using appropriate analytical and computational approaches.

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

PO9 Digital and Technological Skills

CO6. Solve numerical and theoretical problems related to thermodynamics, equilibrium, and phase behavior using appropriate analytical and computational approaches.

PO10 Multicultural Competence, Inclusive Spirit, and Empathy

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

PO11 Value Inculcation and Environmental Awareness

CO2. Apply the laws of thermodynamics to interpret energy transformations, entropy changes, and the spontaneity of chemical and physical processes.

CO4. Correlate Gibbs and Helmholtz free energy with chemical equilibrium and predict the effect of temperature and pressure on equilibrium constants using the Van't Hoff equation.

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

PO12 Autonomy, Responsibility, and Accountability

CO6. Solve numerical and theoretical problems related to thermodynamics, equilibrium, and phase behavior using appropriate analytical and computational approaches.

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

PO13 Community Engagement and Service

CO7. Demonstrate scientific reasoning, effective communication, and ethical responsibility in learning, reporting, and applying physical chemistry principles.

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

Name of the Programme	: B.Sc. Chemistry
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Major Mandatory Theory
Course Name	: Organic and Inorganic Chemistry-II
Course Code	: CHE-252-MRM
No. of Lectures	: 30
No. of Lectures	: 2 credits

Course Objectives:

1. Understand the structure, nomenclature, and methods of preparation of aldehydes, ketones, and amines.
2. Explain and analyze characteristic reactions and mechanisms of carbonyl and amine compounds.
3. Explore the synthesis, reactivity, and properties of aromatic and heterocyclic compounds.
4. Comprehend the principles of coordination chemistry, including bonding, nomenclature, geometries, and stability of complexes.
5. Study the structure, bonding, and reactions of metal carbonyl complexes, including their industrial applications.
6. Develop analytical and problem-solving skills through reaction mechanisms, synthetic strategies, and interpretation of chemical data.
7. Promote research aptitude, effective communication, ethical practice, environmental awareness, and social responsibility in chemical applications.

Course Outcomes:

- CO1. Explain the structure, nomenclature, and preparation methods of aldehydes, ketones, and amines.
- CO2. Analyze and predict the characteristic reactions and mechanisms of carbonyl and amine compounds, including condensation and reduction reactions.
- CO3. Demonstrate understanding of the synthesis, reactions, and properties of aromatic and heterocyclic compounds.
- CO4. Describe the fundamental principles of coordination chemistry, including bonding, geometry, nomenclature, and stability of complexes.
- CO5 .Understand the structure, bonding, and reactivity of metal carbonyl complexes and their applications in industrial catalysis.
- CO6. Solve numerical, mechanistic, and synthetic problems to develop analytical and problem-solving skills in organic and inorganic chemistry.
- CO7. Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

Topics and Learning Points**Unit 1: Aldehydes and Ketones****[7 L]**

Introduction and IUPAC nomenclature, preparation of aldehydes- From primary alcohol, from methyl benzene and from acid chlorides. Preparation of Ketones from secondary alcohol, Friedel -craft acylation and from nitriles. *Reactions* – Reaction with HCN, ROH, NH₂-G derivatives. Aldol Condensation, Cannizzaro's reaction, Benzoin condensation, Clemenson reduction, Wolff-Kishner reduction and Meerwein-Pondorff Verley reduction.

Ref 1

Unit 2: Aliphatic and Aromatic amines**[5 L]**

Introduction, nomenclature, physical Properties, preparation of amine from – reduction of nitro compounds, reductive amination, reduction of nitriles, Hoffmann degradation of amides. Reactions of amines - alkylation, conversion into amides, ringsubstitution in aromatic amines, Hoffmann elimination, diazonium salts – preparation, Sandmeyer reactions, analysis of amines.

Ref 1

Unit 3: Aromatic Homocyclic and Heterocyclic compounds**[8 L]**

Homocyclic compounds-Nomenclature, synthesis, and reactions of naphthalene and anthracene
Heterocyclic compounds- Definition, classification, aromatic character. Synthesis of heterocyclic compound containing one hetero atom- pyrrole, furan, thiophene and pyridine and their reactions – nitration, sulphonation, acylation and catalytic reductions.

Ref 1,3

Unit 4: Intraduction to Co-ordination Chemistry**[6 L]**

General account and meaning of the terms involved in coordination chemistry: Coordinate bond, central metal atom or ions, ligand, double salt, coordination compound, coordination number, charge on the complex ion, oxidation number of central metal ion, first and second coordination sphere, Ligands: Definition, Classification, Chelate and chelating agents, IUPAC nomenclature of coordination compounds, Different geometries of coordination compounds with C. N.= 4 and 6 with examples of each geometry. Stability of coordination complexes

Ref 5,6

Unit 5. Chemistry of Carbonyl Complexes.**[4 L]**

Introduction, Definition, bonding in carbonyl complexes, 18 electron rule-M bonds in carbonyl complexes, geometries of coordination complexes, CO π acid Ligands. Synthesis of carbonyl complexes: direct reaction, reductive carboxylation, photolysis, thermolysis, and homogeneous catalysis: hydro-formylation by Cobalt carbonyl complex, Wacker's process and Monsanto acetic acid process, Wilkinson catalyst.

Ref 6,7

References

1. Organic Chemistry: Morrison and Boyd, 6th Edn.
2. Organic Chemistry: Clayden, Oxford Uni. Press.
3. Heterocyclic Chemistry by Joule and Mill, 5th Edn.
4. Bahl, A. and Bahl, B.S. *Advanced Organic Chemistry*, S. Chand,.
5. Basic Inorganic Chemistry, Cotton, F.A., Wilkinson, G. & Gaus, P.L. 3rd ed., Wiley.
6. Concepts and Models in Inorganic Chemistry, Douglas, B.E., McDaniel, D.H. & Alexander, J.J. John Wiley & Sons.
7. Inorganic Chemistry: Principles of Structure and Reactivity, Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Pearson (2006)

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Organic and Inorganic Chemistry-II**Course Code** : CHE-252-MRM**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation**Mapping of COs with POs**

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

Justification for the mapping**PO1. Comprehensive Knowledge and Understanding**

CO1 Explain the structure, nomenclature, and preparation methods of aldehydes, ketones, and amines.

CO2 Analyze and predict the characteristic reactions and mechanisms of carbonyl and amine compounds, including condensation and reduction reactions.

CO3 Demonstrate understanding of the synthesis, reactions, and properties of aromatic and heterocyclic compounds.

