केंद्रीयजनजातीयविश्वविद्यालयआंध्रप्रदेश

CENTRAL TRIBAL UNIVERSITY OF ANDHRA PRADESH

(A CENTRAL UNIVERSITY ESTABLISHED BY AN ACT OF PARLIAMENT)

CURRICULUM & SYLLABUS

B.Sc. (Hons.) Chemistry /
B.Sc. (Hons. with Research) Chemistry

[Duration: 4 years]

(As per National Education Policy 2020)

w.e.f. 2023-24 admitted batch

DEPARTMENT OF CHEMISTRY
SCHOOL OF SCIENCES
CENTRAL TRIBAL UNIVERSITY OF ANDHRA PRADESH
VIZIANAGARAM – 535003, A.P.

B.Sc. (Hons.) Chemistry/
B.Sc. (Hons. with Research) Chemistry

(w.e.f. 2023-24 admitted batch)

DEPARTMENT OF CHEMISTRY

The Department of Chemistry at CTUAP is dedicated to providing students with a comprehensive education in Chemistry, aligned with the National Education Policy (NEP-2020). Our undergraduate and postgraduate Chemistry programs integrate fundamental principles, theories, and practical applications, covering diverse subjects such as Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, Physical Chemistry, and Chemical Biology. The department focuses on addressing global challenges in Synthetic Organic Chemistry, Renewable Energy, Environmental Sustainability, Nanotechnology, and the welfare of Tribal communities through its research endeavors.

PROGRAM OBJECTIVES

The B.Sc. (Hons.) Chemistry or B.Sc. (Hons. with Research) Chemistry program, designed in accordance with the objectives outlined in the NEP-2020, is committed to providing students with a rigorous academic foundation, research opportunities, and practical skills necessary for success in the field of chemistry and beyond. By integrating interdisciplinary learning, research orientation, and ethical principles, the program seeks to nurture the next generation of competent and socially responsible scientists poised to address global challenges and contribute to scientific innovation and progress.

PROGRAM REGULATIONS

1. CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMMES

The National Education Policy (NEP) 2020 recognizes that higher education plays an extremely important role in promoting human as well as societal well-being. It notes that "given the 21st-century requirements, quality higher education must aim to develop good, thoughtful, well-rounded, and creative individuals".

A new student-centric "Curriculum and Credit Framework for Undergraduate Programmes (CCFUP)" incorporating a flexible choice-based credit system, multidisciplinary approach, and multiple entry and exit options. This will facilitate students to pursue their career path by choosing the subject/field of their interest.

The NEP envisages several transformative initiatives in higher education. These include:

- Adoption of flexible curricular structures in order to enable creative combinations of disciplinary areas for study in multidisciplinary contexts that would also allow flexibility in course options that would be on offer to students, in addition to rigorous specialization in a subject or subjects.
- B.Sc Chemistry degree program of either 3 or 4-year duration, with multiple entry and exit points and re-entry options, with appropriate certifications such as:

- UG certificate after completing 1 year (2 semesters) of study in Chemistry.
- UG diploma in Chemistry after 2 years (4 semesters) of study.
- B.Sc in Chemistry after a 3-year (6 semesters) programme of study,
- 4-year B.Sc (Honours) after eight semesters programme of study. If the student completes a rigorous research project in their major area(s) of study in the 4th year of a B.Sc (Honours with Research).
- The 4-year bachelor's degree programme is considered a preferred option since it would provide the opportunity to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per the choices of the student.
- Inclusion of credit-based courses and projects in the areas of community engagement and service, environmental education, and value-based education.
- Value-based education to include the development of humanistic, ethical, Constitutional, and universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values, and life skills.

2. SEMESTER/CREDITS

- A semester comprises 90 working days and an academic year is divided into two semesters.
- A summer term is for eight weeks during summer vacation. Internship/apprenticeship/work-based vocational education and training can be carried out during the summer term, especially by students who wish to exit after two semesters or four semesters of study. Regular courses may also be offered during the summer on a fast-track mode to enable students to do additional courses or complete backlogs in coursework.

3. MAJOR AND MINOR DISCIPLINES

- **Major discipline: Chemistry** is the discipline or subject of main focus and the degree will be awarded in Chemistry. Students should secure the prescribed number of credits (about 50% of total credits) through core courses in the major discipline.
- **Minor discipline** helps a student to gain a broader understanding beyond the major discipline. For example, if a student pursuing a Chemistry major obtains a minimum of 12 credits from a bunch of courses in Physics, then the student will be awarded a B.Sc. degree in Chemistry with a Minor in Physics. The Department of Chemistry will encourage the students to take up minors in Physics/Mathematics/Botany/Geology/AI etc.

4. AWARDING UG CERTIFICATE, UG DIPLOMA, AND DEGREES

- **UG Certificate:** Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG certificate if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the

degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

- **UG Diploma**: Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma if, in addition, they complete one vocational course of 4 credits during the summer vacation of the second year.
- Students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.
- **3-year UG Degree*:*** Students who wish to undergo a 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 120 credits and satisfying the minimum credit requirement.
- **4-year UG Degree (Honours):** A four-year UG Honours degree in the major discipline will be awarded to those who complete a four-year degree programme with 160 credits and have satisfied the credit requirements.
- **4-year UG Degree (Honours with Research):** Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

5. CREDIT HOURS FOR DIFFERENT TYPES OF COURSES

The workload relating to a course is measured in terms of credit hours. A credit is a unit by which the coursework is measured. It determines the number of hours of instruction required per week over the duration of a semester (minimum 15 weeks).

- Each course may have only a lecture component or a lecture and tutorial component or a lecture and practicum component or a lecture, tutorial, and practicum component, or only practicum component. For example, a three-credit lecture course in a semester means three one-hour lectures per week with each one-hour lecture counted as one credit. In a semester of 15 weeks duration, a three-credit lecture course is equivalent to 45 hours of teaching.
- One credit for tutorial work means one hour of engagement per week. In a semester of 15 weeks duration, a one-credit tutorial in a course is equivalent to 15 hours of engagement.
- A one-credit course in practicum or lab work, community engagement and services, and fieldwork in a semester mean two-hour engagement per week. In a semester of 15 weeks duration, a one-credit practicum in a course is equivalent to 30 hours of engagement.
- A one-credit of Seminar or Internship or Studio activities or Field practice/projects or Community engagement and service means two-hour engagements per week. Accordingly, in a semester of 15 weeks duration, one credit in these courses is equivalent to 30 hours of engagement.

6. ELIGIBILITY FOR THE UG PROGRAMMES

Senior Secondary School Leaving Certificate or Higher Secondary (12th Grade) Certificate obtained after successful completion of Grade 12 or equivalent stage of education corresponding to Level-4.