CO4 Describe the fundamental principles of coordination chemistry, including bonding, geometry, nomenclature, and stability of complexes.

CO5 Understand the structure, bonding, and reactivity of metal carbonyl complexes and their applications in industrial catalysis.

PO2 Practical, Professional, and Procedural Knowledge

CO1 Explain the structure, nomenclature, and preparation methods of aldehydes, ketones, and amines.

CO2 Analyze and predict the characteristic reactions and mechanisms of carbonyl and amine compounds, including condensation and reduction reactions.

CO3 Demonstrate understanding of the synthesis, reactions, and properties of aromatic and heterocyclic compounds.

CO4 Describe the fundamental principles of coordination chemistry, including bonding, geometry, nomenclature, and stability of complexes.

CO6 Solve numerical, mechanistic, and synthetic problems to develop analytical and problem-solving skills in organic and inorganic chemistry.

PO3 Entrepreneurial Mindset and Knowledge

CO5 Understand the structure, bonding, and reactivity of metal carbonyl complexes and their applications in industrial catalysis.

PO4 Specialized Skills and Competencies

CO2 Analyze and predict the characteristic reactions and mechanisms of carbonyl and amine compounds, including condensation and reduction reactions.

- CO3 Demonstrate understanding of the synthesis, reactions, and properties of aromatic and heterocyclic compounds.
- CO4 Describe the fundamental principles of coordination chemistry, including bonding, geometry, nomenclature, and stability of complexes.
- CO5 Understand the structure, bonding, and reactivity of metal carbonyl complexes and their applications in industrial catalysis.
- CO6 Solve numerical, mechanistic, and synthetic problems to develop analytical and problem-solving skills in organic and inorganic chemistry.

PO5 Capacity for Application, Problem-Solving, and Analytical Reasoning

- CO1 Explain the structure, nomenclature, and preparation methods of aldehydes, ketones, and amines.
- CO2 Analyze and predict the characteristic reactions and mechanisms of carbonyl and amine compounds, including condensation and reduction reactions.
- CO3 Demonstrate understanding of the synthesis, reactions, and properties of aromatic and heterocyclic compounds.
- CO4 Describe the fundamental principles of coordination chemistry, including bonding, geometry, nomenclature, and stability of complexes.
- CO5 Understand the structure, bonding, and reactivity of metal carbonyl complexes and their applications in industrial catalysis.
- CO6 Solve numerical, mechanistic, and synthetic problems to develop analytical and problem-solving skills in organic and inorganic chemistry.

PO6 Communication Skills and Collaboration

- CO7 Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

PO7 Research-Related Skills

- CO2 Analyze and predict the characteristic reactions and mechanisms of carbonyl and amine compounds, including condensation and reduction reactions.
- CO7 Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

PO8 Learning How to Learn Skills

- CO6 Solve numerical, mechanistic, and synthetic problems to develop analytical and problem-solving skills in organic and inorganic chemistry.
- CO7 Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

PO9 Digital and Technological Skills

- CO6 Solve numerical, mechanistic, and synthetic problems to develop analytical and problem-solving skills in organic and inorganic chemistry.

PO10 Multicultural Competence, Inclusive Spirit, and Empathy

- CO7 Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

PO11 Value Inculcation and Environmental Awareness

CO7 Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

PO12 Autonomy, Responsibility, and Accountability

CO7 Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

PO13 Community Engagement and Service

CO7 Apply research skills, ethical principles, effective communication, and environmental awareness in chemical practice and reporting.

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

Name of the Programme	: B.Sc. Chemistry
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Major Mandatory Practical
Course Name	: Chemistry Practical-IV
Course Code	: CHE-253-MRM
No. of Lectures	: 60
No. of Lectures	: 2 credits

Course Objectives:

1. Develop a fundamental understanding of experimental techniques in Physical, Organic, and Inorganic Chemistry, including measurement of thermodynamic and reaction parameters.
2. Acquire practical skills to determine thermodynamic properties such as transition temperature, heat of solution, heat of neutralization, enthalpy (ΔH), and entropy (ΔS).
3. Apply kinetic principles to study the effect of concentration on reaction rates and analyze experimental data to derive rate laws.
4. Develop the ability to perform qualitative analysis of inorganic salts, including identification of acidic and basic radicals using systematic and confirmatory tests.
5. Gain proficiency in organic qualitative analysis, including separation of binary mixtures and determination of physical constants of organic compounds.
6. Acquire practical skills in organic synthesis through laboratory preparation of compounds such as acetylated amines, aldol condensation products, and quinones using green chemistry approaches.
7. Foster scientific reasoning, analytical thinking, safe laboratory practices, effective communication, and ethical responsibility in conducting chemical experiments.

Course Outcomes:

- CO1. Perform physical chemistry experiments to determine thermodynamic properties such as transition temperature, heat of solution, heat of neutralization, enthalpy (ΔH), and entropy (ΔS).
- CO2. Apply kinetic principles to investigate the effect of concentration on reaction rates and analyze experimental data quantitatively.
- CO3. Determine critical solution temperatures, densities, and partial molar volumes to understand solution behavior.
- CO4. Conduct qualitative analysis of inorganic salts, including identification of basic and acidic radicals using systematic and confirmatory tests.
- CO5. Perform organic qualitative analysis, including separation of binary mixtures and determination of physical constants.

- CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.
- CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

Topics and Learning Points

Unit 1: Physical Chemistry Practical (Any Five)

1. To determine the transition temperature of a hydrated salt by Thermometric method.
2. Determination the heat of solution of KNO_3 / NH_4Cl .
3. To study the effect of change in concentration of sodium thiosulphate on the rate of reaction between sodium thiosulphate and hydrochloric acid.
4. Determination of critical solution temperature (CST) of phenol-water system.
5. Determination of heat of neutralization of strong base and strong acid.
6. Determine ΔH and ΔS of the following Chemical reaction
$$\text{Zn (s)} + \text{CuSO}_4 \text{ (aq.)} \rightarrow \text{Cu (s)} + \text{ZnSO}_4 \text{ (aq.)}$$
7. Determine the enthalpy change during the interaction (hydrogen bond formation) between acetone and chloroform.
8. Determine the densities of series on solutions and to calculate partial molar volume of the component.