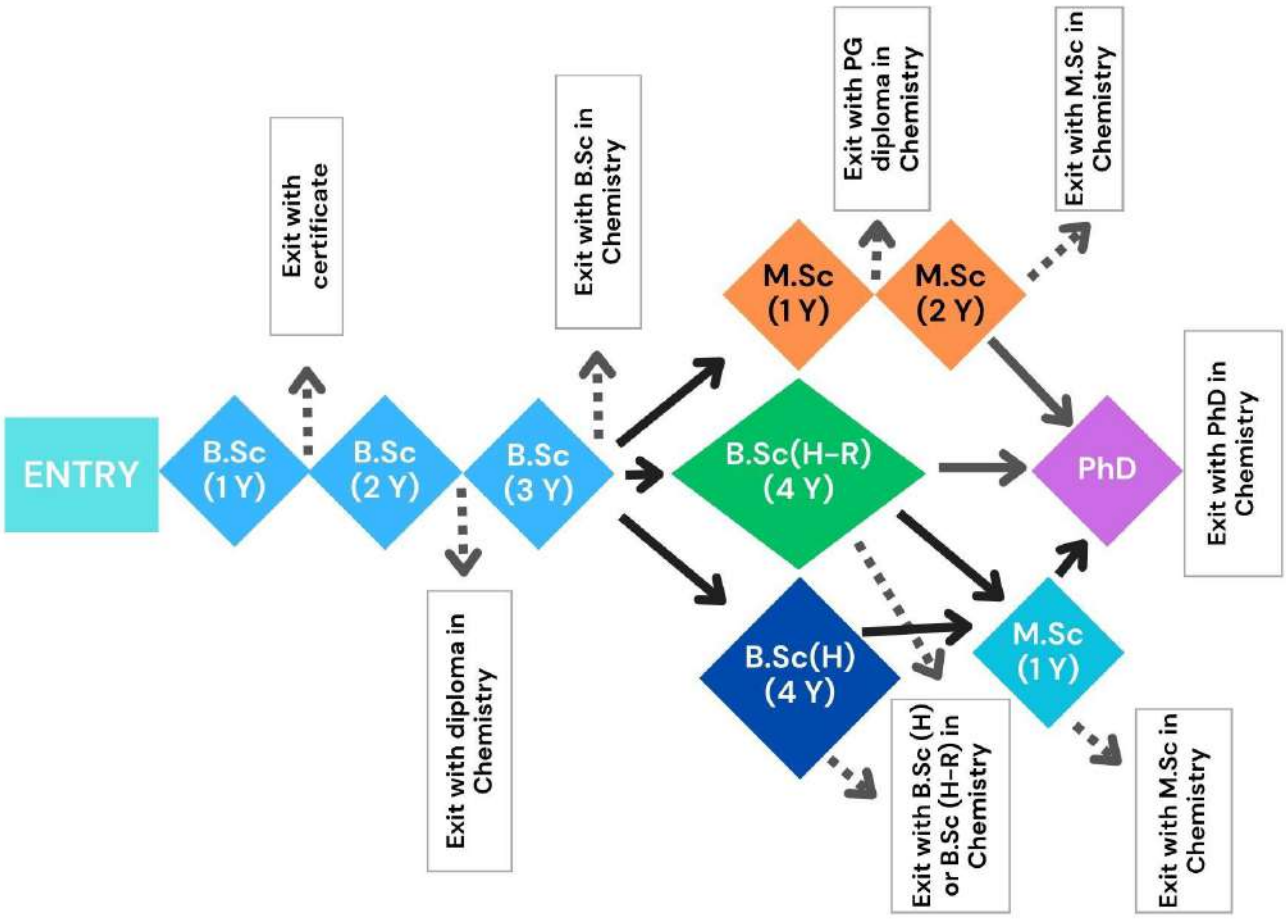
7. DURATION OF THE PROGRAMME

- The duration of the UG programme is 4 years or 8 semesters. Students who desire to undergo a 3-year UG Programme will be allowed to exit after completion of the 3rd year. If a student wants to leave after the completion of the first or second year, the student will be given a UG Certificate or UG Diploma, respectively, provided they secure the prescribed number of credits (as given in Table 3). Students who exit with a UG certificate or UG diploma are permitted to re-enter within three years and complete the degree programme.
- Students may be permitted to take a break from the study during the period of study but the total duration for completing the programme shall not exceed 7 years.

8. STRUCTURE OF THE UNDERGRADUATE PROGRAMME

The UG programme will consist of the following categories of courses and the minimum credit requirements for 3-year UG and 4-year UG (Honours) or UG (Honours with Research) programmes are given below:

S. No.	Broad Category of Course	Minimum Credit Requirement	
		3-year UG	4-Year UG
1	Major (Core)	60	80
2	Minor Stream	24	32
3	Multidisciplinary	09	09
4	Ability Enhancement Courses (AEC)	08	08
5	Skill Enhancement Courses (SEC)	09	09
6	Value Added Courses common for all UG	06 - 08	06 – 08
7	Summer Internship	02 - 04	02 – 04
8	Research Project / Dissertation	-	12
Total		**120**	**160**



SCHEME – MULTIPLE ENTRY/EXIT OPTIONS AS PER NEP-2020

CURRICULUM STRUCTURE

4-Year B.Sc. (Hons.) Chemistry / B.Sc. (Hons. with research) Chemistry

Semester	Major Core	Minor stream	Multidiscipline Courses	Ability Enhancement Courses	Skill Enhancement Courses/ Internship	Value added Courses	Total credits	
I	Chem-I (3+0+2)	Minor-I (3+0+1)	Course-I (3+0+0)	English for Communication-I (2+0+0)	Soft skills-1 (1+1+0) Soft Skills-2 (1+1+0)	Indian Constitution & Heritage (3+0+0)	21	
II	Chem-II (3+0+2)	Minor-II (3+0+1)	Course-II (3+0+0)	Telugu-I/Hindi-I (2+0+0)	Soft Skills-3 (1+1+0) Soft Skills-4 (1+1+0)	Environmental Studies (3+0+0)	21	42
Exit option with Certificate in Chemistry & Option of major and minor interconversion *#								**42**
III	Chem -III (3+0+2) Chem -IV (3+0+2)	Minor-III (3+0+1)	Course-III (3+0+0)	English for Communication-II (2+0+0)	Soft Skills-5 (1+1+0)	-	21	
IV	Chem -V (3+0+2) Chem -VI (3+0+2)	Minor-IV (3+0+1)	-	Telugu-II/Hindi-II (2+0+0)	GLP (1+1+0)	Human Values and Ethics (1+1+0)	20	41
Exit option with Diploma in Chemistry#								**83**
V	Chem -VII (3+0+2) Chem -VIII (3+0+2) Chem -IX (3+0+2)	Minor-V (3+0+1)	-	-	Internship (2)	-	21	
VI	Chem -X (3+0+2) Chem -XI (3+0+2) Chem -XII (3+0+2) Chem Project (2)	Minor-VI (3+0+1)	-	-	-	-	21	42
	62	24	9	8	12 + 2	8		**125**
Exit option with B.Sc. Chemistry * Candidate has to complete the 2 credit Laboratory course from latest chosen major if interchanged the first chosen Minor to Major. # Candidate who wants to exit the program has to complete an additional 4 credit Vocational Course/Internship to get the Certificate/ Diploma.								
VII	Chem -XIII (3+0+2) Chem -XIV (3+0+2) Chem -XV (Elective)$(3+0+0) Research Methodology (3)	Minor-VII– (3+0+1)	-	-	-	-	20	**42**(H) / **41** (H-R)
VIII	**Hons.**							
	Chem -XVI (3+0+0) Chem -XVII (3+0+2) Chem -XVIII (3+0+2) Chem -XIX (Elective) (3+0+0) Minor Project (2)	Minor-VIII (3+0+1)	-	-	-	-	22	
	Hons. with Research							
	Chem-XVI (Elective) (3+0+0) Pre-project Seminar (2) Research Project & Dissertation (12)	Minor-VIII (3+0+1)	-	-	-	-	21	
	34 (96)/ 33 (95)							**167/ 166**
Exit with B.Sc. (Hons.) Chemistry or B.Sc. (Hons. with Research) Chemistry								

YEAR-WISE CURRICULA PLAN

1st Year

	COURSE LEVEL	COURSE CODE	TITLE OF THE COURSE	CATEGORY	CREDIT HOURS			CREDITS
					LECTURES	TUTORIAL	PRACTICUM	
SEMESTER-I	100	CHE101/ CHE121	Inorganic Chemistry-I	Major	3	0	0	3
	100	PHY121	Minor-I	Minor	3	0	0	3
	100	MDC101 to MDC105	Course-1 (AI/Biology/Chemistry/Geology/Management)	Multi-discipline	3	0	0	3
	100	AEC101	English for Communication-I	AEC	2	0	0	2
	100	SEC101	Soft Skills-I: Verbal Ability and Quantitative Aptitude	SEC	1	1	0	2
	100	SEC102	Soft Skills-2: Personality Development	SEC	1	1	0	2
	100	VAC101	Indian Constitution & Heritage	VAC	3	0	0	3
	100	CHE111	Inorganic Chemistry-1 Practicum	Major	0	0	4	2
	100	PHY131	Minor-I Practicum	Minor	0	0	2	1
							Total	**21**
SEMESTER-II	100	CHE151/ CHE171	Organic Chemistry-I	Major	3	0	0	3
	100	PHY171	Minor-II	Minor	3	0	0	3
	100	MDC151 to MDC155	Course-II (AI/Biology/Chemistry/Geology/Management)	Multi-discipline	3	0	0	3
	100	AEC151/ AEC152	Telugu-I / Hindi-I	AEC	2	0	0	2
	100	SEC151	Soft Skills-III: Emotional Intelligence & Reasoning skills	SEC	1	1	0	2
	100	SEC152	Soft Skills-IV: Fundamentals of IT	SEC	1	1	0	2
	100	VAC151	Environmental Studies	VAC	3	0	0	3
	100	CHE161	Organic Chemistry-1 Practicum	Major	0	0	4	2
	100	PHY181	Minor-II Practicum	Minor	0	0	2	1
							Total	**21**

*[**Major**: Major core, **Minor**: Minor stream, **Multidiscipline**: Multidiscipline courses, **AEC**: Ability Enhancement Courses, **SEC**: Skill Enhancement Courses, **VAC**: Value Added Courses*

2nd Year

	COURSE LEVEL	COURSE CODE	TITLE OF THE COURSE	CATEGORY	CREDIT HOURS			CREDITS
					LECTURES	TUTORIAL	PRACTICUM	
SEMESTER-III	200	CHE201/ CHE221	Physical Chemistry-I	Major	3	0	0	3
	200	CHE202/ CHE222	Inorganic Chemistry-II	Major	3	0	0	3
	200	PHY221	Minor-III	Minor	3	0	0	3
	200	MDC201 to MDC205	Course-III (AI/Biology/Chemistry/Geology/Management)	Multi-discipline	3	0	0	3
	200	AEC201	English for Communication-II	AEC	2	0	0	2
	200	SEC201	Soft Skills-V: Leadership & Management skills	SEC	1	1	0	2
	200	CHE211	Physical Chemistry-I Practicum	Major	0	0	4	2
	200	CHE212	Inorganic Chemistry-II Practicum	Major	0	0	4	2
	200	PHY231	Minor-III Practicum	Minor	0	0	2	1
							Total	**21**
SEMESTER-IV	200	CHE251/ CHE271	Organic Chemistry-II	Major	3	0	0	3
	200	CHE252/ CHE272	Physical Chemistry-II	Major	3	0	0	3
	200	PHY271	Minor-IV	Minor	3	0	0	3
	200	AEC251/ AEC252	Telugu-II / Hindi-II	AEC	2	0	0	2
	200	SEC251	Good Laboratory Practices	SEC	1	1	0	2
	200	VAC251	Human Values and Ethics	VAC	1	1	0	2
	200	CHE261	Organic Chemistry-II Practicum	Major	0	0	4	2
	200	CHE262	Physical Chemistry-II Practicum	Major	0	0	4	2
	200	PHY281	Minor-IV Practicum	Minor	0	0	2	1
							Total	**20**

*[**Major**: Major core, **Minor**: Minor stream, **Multidiscipline**: Multidiscipline courses, **AEC**: Ability Enhancement Courses, **SEC**: Skill Enhancement Courses, **VAC**: Value Added Courses]*

3rd Year

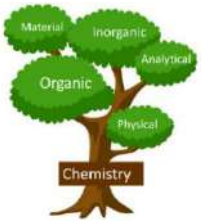
	COURSE LEVEL	COURSE CODE	TITLE OF THE COURSE	CATEGORY	CREDIT HOURS			CREDITS
					LECTURES	TUTORIAL	PRACTICUM	
SEMESTER-V	300	CHE301	Inorganic Chemistry-III	Major	3	0	0	3
	300	CHE302	Organic Chemistry-III	Major	3	0	0	3
	300	CHE303	Physical Chemistry-III	Major	3	0	0	3
	300	PHY 321	Minor-V	Minor	3	0	0	3
	300	CHE311	Inorganic Chemistry-III Practicum	Major	0	0	4	2
	300	CHE312	Organic Chemistry-III Practicum	Major	0	0	4	2
	300	CHE313	Physical Chemistry-III Practicum	Major	0	0	4	2
	300	PHY331	Minor-V	Minor	0	0	2	1
	300	CHE341	Summer Internship	Internship	0	0	4	2
							Total	**21**
SEMESTER-VI	300	CHE351	Fundamentals of Analytical Chemistry	Major	3	0	0	3
	300	CHE352	Green Chemistry	Major	3	0	0	3
	300	CHE353	Basic Organic Spectroscopy	Major	3	0	0	3
	300	PHY 371	Minor-VI	Minor	3	0	0	3
	300	CHE361	Fundamentals of Analytical Chemistry Practicum	Major	0	0	4	2
	300	CHE362	Green Chemistry Practicum	Major	0	0	4	2
	300	CHE363	Basic Organic Spectroscopy Practicum	Major	0	0	4	2
	300	PHY381	Minor-VI Practicum	Minor	0	0	2	1
	300	CHE391	Minor Project	Major	0	0	4	2
							Total	**21**

*[**Major**: Major core, **Minor**: Minor stream]*

4rd Year (Tentative scheme with titles)