Unit 2: Inorganic Chemistry Practical (Any Five Mixtures without phosphate and borate)

1. Preliminary Tests, Dry tests for Basic radical, Preparation of solution, Analysis of basic radicals into group with confirmatory tests.
2. Preliminary Tests, Dry tests for Acidic radical, Preparation of solution, detection of acidic radicals and confirmatory tests

Unit 3: Organic Chemistry Practical

1. **Organic Qualitative Analysis** (Three mixtures: solid-solid, solid-liquid, and liquid- liquid type)
Determination of type, separation of two components and determination of physical constant from given binary mixture of organic compounds.
2. **Organic Preparations** (Any two)
 1. Acetylation of primary aromatic amine (Green approach)
 2. Base Catalyzed Aldol condensation (Green approach)
 3. Preparation of Quinone from hydroquinone

References

1. Practical Organic Chemistry by – A.I. Vogel.
2. Practical Organic Chemistry by – O.P. Agarwal
3. Vogel's Textbook Quantitative Chemical Analysis, 3rd and 5th Ed. Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
4. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001).
5. Khosla, B. D.; Garg, V. C. & Ulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
7. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Chemistry Practical-II**Course Code** : CHE-253-MRM**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation**Mapping of COs with Pos**

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

Justification for the mapping**PO1 Comprehensive Knowledge and Understanding**

- CO1. Perform physical chemistry experiments to determine thermodynamic properties such as transition temperature, heat of solution, heat of neutralization, enthalpy (ΔH), and entropy (ΔS).
- CO2. Apply kinetic principles to investigate the effect of concentration on reaction rates and analyze experimental data quantitatively.
- CO3. Determine critical solution temperatures, densities, and partial molar volumes to understand solution behavior.
- CO4. Conduct qualitative analysis of inorganic salts, including identification of basic and acidic radicals using systematic and confirmatory tests.
- CO5. Perform organic qualitative analysis, including separation of binary mixtures and determination of physical constants.
- CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.

PO2 Practical, Professional, and Procedural Knowledge

- CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO3 Entrepreneurial Mindset and Knowledge

- CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.

PO4 Specialized Skills and Competencies

- CO2. Apply kinetic principles to investigate the effect of concentration on reaction rates and analyze experimental data quantitatively.

- CO3. Determine critical solution temperatures, densities, and partial molar volumes to understand solution behavior.
- CO4. Conduct qualitative analysis of inorganic salts, including identification of basic and acidic radicals using systematic and confirmatory tests.
- CO5. Perform organic qualitative analysis, including separation of binary mixtures and determination of physical constants.
- CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.

PO5 Capacity for Application, Problem-Solving, and Analytical Reasoning

- CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO6 Communication Skills and Collaboration

- CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO7 Research-Related Skills

- CO2. Apply kinetic principles to investigate the effect of concentration on reaction rates and analyze experimental data quantitatively.
- CO3. Determine critical solution temperatures, densities, and partial molar volumes to understand solution behavior.
- CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.
- CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO8 Learning How to Learn Skills

- CO2. Apply kinetic principles to investigate the effect of concentration on reaction rates and analyze experimental data quantitatively.
- CO3. Determine critical solution temperatures, densities, and partial molar volumes to understand solution behavior.
- CO5. Perform organic qualitative analysis, including separation of binary mixtures and determination of physical constants.
- CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.
- CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO9 Digital and Technological Skills

- CO1. Perform physical chemistry experiments to determine thermodynamic properties such as transition temperature, heat of solution, heat of neutralization, enthalpy (ΔH), and entropy (ΔS).
- CO2. Apply kinetic principles to investigate the effect of concentration on reaction rates and analyze experimental data quantitatively.

CO3. Determine critical solution temperatures, densities, and partial molar volumes to understand solution behavior.

CO5. Perform organic qualitative analysis, including separation of binary mixtures and determination of physical constants.

CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.

PO10 Multicultural Competence, Inclusive Spirit, and Empathy

CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO11 Value Inculcation and Environmental Awareness

CO6. Execute organic synthesis experiments, such as acetylation of amines, base-catalyzed aldol condensation, and quinone preparation, applying green chemistry principles.

CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO12 Autonomy, Responsibility, and Accountability

CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

PO13 Community Engagement and Service

CO7. Demonstrate laboratory safety, analytical reasoning, effective reporting, ethical conduct, and environmental awareness in chemical experimentation.

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

Name of the Programme	: B.Sc. Chemistry
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Vocational Skill Course Theory
Course Name	: Introduction to Analytical Chemistry
Course Code	: CHE-254-VSC
No. of Lectures	: 30
No. of Lectures	: 2 credits

Course Objectives:

1. Develop a fundamental understanding of chemical analysis, its types, applications, and the principles of analytical chemistry.
2. Understand and evaluate errors, accuracy, precision, and reliability of analytical results, including statistical treatment of data.
3. Gain proficiency in volumetric analysis techniques including neutralization, complexometric, redox, precipitation, and iodometric titrations.
4. Learn the preparation, standardization, and calibration of solutions and analytical apparatus for accurate quantitative analysis.
5. Develop practical skills to perform analytical experiments, determine equivalence points, and calculate concentrations with precision.
6. Understand the principles, instrumentation, working, and applications of modern analytical tools such as pH meters and conductivity meters.
7. Foster analytical thinking, problem-solving, safe laboratory practices, effective documentation, and ethical responsibility in chemical analysis.

Course Outcomes:

- CO1 Understand the fundamentals of analytical chemistry, including types, techniques, applications, and factors affecting the choice of analytical methods.
- CO2 Identify and evaluate different types of errors, understand accuracy and precision, and apply statistical methods to improve reliability of analytical results.
- CO3 Perform volumetric analysis accurately, including neutralization, complexometric, redox, precipitation, and iodometric titrations.
- CO4 Calibrate analytical apparatus, prepare and standardize solutions, and determine equivalence points for quantitative analysis.
- CO5 Analyze experimental data, calculate concentrations, and apply problem-solving skills in various titration methods.

CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.

CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

Topics and Learning Points

Unit-1: Introduction to Analytical Chemistry

[4 L]

Introduction, chemical analysis, applications of chemical analysis, sampling, types of analysis, common techniques, Instrumental methods of analysis, factor affecting on choice of method.

Unit-2: Errors in Quantitative analysis

[6 L]

Introduction to Error, Accuracy, Precision, Methods of expressing accuracy and precision, Classifications of errors, Significant figures, Distribution of random errors, Mean and Standard deviations, Reliability of results, Numerical.

Unit-3: Volumetric Analysis

[4 L]

Introduction to volumetric analysis, Calibration of apparatus, Standard solutions, Equivalent weights in different type of reactions, Classification of volumetric analysis, Neutralization titration: Acid base indicators, Ostwald's theory of indicators, Neutralization curves for strong acid- strong base, weak acid- strong base, weak base- strong acid, Determination of equivalence point and calculations. Problems.

Complexometric titration: Principle, Mg- EDTA titration, metal ion indicators, choice of indicators. Applications,

Redox titration: Principle, detection of equivalence point using suitable Indicators. Titration between oxalic acid and KMnO_4 . Applications.

Precipitation titration: Principle, titration between AgNO_3 and halide ions by Volhard's method and Fajan's method. Detection of end point of the titration. Applications.

Iodometric titration: Principle, detection of end point, difference between iodometry and iodimetry, standardization of $\text{Na}_2\text{S}_2\text{O}_3$ solution using $\text{K}_2\text{Cr}_2\text{O}_7$ and estimation of iodine. Applications

Unit-4: Instrumental methods

[6 L]

Instrumentation- Principle, working and applications of pH meter and conductivity meter, Numerical problems.

References

1. Instrumental Methods of Chemical Analysis-Chatwal and Anand
2. Basic Concept of Analytical Chemistry- 2nd edition S.M. Khopkar
3. Vogel's text book of Quantitative Inorganic Analysis-4th edition
4. Instrumental Methods of Chemical Analysis- 6th edition Willard, Merritt, Dean and Settle
5. Analytical Chemistry by Skoog
6. Introduction to Instrumental Analysis-R.D. Braun
7. Instrumental methods of Chemical Analysis- Willard, Dean & errit-6th Edition

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Introduction to Analytical Chemistry**Course Code** : CHE-254-VSC**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation**Mapping of COs with POs**

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

Justification for the mapping**PO1 Comprehensive Knowledge and Understanding**

- CO1. Understand the fundamentals of analytical chemistry, including types, techniques, applications, and factors affecting the choice of analytical methods.
- CO2 Identify and evaluate different types of errors, understand accuracy and precision, and apply statistical methods to improve reliability of analytical results.
- CO3 Perform volumetric analysis accurately, including neutralization, complexometric, redox, precipitation, and iodometric titrations.
- CO4 Calibrate analytical apparatus, prepare and standardize solutions, and determine equivalence points for quantitative analysis.
- CO5 Analyze experimental data, calculate concentrations, and apply problem-solving skills in various titration methods.
- CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.

PO2 Practical, Professional, and Procedural Knowledge

- CO3 Perform volumetric analysis accurately, including neutralization, complexometric, redox, precipitation, and iodometric titrations.
- CO4 Calibrate analytical apparatus, prepare and standardize solutions, and determine equivalence points for quantitative analysis.
- CO5 Analyze experimental data, calculate concentrations, and apply problem-solving skills in various titration methods.
- CO6 Understand the principles, working, and applications of instrumental methods such as pH meters

and conductivity meters, and perform numerical calculations.

PO3 Entrepreneurial Mindset and Knowledge

CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.

PO4 Specialized Skills and Competencies

CO2 Identify and evaluate different types of errors, understand accuracy and precision, and apply statistical methods to improve reliability of analytical results.

CO3 Perform volumetric analysis accurately, including neutralization, complexometric, redox, precipitation, and iodometric titrations.

CO4 Calibrate analytical apparatus, prepare and standardize solutions, and determine equivalence points for quantitative analysis.

CO5 Analyze experimental data, calculate concentrations, and apply problem-solving skills in various titration methods.

CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.

PO5 Capacity for Application, Problem-Solving, and Analytical Reasoning

CO2 Identify and evaluate different types of errors, understand accuracy and precision, and apply statistical methods to improve reliability of analytical results.

CO3 Perform volumetric analysis accurately, including neutralization, complexometric, redox, precipitation, and iodometric titrations.

CO4 Calibrate analytical apparatus, prepare and standardize solutions, and determine equivalence points for quantitative analysis.

CO5 Analyze experimental data, calculate concentrations, and apply problem-solving skills in various titration methods.

PO6 Communication Skills and Collaboration

CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

PO7 Research-Related Skills

CO2 Identify and evaluate different types of errors, understand accuracy and precision, and apply statistical methods to improve reliability of analytical results.

CO5 Analyze experimental data, calculate concentrations, and apply problem-solving skills in various titration methods.

CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.

CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

PO8 Learning How to Learn Skills

- CO2 Identify and evaluate different types of errors, understand accuracy and precision, and apply statistical methods to improve reliability of analytical results.
- CO5 Analyze experimental data, calculate concentrations, and apply problem-solving skills in various titration methods.
- CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.
- CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

PO9 Digital and Technological Skills

- CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.

PO10 Multicultural Competence, Inclusive Spirit, and Empathy

- CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

PO11 Value Inculcation and Environmental Awareness

- CO6 Understand the principles, working, and applications of instrumental methods such as pH meters and conductivity meters, and perform numerical calculations.
- CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

PO12 Autonomy, Responsibility, and Accountability

- CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

PO13 Community Engagement and Service

- CO7 Demonstrate safe laboratory practices, effective documentation, analytical reasoning, ethical conduct, and environmental awareness in chemical analysis.

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

Name of the Programme	: B.Sc. Chemistry
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Minor Theory
Course Name	: Advanced Chemistry-II
Course Code	: CHE-256-MN
No. of Lectures	: 30
No. of Lectures	: 2 credits

Course Objectives:

1. To understand the fundamental concepts of thermodynamics including system, surroundings, state and path functions, and various thermodynamic processes.
2. To study the First Law of Thermodynamics and its application in calculating heat, work, internal energy, and enthalpy changes.
3. To learn the principles of thermochemistry, enthalpy of reactions, bond energies, and Kirchhoff's equation for temperature dependence of reaction enthalpy.
4. To understand the structure, bonding, and Lewis acidity of boron compounds and their applications in chemical reactions.
5. To study the chemistry of nitrogen family elements with emphasis on preparation, structure, and reactivity of oxides of nitrogen.
6. To develop spatial understanding of organic molecules through different types of isomerism and their representations.
7. To gain knowledge of stereochemical concepts including conformational, geometrical, and optical isomerism and related nomenclature (E/Z, R/S).

Course Outcomes:

After successful completion of the course, the student will be able to:

- CO1. Identify and classify thermodynamic systems, variables, and processes in chemical reactions.
- CO2. Apply the first law of thermodynamics to calculate energy changes in physical and chemical transformations.