	COURSE LEVEL	COURSE CODE	TITLE OF THE COURSE	CATEGORY	CREDIT HOURS			CREDITS
					LECTURES	TUTORIAL	PRACTICUM	
SEMESTER-VII	400	CHE401	Inorganic Chemistry-IV	Major	3	0	0	3
	400	CHE402	Organic Chemistry-IV	Major	3	0	0	3
	400	CHE403	Research Methodology	Major	3	0	0	3
	400	CHE404/ CHE405/ CHE406	Elective-I	Major	3	0	0	3
	400	CHE421	Minor-VII	Minor	3	0	0	3
	400	CHE411	Inorganic Chemistry-IV Practicum	Major	0	0	4	2
	400	CHE412	Organic Chemistry-IV Practicum	Major	0	0	4	2
	400	PHY431	Minor-VII Practicum	Minor	0	0	2	1
							Total	**20**
SEMESTER-VIII	**Courses for B.Sc (Hons.) Chemistry**							
	400	CHE451H	Physical Chemistry-IV	Major	3	0	0	3
	400	CHE452H	Organic Chemistry-V	Major	3	0	0	3
	400	CHE453H	Analytical Techniques	Major	3	0	0	3
	400	CHE454/ CHE455/ CHE456	Elective-II (Advanced Inorganic Chem/Adv. Organic Chem/Adv. Physical Chem)	Major	3	0	0	3
	400	CHE471	Minor-VIII	Minor	3	0	0	3
	400	CHE461H	Physical Chemistry-IV Practicum	Major	0	0	4	2
	400	CHE462H	Organic Chemistry-V Practicum	Major	0	0	4	2
	400	PHY481	Minor-VIII Practicum	Minor	0	0	2	1
	400	CHE491	Minor project	Major	0	0	4	2
							Total	**22**
	Courses for B.Sc (Hons. with Research) Chemistry							
	400	CHE454/ CHE455/ CHE456	Elective-II (Advanced Inorganic Chem/Adv. Organic Chem/Adv. Physical Chem)	Major	3	0	0	3
	400	CHE491R	Research Seminar	Major	0	0	4	2
	400	CHE492R	Research Project & Dissertation	Major	0	0	24	12
	400	PHY471	Minor-VIII	Minor	3	0	0	3
	400	PHY481	Minor-VIII Practicum	Minor	0	0	2	1
							Total	**21**

*[**Major**: Major core, **Minor**: Minor stream]*



LIST OF CHEMISTRY COURSES UNDER MAJOR CORE

Semester	Level	Course Code	Course	Credits
I	100	CHE101/CHE121	Inorganic Chemistry-I	3
	100	CHE111	Inorganic Chemistry-I Practicum	2
II	100	CHE151/CHE171	Organic Chemistry-I	3
	100	CHE161	Organic Chemistry-I Practicum	2
III	100	CHE201/CHE221	Physical Chemistry-I	3
	100	CHE211	Physical Chemistry-I Practicum	2
	200	CHE202/CHE222	Inorganic Chemistry-II	3
	200	CHE212	Inorganic Chemistry-II Practicum	2
IV	200	CHE251/CHE271	Organic Chemistry-II	3
	200	CHE261	Organic Chemistry-II Practicum	2
	200	CHE252/CHE272	Physical Chemistry-II	3
	200	CHE262	Physical Chemistry-II Practicum	2
V	300	CHE301	Inorganic Chemistry-III	3
	300	CHE311	Inorganic Chemistry-III Practicum	2
	300	CHE302	Organic Chemistry-III	3
	300	CHE312	Organic Chemistry-III Practicum	2
	300	CHE303	Physical Chemistry-III	3
	300	CHE313	Physical Chemistry-III Practicum	2
VI	300	CHE351	Fundamentals of Analytical Chemistry	3
	300	CHE361	Analytical Chemistry Practicum	2
	300	CHE352	Green Chemistry	3
	300	CHE362	Green Chemistry Practicum	2
	300	CHE353	Basic Organic Spectroscopy	3
	300	CHE363	Basic Organic Spectroscopy Practicum	2
	300	CHE391	Minor Project	2

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE101/ CHE121	**INORGANIC CHEMISTRY-I**	**3**	**I**

Course Objectives: On completion of this course, the students will be able to understand:
Atomic theory and its evolution • Learning scientific theory of atoms, concept of wave function • Elements in periodic table; physical and chemical characteristics, periodicity • To predict the atomic structure, chemical bonding, and molecular geometry based on accepted models • Hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.

UNIT-I

Atomic structure- Bohr's theory, its limitations, and the atomic spectrum of the hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, the significance of ψ and ψ2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for the hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d, and f orbitals.

UNIT-II

Periodicity of elements - s, p, d, and f-block elements, the long form of the periodic table. A detailed discussion of the following properties of the elements, with reference to s, p, d, and f-block.
(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in the periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies, and factors affecting ionization energy.

UNIT-III

Chemical bonding: Ionic bond: General characteristics, types of ions, size effects, radius ratio rule, and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Born-Haber cycle and its application. Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Molecular Orbital Theory (MOT), molecular orbital diagrams of diatomic and simple polyatomic molecules. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.

UNIT-IV

Metallic bonding and Weak chemical forces: Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment).

Recommended Books

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
3. Rodger, G.E. Inorganic and Solid-State Chemistry, Cengage Learning India Edition, 2002.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE111	**INORGANIC CHEMISTRY-I PRACTICUM**	**2**	**I**

(A) **Titrimetric Analysis**

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) **Acid-Base Titrations**

(i) Estimation of carbonate and hydroxide present together in a mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(C) **Oxidation-Reduction Titrimetry**

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using diphenylamine or anthranilic acid as external indicator.

Recommended Books

Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6thEd., Pearson, 2009

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE151/ CHE171	**ORGANIC CHEMISTRY-I**	**3**	**II**

Course Objectives: On completion of this course, the students will be able to understand:
Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms • Stereochemistry of organic molecules • Aromatic compounds and aromaticity, mechanism of aromatic reactions • Understanding hybridization • Reactivity, stability of organic molecules, structure, stereochemistry • Mechanism of organic reactions.

UNIT-I

Basics of organic chemistry: Organic compounds: Classification, nomenclature and hybridization. Electronic displacements: Inductive, electromeric, resonance, mesomeric, hyperconjugation effect and their applications; dipole moment, bond fission (homolytic and heterolytic) with suitable examples; curly arrow rules; reactive intermediates–carbocation, carbanion, Free radical and carbene; organic reagents – electrophile and nucleophile; nucleophilicity and basicity. Introduction to types of organic reactions and their mechanism – Addition, elimination and Substitution reactions (only basics).

UNIT-II

Stereochemistry: Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixtures, Relative and absolute configuration: D/L and R/S designations**.**

UNIT-III

Chemistry of aliphatic hydrocarbons-1 (Carbon-Carbon sigma pi bonds): Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz- Fittig Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.
Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), Diels-Alder reaction; Allylic and benzylic bromination and mechanism.

UNIT-IV

Aromatic hydrocarbons: Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of substituent groups.

Recommended Books

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
3. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
4. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE161	**ORGANIC CHEMISTRY-I PRACTICUM**	**2**	**II**

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
a. Water (b) Alcohol (c) Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography
   a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
   b. Separation of a mixture of two sugars by ascending paper chromatography
   c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin-layer chromatography (TLC)

Recommended Books

1. Vogel's textbook of Organic Analysis, Longman Publishers
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE201/ CHE221	**PHYSICAL CHEMISTRY-I**	**3**	**III**

Course objectives: On completion of this course, the students will be able to understand:
Physical properties of each state of matter and laws related to describe the states • Understanding Kinetic model of gas and its properties • Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, andlaw of corresponding states • Liquid state and its physical properties related to temperature and pressure variation • Chemistry of Solids - Ionic equilibria – electrolyte, ionization, dissociation • Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.

UNIT-I

Gaseous state: Deviations from ideal gas behaviour, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.
Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

UNIT-II

Liquid state: Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

UNIT-III

Ionic equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids. Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry
Solubility and solubility product. Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.
Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.

UNIT-IV

Solid state: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law.

Recommended Books

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009)
5. G. M. Barrow, Tata McGraw Hill (Fifth Edition) (2007)

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE211	**PHYSICAL CHEMISTRY-I PRACTICUM**	**2**	**III**

1. **Surface tension measurements.**
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
   b. Study the variation of surface tension of detergent solutions with concentration'

2. **Viscosity measurements using Ostwald's viscometer**.
   Determination of viscosity of aqueous solutions of (i) ethanol and (ii) sugar at room temperature.

3. **pH metry**
   a. Effect on pH of addition of HCl/NaOH to solutions of acetic acid
   b. Preparation of buffer solutions of different pH (a) Sodium acetate-acetic acid (b) Ammonium chloride-ammonium hydroxide.
   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

Recommended Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co., New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
3. Athawale V. D. and Mathur P. Experimental Physical Chemistry, New Age International, (2001)

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE202/ CHE222	**INORGANIC CHEMISTRY-II**	**3**	**III**

Course objectives: After completion of the course, the learner shall be able to understand:
Structure, bonding of s and p block materials and their oxides/compounds • Chemistry of transition elements • Chemistry of noble gases and their compounds • Understanding chemistry of inorganic polymers, their structures and uses.

UNIT-I

Oxidation-Reduction and general principle of metallurgy:

Redox equations, Standard Electrode Potential and its application to inorganic reactions. Occurrence of metals based on standard electrode potentials. Carbon reduction method. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Zone refining.

UNIT-II

Chemistry of *s* and *p* Block Elements: Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate.

Structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Per-oxo acids of Sulphur inter-halogen compounds, poly- halide ions, pseudo-halogens, properties of halogens.

UNIT-III

Noble Gases: Occurrence and uses, rationalization of the inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF2), Shapes of noble gas compounds (VSEPR theory).

UNIT-IV

Inorganic Polymers: Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and poly sulphates.

Recommended books

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry, 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010
6. Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE212	**INORGANIC CHEMISTRY-II PRACTICUM**	**2**	**III**

(A) Iodo / Iodimetric Titrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2
(ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chrome alum.

Recommended books

Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* Sixth Edition Pearson, 2009.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE251/ CHE271	**ORGANIC CHEMISTRY-II**	**3**	**IV**

Course objectives: After completion of the course, the learner shall be able to understand:
Familiarization about classes of organic compounds and their methods of preparation • Basic uses of reaction mechanisms • Name reactions, uses of various reagents and the mechanism of their action • Use of reagents in various organic transformation reactions.

UNIT-I

Chemistry of Halogenated Hydrocarbons: *Alkyl halides:* Methods of preparation, nucleophilic substitution reactions – SN1, SN2 and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs.
elimination.
Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

UNIT-II

Alcohols, Phenols, Ethers and Epoxides: *Alcohols:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions,
Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols,
ammonia derivatives and LiAlH4

UNIT-III

Carbonyl Compounds: Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff- Kishner, LiAlH4, NaBH4, MPV, PDC and PGC);

UNIT-IV

Carboxylic Acids and their Derivatives:

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

Recommended Books/references:

1. Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry,* John Wiley & Sons, Inc (2009).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013.
3. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.
4. Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India, 2003.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE261	**ORGANIC CHEMISTRY-II PRACTICUM**	**2**	**IV**

(List of experiments given are suggestive. One experiment from each group to be demonstrated)

1 Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.

2 Organic preparations:

i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistry approach)

ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination (any one)

a. Acetanilide by conventional methods

b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration: (any one)

a. Acetanilide/nitrobenzene by conventional method

b. Salicylic acid by green approach (using ceric ammonium nitrate).

vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.

vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE252/ CHE272	**PHYSICAL CHEMISTRY-II**	**3**	**IV**

Course objectives: After completion of the course, the learner shall be able to understand:
Laws of thermodynamics and concepts • Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc.• Understanding the concept of entropy; reversible, irreversible processes. Calculation of entropy using 3nd law of thermodynamics • Understanding theories/thermodynamics of dilute solutions Dilute solution and its properties.

UNIT-I

Introduction to thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. *First law:* Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

UNIT-II

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations), pressure on enthalpy of reactions.

UNIT-III

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third law of thermodynamics: Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

UNIT-IV

Partial molar quantities: Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Dilute solutions: Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties: [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Recommended Books/References

1. Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.
2. Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa, 2004.
3. Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall, 2012.
4. McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.

5. Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001
6. *Commonly Asked Questions in Thermodynamics.* CRC Press, 2011.
7. Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010.
8. Metz, C.R. *2000 solved problems in chemistry,* Schaum Series, 2006.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE262	**PHYSICAL CHEMISTRY-II PRACTICUM**	**2**	**IV**

(A list of suggested experiments are given. However, more experiments can be added based on facilities available in the laboratories).

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Study the equilibrium of at least one of the following reactions by the distribution method:
   (i) I_2 (aq) + I^- -→ I_3^- (aq)
   (ii) Cu^{2+}(aq) + $n$$NH_3$ → Cu(NH3)n
3. Study the kinetics of the following reactions.
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.

   Adsorption
   Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal.
   (Use of calorimeter for calculation of heat of reactions may be demonstrated)

Recommended Books/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand, New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry,* Eighth Edition, McGraw-Hill(2003).
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry,* Third Edition, W, H. Freeman (2003).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE301	**INORGANIC CHEMISTRY-III**	**3**	**V**

Course objectives: After completion of the course, the learner shall be able to understand:
Nomenclature of coordination compounds/complexes, Molecular orbital theory, d-orbital splitting in tetrahedral, octahedral, square planar complexes, chelate effects • Chemistry of cage and metal clusters • The separation of Lanthanoids and Actinoids, its colour, spectra and magnetic behaviour • bioinorganic chemistry of metals in biological systems.

UNIT-I

Coordination Chemistry: Werner's theory, EAN rule, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, d orbital splitting in square pyramidal and square planar environments, CFSE, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelate effect.

UNIT-II

Transition Elements: General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

UNIT-III

Lanthanoids and Actinides: Electronic configuration, oxidation states, colour, spectra and magnetic behaviour, lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT-IV

Bioinorganic Chemistry: Metal ions present in biological systems, classification of elements according to their action in biological systems, Molecular mechanism of ion transport across membranes-ionophores, Na/K-pump, Excess and deficiency of some trace metals, Role of metal ions in Carbonic anhydrase and Carboxypeptidase, Toxicity of metal ions of Hg, Pb, Cd and As.

Recommended textbooks/References:

1. Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977.
2. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Co., 1994.
4. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999,
5. Basolo, F, and Pearson, R.C. Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY, 1967.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE311	**INORGANIC CHEMISTRY-III PRACTICUM**	**2**	**V**

1. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given on understanding of the chemistry of different reactions. Following radicals may be analyzed: Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2- and NO_3^-, Cl- and Br-, Cl- and I^-, Br^- and I^-, NO_3^- and Br-, NO_3^- and I^-. Spot analysis/tests should be done whenever possible.