- CO3. Evaluate various enthalpy changes such as formation, combustion, and bond energies using thermochemical equations and Kirchhoff's law.
- CO4. Explain the structure, bonding, and Lewis acidity of electron-deficient boron compounds and predict their reactivity.
- CO5. Compare the properties and structures of oxides and other compounds of the nitrogen family.
- CO6. Represent organic molecules in three dimensions and analyze conformations of simple alkanes with energy profiles.
- CO7. Distinguish between geometrical and optical isomers and assign correct E/Z and R/S configurations.

Topics and Learning Points

Unit 1: Chemical Thermodynamics

[10 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).

Thermo chemistry: 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 thermo chemical data, Kirchhoff's equation. (Numerical problems expected wherever necessary) Ref 1, 2 3

Unit 2: P-block elements:

[10 L]

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 Nitrogen family

Trends in chemical reactivity, formation of hydrides, halides, oxides, oxides of nitrogen with respect to preparation and structure of NO, NO_2 , N_2O , and N_2O_4 .

Ref. 4, 5

Unit 3: Stereochemistry

[10 L]

Concept of isomerism, representation of organic molecules in 3D on paper, 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. 6

References

1. Principles of Physical Chemistry, Marron and Prutton, 4th Edition.
2. Essentials of Physical Chemistry, Bahl and Tuli,
3. Principles of Physical Chemistry, Puri, Sharma and Phathania
4. Concise Inorganic Chemistry, J. D. Lee, 5th Edition
5. Concept and Models of Inorganic Chemistry, Douglass and Daniel, 3rd Edition
6. Stereochemistry of carbon compounds, E.L. Eliel

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Advanced Chemistry-II**Course Code** : CHE-256-MN**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation**Mapping of COs with POs**

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

Justification for the mapping**PO1 – Comprehensive Knowledge and Understanding**

CO1: Understands thermodynamic systems and variables.

CO2: Applies the First Law of Thermodynamics.

CO3: Calculates enthalpies, bond energies, and thermochemical data.

CO4: Explains boron compounds and Lewis acidity.

CO5: Describes nitrogen oxides and chemical trends.

CO6: Represents molecules in 3D and compares conformations.

CO7: Assigns E/Z and R/S stereochemical configurations.

PO2 – Practical, Professional, and Procedural Knowledge

CO2: Performs thermodynamic calculations for work, heat, and energy.

CO3: Solves numerical problems related to reaction enthalpies and bond energies.

CO4: Prepares and analyzes boron compounds experimentally.

CO5: Understands nitrogen family chemistry for laboratory applications.

CO6: Uses 3D molecular representations to communicate chemical structures effectively.

PO3 – Entrepreneurial Mindset and Knowledge

CO3: Develops analytical and systematic problem-solving skills applicable to chemical innovation.

CO6: Uses molecular modeling and visualization tools that support innovative solutions in chemistry-based industries.

PO4 – Specialized Skills and Competencies

COs: CO1, CO2, CO3, CO4, CO5, CO6, CO7

Justification:

CO1–CO3: Strengthens analytical, calculation, and reasoning skills.

CO4–CO5: Enhances understanding of structure, bonding, and reactivity.

CO6–CO7: Develops stereochemical visualization, molecular representation, and effective communication of chemical information.

PO5 – Capacity for Application, Problem-Solving, and Analytical Reasoning

CO1–CO3: Applies thermodynamic and thermochemical concepts to solve numerical problems.

CO4–CO5: Uses structural and bonding knowledge to predict chemical reactivity.

PO6 – Communication Skills and Collaboration

CO6: Communicates molecular structures through 3D diagrams.

CO7: Explains stereochemistry to peers in a collaborative learning environment.

PO7 – Research-related Skills

CO2: Designs and performs thermodynamic calculations.

CO6: Uses modeling to study molecular conformations.

CO7: Analyzes stereochemical data for research-based reasoning.

PO8 – Learning How to Learn Skills

CO2: Learns thermodynamics through problem-solving and experiments.

CO4–CO5: Acquires knowledge independently in boron and nitrogen chemistry.

CO6: Develops spatial and conceptual understanding of molecules.

PO9 – Digital and Technological Skills

CO3: Uses digital tools for thermochemical calculations.

CO4: Applies software or simulations for bonding and structural analysis.

CO6: Employs molecular modeling software for 3D visualization.

PO10 – Multicultural Competence, Inclusive Spirit, and Empathy

CO7: Collaborates in stereochemistry exercises, respecting diverse approaches and perspectives in learning.

PO11 – Value Inculcation and Environmental Awareness

CO4–CO5: Understands environmental implications of boron and nitrogen compounds.

CO7: Practices safe and ethical laboratory techniques during stereochemistry experiments.

PO12 – Autonomy, Responsibility, and Accountability

CO2: Performs thermodynamic calculations independently.

CO6–CO7: Analyzes molecular structures and stereochemistry responsibly, showing accountability for experimental results.

PO13 – Community Engagement and Service

CO7: Participates in group learning and peer-assisted activities, contributing knowledge to support community learning.

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

Name of the Programme	: B.Sc. Chemistry
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Minor Practical
Course Name	: Practicals on Advanced Chemistry-II
Course Code	: CHE-257-MN
No. of Lectures	: 60
No. of Lectures	: 2 credits

Course Objectives:

1. To understand and perform fundamental physical chemistry experiments involving kinetics, reaction rates, pH-metry, and conductometry.
2. To determine rate constants, reaction order, and related kinetic parameters from experimental data.
3. To gain proficiency in volumetric and instrumental titrations using pH-metry and conductometry.
4. To develop practical skills in inorganic qualitative analysis for identification of acidic and basic radicals.
5. To acquire techniques in organic qualitative analysis, including separation, identification, and determination of physical constants of binary mixtures.
6. To enhance analytical reasoning and experimental problem-solving through observation, calculation, and interpretation of results.
7. To cultivate laboratory discipline, safety, and documentation skills essential for professional chemical practice.

Course Outcomes:

- CO1. Perform kinetic experiments to determine rate constants and analyze reaction order accurately.
- CO2. Apply first-order and second-order kinetic equations to interpret experimental data in chemical reactions.
- CO3. Conduct pH-metric and conductometric titrations between acids and bases and interpret titration curves.
- CO4. Identify acidic and basic radicals in water-soluble inorganic mixtures through systematic qualitative analysis.

- CO5. Analyze binary mixtures of organic compounds, separate components, and determine their physical constants.
- CO6. Apply practical knowledge to solve experimental problems, calculate values, and interpret results reliably.
- CO7. Maintain laboratory records, follow safety protocols, and demonstrate accountability and teamwork in practical work.

Topics and Learning Points

Unit 1: Physical Chemistry Practical (any Five)

1. Determination of rate constant of a reaction between potassium per sulphate and potassium iodide for equal initial concentration of the reactants.
2. To determine the first order rate constant of acid catalyzed ester hydrolysis.
3. To study the kinetics of iodination of acetone and hence determine the order of reaction.
4. Titration between strong/weak acid and strong base by using pH-metry.
5. Titration between strong/weak acid and strong base by using conductometry.
6. Determine the densities of series on solutions and to calculate partial molar volume of the component.

Unit 2: Inorganic Chemistry Practical (any Five)

Inorganic qualitative analysis – water soluble mixture Acidic / Basic radicals (any five)

Unit 3: Organic Chemistry Practical

Organic Qualitative Analysis (five mixtures: solid-solid, solid-liquid, and liquid-liquid type)

Determination of type, separation of two components and determination of physical constant from given binary mixture of organic compounds.

References

1. Practical Organic Chemistry by – A.I. Vogel.
2. Practical Organic Chemistry by – O.P. Agarwal
3. Vogel's Textbook Quantitative Chemical Analysis, 3rd and 5th ed
4. Practical Inorganic Chemistry by – A.I. Vogel.

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Practical on Advanced Chemistry-II**Course Code** : CHE-257-MN**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation**Mapping of COs with POs**

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

Justification for the mapping**PO1 – Comprehensive Knowledge and Understanding**

Students acquire a strong foundation in experimental techniques across physical, inorganic, and organic chemistry and develop broad chemical knowledge

CO1: Performs kinetics experiment to understand rate constants and reaction order.

CO2: Determines first-order and second-order kinetic parameters.

CO3: Studies reaction order of iodination of acetone.

CO4: Performs pH-metric titration of acids and bases.

CO5: Performs conductometric titration of acids and bases.

CO6: Determines densities and partial molar volumes of solutions.

CO7: Performs qualitative analysis of organic binary mixtures.

PO2 – Practical, Professional, and Procedural Knowledge

Students gain hands-on experience in professional lab practices, following standardized procedures.

CO1: Applies procedural steps for reaction kinetics measurements.

CO2: Follows correct methodology for first-order reaction experiments.

CO3: Applies systematic procedures for iodination kinetics.

CO4: Performs pH-metric titrations following standard protocols.

CO5: Executes conductometric titrations using proper techniques.

CO6: Determines densities and partial molar volumes using correct procedures.

CO7: Separates and identifies components in organic qualitative analysis.

PO3 – Entrepreneurial Mindset and Knowledge

Problem-solving and analytical skills in experiments encourage innovative thinking applicable to chemical industries and entrepreneurship

CO6: Uses data interpretation from densities and partial molar volumes to innovate solution analysis.

CO7: Designs strategies for separation and identification in organic mixtures.

PO4 – Specialized Skills and Competencies

Students acquire specialized lab skills in kinetics, titrations, qualitative and quantitative analysis.

CO1: Measures reaction rates accurately.

CO2: Calculates kinetic parameters reliably.

CO3: Interprets kinetic data for iodination of acetone.

CO4: Plots and analyzes pH titration curves.

CO5: Analyzes conductometric titration data.

CO6: Calculates partial molar volumes from density data.

CO7: Identifies organic compounds and determines their physical constants.

PO5 – Capacity for Application, Problem-Solving, and Analytical Reasoning

Students develop strong analytical reasoning and problem-solving skills through hands-on experiments.

CO1: Uses experimental data to calculate rate constants.

CO2: Applies kinetic formulas to solve reaction order problems.

CO3: Analyzes reaction mechanism from experimental results.

CO4: Interprets pH-metric titration curves.

CO5: Analyzes conductometric titration results.

CO6: Solves problems to calculate partial molar volumes.

PO6 – Communication Skills and Collaboration

Lab exercises enhance scientific communication, reporting, and teamwork.

CO7: Prepares lab reports for organic mixture analysis and communicates results effectively.

CO4 & CO5: Discuss titration results and collaborate in lab groups.

PO7 – Research-related Skills

Students learn to formulate observations, analyze experimental data, and develop basic research skills.

CO1: Observes reaction progress and measures rates accurately.

CO2: Designs kinetic experiments and analyzes data critically.

CO6: Uses density measurements to investigate solution behavior.

PO8 – Learning How to Learn Skills

Encourages self-directed learning, adaptability, and acquisition of new laboratory skills

CO1–CO6: Students perform various physical and inorganic experiments independently.

CO7: Students learn techniques for organic mixture analysis through guided practice.

PO9 – Digital and Technological Skills

Students develop proficiency in digital tools for experimental data analysis.

CO3: Plots kinetic data using software or calculators.

CO4 & CO5: Uses pH meters, conductivity meters, or digital plotting tools.

CO6: Uses software or calculators for density and partial molar volume calculations.

PO10 – Multicultural Competence, Inclusive Spirit, and Empathy

Promotes teamwork, respect for diverse approaches, and cooperative problem-solving

CO7: Works collaboratively in pairs or groups for organic mixture separation and identification.

PO11 – Value Inculcation and Environmental Awareness

Students develop ethical awareness and responsibility for safe and sustainable chemical practices.

CO4, CO5, CO6, CO7: Practices chemical safety, proper disposal, and environmentally responsible lab conduct.

PO12 – Autonomy, Responsibility, and Accountability

Students learn accountability, time management, and responsible conduct in laboratory work.

CO1–CO7: Performs experiments independently, maintains lab records, and ensures accurate reporting.

PO13 – Community Engagement and Service

Encourages peer support, mentorship, and contribution to the learning community.

CO6 & CO7: Shares techniques and helps peers during practical sessions.

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

Name of the Programme	: B.Sc. Chemistry
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Open Elective (OE) Practical
Course Name	: Practicals on Dairy Chemistry
Course Code	: CHE-258-OE
No. of Lectures	: 60
No. of Lectures	: 2 credits

Course Objectives:

1. To develop skills for determining pH, acidity, viscosity, and specific gravity of milk and milk products.
2. To identify and detect additives, preservatives, neutralizers, and contaminants in milk.
3. To determine fat, protein, moisture, and total solids content in milk and milk products.
4. To understand methods for analyzing dairy products, including Channa, Paneer, Ghee, Khoa, and Ice Cream.
5. To perform quantitative estimation of albumin and calcium in milk samples.
6. To interpret experimental results and apply analytical reasoning in dairy quality assessment.
7. To develop laboratory discipline, safety awareness, and documentation skills relevant to dairy analysis.