Recommended text books/references:

1. Vogel's *Qualitative Inorganic Analysis,* Revised by G. Svehla. Pearson Education, 2002.
2. Marr & Rockett *Practical Inorganic Chemistry*. John Wiley & Sons 1972.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE302	**ORGANIC CHEMISTRY-III**	**3**	**V**

Course objectives: After completion of the course, the learner shall be able to understand:
Understanding reactions and reaction mechanism of nitrogen containing functionalgroups • Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons • Understanding the structure, mechanism of reactions of selected heterocyclic compounds • Classification, structure, mechanism of reactions of few selected alkaloids and terpenes.

UNIT-1

Nitrogen Containing Functional Groups: Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium salts: Preparation and synthetic applications.

UNIT-II

Polynuclear Hydrocarbons: Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons. Heterocyclic Compounds: (12 classes of 60 minutes duration each)
Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

UNIT-III

Alkaloids: Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

UNIT-IV

Terpenes: Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.

Recommended Text Books/references:

1 Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.
2 Acheson, R.M. Introduction to the Chemistry of Heterocyclic compounds, John Welly & Sons (1976).
3 Solomons, T.W., Fryhle Craig, Organic Chemistry, John Wiley & Sons, Inc (2009).
4 McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5 Kalsi, P. S. Organic reacations and their mechanisms, New Age Science (2010).
6 Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press Inc., New York (2001).
7 Singh, J.; Ali, S.M. & Singh, J. Natural Product Chemistry, Prajati Parakashan (2010).
8 Bansal R. K. Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms, New Age, Third Edition (1999).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE312	**ORGANIC CHEMISTRY-III PRACTICUM**	**2**	**V**

1 Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.

2 Identification of functional groups of simple organic compounds by IR spectroscopy andNMR spectroscopy (IR and NMR of simple organic compounds may be done wherever facilities are available, otherwise sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc., for identification of functional groups. References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill).

3 Preparation of methyl orange.

4 Extraction of caffeine from tea leaves.

5 Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars usingsimple lab procedures.

Recommended Books/References:

1. Vogel, A.I. *Quantitative Organic Analysis,* Part 3, Pearson (2012).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (20
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparationand Quantitative Analysis,* University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: QualitativeAnalysis,* University Press (2000).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE303	**PHYSICAL CHEMISTRY-III**	**3**	**V**

Course objectives: After completion the course, the learner shall be able to understand:
Understanding phases, components, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phase diagram • Understanding the basics of chemical kinetics • Catalyst – mechanism of catalytic action, enzyme catalysis • Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory and significance.

UNIT-I

Phase Equilibria: Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water- chloroform-acetic acid system, triangular plots. Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-II

Chemical Kinetics: Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-III

Catalysis: Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

UNIT-IV

Surface Chemistry: Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Recommended books:

1. Atkins P. W. and De Paula J., *Physical Chemistry, (*tenth edition) Oxford University Press,2014.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa , 2004
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books, 2004.4 Engel, T. & Reid, P. *Physical Chemistry* Third Edition*,* Prentice-Hall,2012.
4. Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 20116 Ball, D. W. *Physical Chemistry* Cengage India, 2012.
5. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP, 2009.8.Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill, 2011.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE313	**PHYSICAL CHEMISTRY-III PRACTICUM**	**2**	**V**

Conductometry

1 Determination of cell constant
2 Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3 Conductometric titrations of: Strong acid Vs. strong base (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and (iv)weak acid vs. strong base, Strong acid vs. weak base.

Potentiometry

Potentiometric titrations of: (i) Strong acid vs. strong base (ii) Weak acid vs. strong base (iii) Dibasic acid vs. strong base (iv) Potassium dichromate vs. Mohr's salt.

Recommend books/References:

1. Khosla, B. D.; Garg, V. C. and Gulati, A. *Senior Practical Physical Chemistry,* R. ChandNew Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry* EighthEdition*;* McGraw-Hill: New York, 2003.
3. Halpern, A. M. and McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman& Co.: New York, 2003.
4. (List of experiments and references are suggestive. However, more experiments can be added/listof experiments can be revised as per available facilities).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE341	**SUMMER INTERNSHIP**	**2**	**V**

Summer internships offer chemistry students valuable hands-on experience and deep insights into their field, aiding them in advancing their educational and career aspirations. These opportunities enable students to explore various facets of chemistry, providing a clearer picture of potential career paths. Therefore, it is highly recommended that students pursue an industrial internship and present a detailed report documenting their experiences.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE351	**FUNDAMENTALS OF ANALYTICAL CHEMISTRY**	**3**	**VI**

Course objectives: After completion of the course, the student shall be able to understand:
Understanding analytical tools, statistical methods applied to analytical chemistry • Understanding principle of UV-Vis spectroscopy and its applications • Understanding principles of thermo-gravimetric analysis and study of thermal decomposition of materials/characterization of materials • Understanding basics of electro-analytical techniques and its applications.

UNIT-I

Qualitative and quantitative aspects of analysis: Tools in analytical chemistry and their applications, sampling, evolution of analytical data, errors, accuracy and precision, statistical test of data, F, Q and t-test, rejection of data, and confidence intervals.

UNIT-II

Quality assurance and management systems: elements of quality assurance, quality assurance in design, development, production and services, quality and quantity management system, ISO 9000 and ISO 14000 series-meaning of quality, quality process model, customer requirement of quality calibration and testing, statistical process control, process control tools, control chart, statistical quality control, acceptance sampling. Brief out line of ICH guide lines on drug substances and products.

UNIT-III

Separation methods: Solvent extraction- Classification, principle and efficiency of the technique. Mechanism of extraction- extraction by solvation and chelation. Technique of extraction- batch, continuous and counter current extractions.

Chromatography: History, Classification, the definition of terms, Basics of column chromatography, Band broadening and column efficiency: Definition, Plate theory and rate theory of chromatographic techniques, their limitation and applications, principle and applications of Paper chromatography and Thin layer chromatography.

UNIT-IV

Assessment of water, air and soil quality: Sources of water, sampling procedure, types of water pollutants, and water quality standards for drinking water. Determination of dissolved oxygen (DO), Biochemical oxygen demand (BOD), Chemical oxygen demand (COD). Classification of air pollutants, standards for ambient air quality, Chemical analysis of CO, SOX, and NOx for air quality. Soil sampling, determination of moisture, total N, P, humus, and alkali salts

Recommended Books/Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing California, USA, 1988.
3. Christian, G.D, Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Saunder College Publications, (1998).
6. Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE361	**FUNDAMENTALS OF ANALYTICAL CHEMISTRY PRACTICUM**	**2**	**VI**

1. **Chromatography:**
   (i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
   (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.
   iii. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.
   (iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC
2. **Solvent Extractions:**
   (i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.
   (ii) Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
   (iii) Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
3. **Analysis of soil:**
   (i) Determination of pH of soil.
   (ii) Total soluble salt
   (iii) Estimation of calcium, magnesium, phosphate, nitrate
4. **Ion exchange:**
   (i) Determination of exchange capacity of cation exchange resins and anion exchange resins.
   (ii) Separation of metal ions from their binary mixture.
   (iii) Separation of amino acids from organic acids by ion exchange chromatography.
5. **Spectrophotometry**
   (i). Determination of pKa values of indicator using spectrophotometry.
   (ii) Structural characterization of compounds by infrared spectroscopy.
   (iii) Determination of dissolved oxygen in water.
   (iv) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job'smethod.

Note: Maximum 2 experiments from each section.

Recommended text books/references:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE352	**GREEN CHEMISTRY**	**3**	**VI**

Course objectives: After completion of the course, the learner shall be able to understand:
Principles of green chemistry • Design of chemical reactions/chemical synthesis using green chemistry principles • Atom economy and design of chemical reactions using the principle • The use of green chemistry principle and processes in laboratory reactions.

UNIT-I

Introduction to Green Chemistry

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuitof the goals of Green Chemistry

Principles of Green Chemistry and Designing a Chemical synthesis: Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution andelimination reactions).

UNIT-II

Green Synthesis / Reactions-I:

1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

UNIT-III

Green Synthesis / Reactions-II:

1. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
2. Designing of Environmentally safe marine antifoulant.
3. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
4. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats and Oils

UNIT-IV

Future Trends in Green Chemistry: Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C_2S_3); Green chemistry in sustainable development.

Recommended Books/References:

1. Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K, *Green Chemistry-Theory and Practical*, Oxford Univ Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS (2000).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE362	**GREEN CHEMISTRY PRACTICUM**	**2**	**VI**

(Following is the list of suggestive experiments. However, depending upon available resources, experiments may be added/changes may be incorporated): (six experiments may be conducted)

1. Preparation and characterization of nanoparticles of gold using tea leaves.
2. Preparation of biodiesel from vegetable/ waste cooking oil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates Green Chemistry.
4. Reactions like addition, elimination, substitution and rearrangement may also be studied forthe calculation of atom economy.
5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide).
6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.
7. Mechanochemical solvent free synthesis of azomethines
8. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II) complex.
9. Photoreduction of benzophenone to benzopinacol in presence of sunlight.

Recommended Books/References:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice,* Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing ISBN 978-93-81141-55-7 (2013).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE353	**BASIC ORGANIC SPECTROSCOPY**	**3**	**VI**

Course objectives: After completion of the course, the learner shall be able to understand:
Principles of spectroscopy • Principle and applications of UV-Visible spectroscopy • Principle and applications of IR spectroscopy • Principle and applications of NMR and Mass spectroscopy.

UNIT-I

Basic Principles of UV Spectroscopy: Application of Woodward-Fiser rule in interpretation of Organic compounds: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturated compounds.

UNIT-II

Basic principles of IR Spectroscopy: Identification of Functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

UNIT-III

NMR (^{1}H and ^{13}C NMR): Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect in interpretation of NMR spectra, Isotopic exchange

UNIT-IV

Basic principles Mass Spectrometry: Application of fragmentation rule in characterization of organic compounds. Problems on structure elucidation of organic compounds based on spectral data.

Recommended Books/References:

1. R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of OrganicCompounds*, John Wiley & Sons.
2. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India (2012).

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE363	**BASIC ORGANIC SPECTROSCOPY PRACTICUM**	**2**	**VI**

1. Purification method for liquid, solid organic substance (distillation, recrystallization, chromatorgrapy)

2. Analysis of spectra of UV-Vis, FTIR, NMR and Mass of simple organic compounds. (students may encourage to prepare simple organic compounds following given protocol (azodyes, acetanilides, benzoic acid, etc.) (or may use commercially available organic componds) and can be trained to identify/analyze important peaks/functionality, determine mass of the molecules (mass-spectra). They can submit a report regarding their analysis to course teacher.

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
CHE391	**MINOR PROJECT**	**2**	**VI**

In the realm of academic pursuits, student minor projects serve as pivotal steppingstones for cultivating essential skills, fostering creativity, and delving into practical applications of theoretical knowledge. These projects offer undergraduates an opportunity to engage in hands-on experiences, explore interdisciplinary connections, and contribute meaningfully to their fields of study. This detailed write-up aims to provide a comprehensive understanding of the significance, process, and outcomes of student minor project work. It is essential to ensure that all necessary documentation, including signed certificates and acknowledgments, accompanies the report submission.

SKILL ENHANCEMENT COURSE

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
SEC251	**GOOD LABORATORY PRACTICES**	**1+1**	**IV**

UNIT- I:

General Laboratory Practices: Common calculations in laboratories. Understanding the details on the label of reagent bottles. Preparation of solutions. Molarity and normality of common acids and bases. Dilutions. Percentage solutions. Molar, molal and normal solutions.

UNIT-II:

Handling and safety procedures: Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling. Dos and Don'ts in a laboratory.

UNIT-III:

Instrument Techniques: Use of common laboratory equipment like analytical balances, pH meter, autoclaves etc. Use of purified water in lab experiments, Cleaning and drying of glassware.

Recommended books

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlin and Heidelberg GmbH & Co. K; 2nd ed.
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory Practice Standards: Application for field and Laboratory studies. Wiley VCH.

VOCATIONAL COURSES

(II & IV SEMSTERS)

1. Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG certificate if, in addition, they have to complete **one vocational course of 4 credits during the summer vacation of the first year** from the following list.

S.No	Cour code	Title of course	credits	Semester
1	VOC151	Pharma Unit Operations	2+2	II
2	VOC152	Industrial Pollution and Its Control	2+2	II
3	VOC253	Dairy Chemistry & Processing Technology	2+2	II

2. Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma if, in addition, they complete **one vocational course of 4 credits during the summer vacation of the second year** from the following list.

S.No	Cour code	Title of course	credits	Semester
1	VOC251	Flow Chemistry and Process Intensification	2+2	IV
2	VOC252	Inorganic Industry Processes: Cement, Glass, Ceramics, Metals	2+2	IV
3	VOC253	Forensic Chemistry	2+2	IV

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
VOC151	**PHARMA UNIT OPERATIONS**	**2+2**	**II**

Course Objectives: Understand the fundamental principles and concepts of utilities in industrial processes, including water, steam, electricity, and compressed air, Gain knowledge of various unit operations commonly used in chemical and industrial processes, such as distillation, filtration, mixing, and reaction kinetics.

UNIT-I

Utilities in chemical industries: Types and functions of Biolers, Steam generation and its use, Purification and treatment wastewater.

UNIT-II

Unit operations in chemical industries: Fundamental steps such as distillation, evaporation, mixing and drying, filtration, crystallization, extraction involved in chemical processes used in various industries to convert raw materials into desired products.

UNIT-III

Temperature, pressure measurements etc: Methods for temperature measurements, Apparatus used for pressure measurements, Float level devices for flow level measurement, Fluid flow measurements etc.

Practical Skills:

- Video illustration of industrial processes including unit operations.
- Visit of Chemical and Pharmaceutical Industry and learn the unit operations.

Suggested books:

1. Unit Operations in Pharmaceutical Engineering, Sultana, 2019, CBS Publication
2. Handbook of Biotechnology & Chemical Engineering by P. Ponmurugan, 2010, New Age Internationals

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
VOC152	**INDUSTRIAL POLLUTION AND ITS CONTROL**	**2+2**	**II**

Course Objectives: Understand the concept of industrial pollution and its various sources, Identify the different types of pollutants generated by industrial activities, including air pollutants, water pollutants, and solid waste.