Course Outcomes:

1. By the end of the course, students will be able to:
2. Measure pH, titratable acidity, viscosity, and specific gravity of milk and milk products accurately.
3. Detect additives, preservatives, neutralizers, and salts in milk samples.
4. Determine fat, protein, total solids, and moisture content in various dairy products.
5. Analyze dairy-based solids such as Channa, Paneer, Ice Cream, Khoa, and condensed milk.
6. Quantitatively estimate albumin and calcium in milk and related products.

7. Apply practical knowledge for quality assessment and problem-solving in dairy analysis.
8. Maintain accurate lab records, follow safety protocols, and work collaboratively in a laboratory environment.

Topics and Learning Points

Name of the Practicals: (Any 15)

- 1) To Determine pH of given samples of milk and milk products
- 2) Detection of Additives in given sample of milk
- 1) Urea b) Starch c) Sugar
- 3) Detection of Preservatives in given sample of milk
a) Formaldehyde b) Boric acid
- 4) Detection of Neutralizers in given sample of milk
- 5) Determination of specific gravity of milk using a lactometer.
- 6) Determination of the fat content in milk
- 7) Determination of the percentage of total solids in the given samples of milk
- 8) Determination of the protein content in the given samples of milk
- 9) To determine the Titratable acidity of given samples of milk
- 10) To measure viscosity of milk
- 11) Detection of Sodium Chloride in milk
- 12) Determination of Moisture in Channa/Paneer
- 13) Determination of Total Solids in the Ice Cream
- 14) To determine the Titratable acidity of condensed milk
- 15) Determination of Moisture in Dried Milk/ Khoa
- 16) Detection of Vanaspati in Ghee
- 17) Separation of casein from milk
- 18) Determination of albumin in milk
- 19) Determination of calcium in milk.

References

- 1) Lab. Manual 1 manual of methods of analysis of foods milk and milk products food safety and standards authority of India ministry of health and family welfare government of India New Delhi 2015
- 2) Indian Standard Methods of Test For Dairy Industry Part 2: Chemical Analysis of Milk
- 3) Chemistry and Testing of Dairy Products- H.V. Atherton, J. A. New Lander, CBS, Publishers and Distributors

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Practicals on Dairy Chemistry**Course Code** : CHE-258-OE**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation**Mapping of COs with Pos**

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

Justification for the mapping**PO1 – Comprehensive Knowledge and Understanding**

Students develop a strong foundation in dairy chemistry practicals with hands-on experience in analytical methods

CO1: Measures pH, acidity, viscosity, specific gravity of milk.

CO2: Detects additives, preservatives, and neutralizers in milk.

CO3: Determines fat, protein, total solids, and moisture.

CO4: Analyzes dairy-based solids like Channa, Paneer, Ice Cream, Khoa, and condensed milk.

CO5: Estimates albumin and calcium content.

CO6: Applies analytical reasoning to interpret results.

CO7: Maintains lab records and follows protocols.

PO2 – Practical, Professional, and Procedural Knowledge

Ensures competence in professional and standardized lab practices for dairy analysis

CO1–CO7: Follows correct laboratory procedures for all physical and chemical determinations in dairy products.

PO3 – Entrepreneurial Mindset and Knowledge

Supports innovation and practical application in the dairy sector and quality control labs

CO6: Applies analytical reasoning to improve quality assessment processes.

CO5: Designs quantitative analysis for albumin and calcium relevant to dairy industry practices.

PO4 – Specialized Skills and Competencies

Students gain specialized skills directly applicable to dairy laboratories and quality testing.

CO1–CO7: Develops skills in measuring pH, acidity, viscosity, specific gravity, detection of contaminants, fat/protein estimation, and quantitative dairy analysis.

PO5 – Capacity for Application, Problem-Solving, and Analytical Reasoning

Enhances problem-solving and analytical reasoning through hands-on dairy experiments.

CO1–CO6: Uses experimental data to determine composition and quality of milk and milk products.

PO6 – Communication Skills and Collaboration

Develops effective communication and collaborative skills in the lab.

CO7: Prepares reports, documents procedures, and collaborates with peers.

CO4 & CO5: Discusses results and participates in team-based experiments.

PO7 – Research-related Skills

Builds the ability to formulate observations, analyze data critically, and understand experimental outcomes

CO1, CO2, CO6: Observes, analyzes, and interprets experimental data for research-quality reporting.

PO8 – Learning How to Learn Skills

Promotes independent learning and adaptability to new methods and experiments.

CO1–CO6: Encourages self-directed learning and adaptation to different dairy analysis techniques.

PO9 – Digital and Technological Skills

Students gain technological proficiency in dairy quality analysis

CO1–CO5, CO6: Uses instruments like lactometer, viscometer, and pH meter; software or calculators for data plotting and analysis.

PO10 – Multicultural Competence, Inclusive Spirit, and Empathy

Encourages teamwork, inclusion, and respect for diverse learning approaches

CO7: Works collaboratively in lab teams, assisting peers in dairy experiments.

PO11 – Value Inculcation and Environmental Awareness

Students develop ethical awareness and environmental responsibility

CO2, CO3, CO4, CO5, CO6, CO7: Practices safe handling, chemical disposal, and sustainable laboratory practices.

PO12 – Autonomy, Responsibility, and Accountability

Develops responsible and self-directed lab practices

CO1–CO7: Performs experiments independently and maintains accountability for lab work.

PO13 – Community Engagement and Service

Encourages engagement, peer mentoring, and collaborative learning.

CO6 & CO7: Assists peers, shares techniques, and contributes to learning community.

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

Name of the Programme	: B.Sc. Chemistry
Programme Code	: USCH
Class	: S.Y.B.Sc
Semester	: IV
Course Type	: Skill Enhancement Course (SEC) Practical
Course Name	: Practicals on Instrumental Analysis
Course Code	: CHE-259-SEC
No. of Lectures	: 60
No. of Lectures	: 2 credits

Course Objectives:

1. To develop skills for determination of unknown concentrations of solutions using colorimetry, photometry, and flame photometry.
2. To apply titrimetric and conductometric methods for acid-base, redox, and complexometric reactions.
3. To determine cell constants and dissociation constants using conductometry and pH-metry.
4. To perform turbidimetric and potentiometric titrations for analysis of ions in solutions.
5. To calculate molecular and specific refractivity of liquids and determine mixture compositions.
6. To interpret experimental data and apply analytical reasoning and problem-solving in chemical analysis.
7. To cultivate laboratory discipline, safety, and accurate documentation skills essential for professional chemical practice.

Course Outcomes:

After completing this course, students will be able to:

- CO1. Determine unknown concentrations using colorimetry, photometry, and flame photometry techniques.
- CO2. Perform titrations of strong/weak acids and bases using pH-metry and conductometry and interpret titration curves.
- CO3..Calculate cell constants, dissociation constants, and degree of hydrolysis using conductometric and pH-metric methods.

- CO4. Apply turbidimetry and potentiometry for analysis of chloride, silver, and redox systems.
- CO5. Determine molecular and specific refractivity of liquids and the composition of binary mixtures.
- CO6. Analyze experimental data, perform calculations, and solve practical problems accurately.
- CO7. Maintain laboratory safety, proper records, and collaborate effectively during experiments.

Topics and Learning Points

Name of Practicals: (Any 15)

- 1) Determination of unknown concentration of KMnO_4 by Colorimetry.
- 2) Determination of unknown concentration of CuSO_4 by Colorimetry.
- 3) To determine the concentration of given titanium solution of unknown concentration using H_2O_2 at 440 nm by colorimetric method
- 4) To titrate Cu^{2+} ions with EDTA photo metrically.
- 5) To determine the cell constant of given cell using 0.1M KCl solution and determine dissociation constant of given monobasic weak acid.
- 6) Titration between strong acid and strong base by using Conductometric.
- 7) Titration of strong and weak acid with strong base by using conductometry.
- 8) To study the hydrolysis of aniline hydrochloride by conductometry
- 9) Titration between strong acid and strong base by using pH metry
- 10) Titration of strong and weak acid with strong base by using pH metry.
- 11) To determine the degree of hydrolysis of aniline hydrochloride by pH metry
- 12) Determination of dissociation constant of oxalic acid by pH metry.
- 13) Turbidimetry titration.(AgNO_3 Vs KCl)
- 14) To determine the turbidance of given different water sample.
- 15) To determine the concentration of reductant or oxidant by redox titration by potententiometry.
- 16) To determine the molecular refractivity of the given liquids A,B, C and D .
- 17) To determine the specific refractivity of the given liquid A and B and determine percentage composition of the mixture C of liquid A and B.
- 18) Demonstration of Flame photometry.

References

1. Experimental Physical Chemistry V.D. Athawale, Parul Marul, New Age International Publishers
2. Practical Physical Chemistry, A M. Jemes, F.E.Prichard, 3rd edn, Longman
3. Advanced Practical Physical Chemistry, J. B.Yadav, Goel Publishing house

Choice Based Credit System Syllabus (2024 Pattern)**(As per NEP 2020)****Class** : S.Y.B.Sc. (SEM IV)**Subject** : Chemistry**Course Name** : Practicals on Instrumental analysis**Course Code** : CHE-259-SEC**Mapping of Course Outcomes with Program Outcomes****Weightage:** 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation**Mapping of COs with POs**

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

Justification for the mapping**PO6 – Communication Skills and Collaboration**

Enhances scientific communication and teamwork in laboratory settings

CO7: Prepares accurate lab reports and collaborates with peers.

CO2 & CO4: Discusses titration and ion analysis results in groups.

PO7 – Research-related Skills

Builds the ability to formulate observations, analyze data

PO1 – Comprehensive Knowledge and Understanding

Students gain broad analytical knowledge in concentration determination, titrations, and physical property measurements

CO1: Determines unknown concentrations using colorimetry, photometry, and flame photometry.

CO2: Performs pH-metric and conductometric titrations.

CO3: Calculates cell constants and dissociation constants.

CO4: Applies turbidimetry and potentiometry for ion analysis.

CO5: Determines molecular and specific refractivity of liquids.

CO6: Analyzes experimental data and performs calculations.

CO7: Maintains lab records and follows protocols.

PO2 – Practical, Professional, and Procedural Knowledge

Ensures competence in professional laboratory practices for analytical chemistry

CO1–CO7: Follows standardized procedures for titrations, colorimetry, photometry, refractometry, and other analytical experiments.

PO3 – Entrepreneurial Mindset and Knowledge

Supports practical innovation and problem-solving relevant to chemical industries and laboratory services

CO5: Uses refractivity measurements to analyze mixtures, which can support product development.

CO6: Interprets experimental data for innovation in analytical techniques.

PO4 – Specialized Skills and Competencies

Students acquire specialized analytical skills directly applicable to research and quality control laboratories

CO1–CO7: Develops skills in colorimetric, conductometric, pH-metric, turbidimetric, potentiometric, and refractometric analyses.

PO5 – Capacity for Application, Problem-Solving, and Analytical Reasoning

Strengthens problem-solving and analytical reasoning in chemical analysis

CO1–CO6: Applies formulas and calculations to determine concentrations, constants, and composition of samples.

critically, and design experiments.

CO1, CO3, CO6: Observes, analyzes, and interprets experimental data for research-oriented reporting.

PO8 – Learning How to Learn Skills

Promotes independent learning and adaptability to new experimental techniques.

CO1–CO6: Encourages self-directed learning in colorimetry, conductometry, pH-metry, and refractometry.

PO9 – Digital and Technological Skills

Develops technical proficiency in modern analytical tools.

CO1–CO5, CO6: Uses instruments like colorimeters, flame photometers, pH meters, conductivity meters, and refractometers.

PO10 – Multicultural Competence, Inclusive Spirit, and Empathy

Promotes teamwork, inclusion, and respect for diverse approaches in lab settings.

CO7: Collaborates effectively in laboratory groups, supporting peer learning.

PO11 – Value Inculcation and Environmental Awareness

Students develop ethical awareness and environmental responsibility

CO2, CO3, CO4, CO5, CO6, CO7: Practices safe handling, chemical disposal, and ethical laboratory conduct.

PO12 – Autonomy, Responsibility, and Accountability

Develops responsible and self-directed laboratory practices.

CO1–CO7: Performs experiments independently, maintains accurate lab records, and ensures accountability.

PO13 – Community Engagement and Service

Encourages peer mentorship and active engagement in the learning community.

CO6 & CO7: Assists peers, shares experimental knowledge, and contributes to collaborative learning.