UNIT-I

Air pollution: Introduction, composition of air, organic and inorganic pollutants, radiation pollution, greenhouse effect, Measurement of air quality, sampling, dry and wet scrubbers, electrostatic and thermal precipitators to control air pollutants.

UNIT-II

Water pollution: Sources of water pollution, water pollutant analysis, sampling, measurements of water quality, dissolved oxygen, Chemical and biological demands, international standard of quality of water, toxic metals, municipal water treatment, physical and chemical methods of sterilization, Primary and secondary treatment methods of water treatment.

UNIT-III

Industrial waste and treatment: Physical, Chemical, Organic & Biological properties of Industrial Wastes, aerobic and anaerobic digestion, types of industrial waste, treatment of organic, inorganic and biological impurities.

Practical Skills:

- Video illustration of pollutions reactions.
- Case studies analysing real-world scenarios and proposing solutions.
- Visit of Chemical and Pharmaceutical Industry and learn the pollution control measures.

Suggested books:

1. Engineering Technology and Industrial Chemistry with Applications by Francisco Torrens, Reza K. Haghi, 2021, Apple Academic Press Inc.
2. Industrial Chemistry PART 1&2 by B.K. Sharma, 2023, Krishna Prakashan

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
VOC253	**DAIRY CHEMISTRY & PROCESSING TECHNOLOGY**	**2+2**	**II**

Course objectives: Understand the composition of milk and its nutritional components. Explore the physical and chemical properties of milk and dairy products. Learn about the various factors affecting the quality of milk and dairy products, including processing methods and storage conditions.

UNIT-I

Composition of milk: Definition of milk, Differences between the composition of cow and buffalo milks. Constituents of milk - Minor and major constituents. Physico-chemical properties such as Colour, Flavour, Density, Specific gravity, Freezing point, Boiling point, Surface tension, Viscosity, Specific heat, Refractive index, Electrical conductivity, Germicidal property, pH and acidity etc.

UNIT-II

Methods of Pasteurization: Toned milk, Double toned milk, Reconstituted milk, Standardized milk and Full cream milk – Standards and methods of manufacture LTLT, HTST and Uperization. Sterilization of milk. Factors influencing homogenization, effect of homogenization on milk. Standardization of milk.

UNIT-III

Milk packing and Processing techniques: Desirable characters and types of packaging materials; Forms of packaging. Disposal of dairy effluents- Sources of dairy waste; Necessity of treatment of dairy waste; Methods of treatment: Low-cost methods and Conventional methods - Activated sludge process and trickling filters.

Practical Skills:

- Video illustration of dairy products and processing.
- Visit of dairy Industry and learn the process and packing techniques.

Suggested books:

1. Dairy processing handbook – Gosta Bylund.
2. Outlines of Dairy Technology – Sukumar De.
3. Milk products preparation and quality control – C.P. Ananthakrishnan

COURSE CODE	TITLE OF PAPER	CREDITS	SEMESTER
VOC251	**FLOW CHEMISTRY AND PROCESS INTENSIFICATION**	**2+2**	**IV**

Course objectives: This course explores the principles and applications of flow chemistry and process intensification in chemical synthesis. Students will learn about the fundamental concepts, techniques, and equipment used in flow chemistry, as well as the advantages it offers over traditional batch processes. Emphasis will be placed on practical aspects and case studies illustrating the implementation of flow chemistry in various industries.

UNIT-I

Introduction to flow chemistry and process intensification: Introduction to flow chemistry**,** Advantages and applications of flow chemistry**,** Fundamentals of process intensification**,** Comparison with traditional batch processes**,** Design considerations for flow reactors**,** Safety considerations in flow chemistry.

UNIT-II

Reactor types and configurations: Types of flow reactors (continuous, microreactors, segmented flow), Design principles and operation of different reactor configurations, Heat and mass transfer in flow reactors, Reaction kinetics and optimization in flow reactors, Multi-phase and multi-step reactions in flow systems.

UNIT-III

Applications and case studies: Industrial applications of flow chemistry and process intensification**,** Pharmaceutical synthesis in flow reactors**,** Fine chemicals production using flow technology**,** Sustainable processes and green chemistry**,** Case studies of successful implementation of flow chemistry in industry.

Practical Skills:

- Video illustration of flow reactions.
- Visit of Pharma Industry and learn the flow chemistry.

Suggested Books:

1. Continuous Flow Chemistry - A Pharmaceutical Perspective by Vasudev Jadhav, Suman Jadhav, 2021, White Falcon Publishing.
2. Flow Chemistry: Integrated Approaches for Practical Applications: Volume 62 (Green Chemistry Series), Santiago V Luis, Eduardo Garcia-Verdugo, 2019, Royal Society of Chemistry.
3. Plutschack et al. The Hitchhiker's Guide to Flow Chemistry. Chem. Rev. 2017, 117, 11796-11893.
4. Chemical Reactions and Processes under Flow Conditions: Volume 5 (Green Chemistry Series), by Eduardo Garcia-Verdugo, Santiago V Luis, 2009, Royal Society of Chemistry.

VOC252	INORGANIC INDUSTRY PROCESSES: CEMENT, GLASS, CERAMICS, METALS	2+2	IV

Course objectives: Understand the principles of inorganic process industries, including the chemical reactions involved in the production of inorganic chemicals. Learn the different methods and technologies used in the manufacturing of inorganic products, such as extraction, synthesis, purification, and packaging.

UNIT-I

Cement Industry: Introduction, composition of ordinary cement, manufacture of ordinary cement- mixing, burning, grinding. Uses of cement, various types of cement, setting and hardening of cement.

UNIT-II

Glass & Ceramics Industry: Introduction, composition of glass, manufacture of glass- melting, fabrication, annulling, finishing. Properties of glass, types and applications of glass. Introduction, types of ceramics, raw material, manufacture, properties and classification, specialized ceramic products.

UNIT-III

Metal and alloys: Important metals and alloys- Fe, Cu, Al, Pb, Ni, Ti, Pt and their alloys, Mechanical and chemical properties, applications.

Practical Skills:

- Video illustration of cement, glass & Ceramic, and steel industries.
- Visit of Cement industry, Glass & Refractory industry, Steel & alloy industries.

Suggested books:

1. Engineering Technology and Industrial Chemistry with Applications by Francisco Torrens, Reza K. Haghi, 2021, Apple Academic Press Inc.
2. Industrial Chemistry PART 1&2 by B.K. Sharma, 2023, Krishna Prakashan.

VOC253	FORENSIC CHEMISTRY	2+2	IV

Course objectives: This course explores the application of chemical principles and techniques in criminal investigations, helping to identify evidence and solve crimes.

UNIT-I

Introduction to forensic chemistry: Types of forensic evidence (fibers, paints, glass, drugs, explosives, etc.), Crime scene investigation and evidence collection, Chain of custody and evidence handling procedures, Ethical considerations in forensic science.

UNIT-II

Instrumental Analysis in Forensic Chemistry: Identify common instrumental techniques used in forensic chemistry, Understand the operating principles and limitations of each technique, interpret data generated from instrumental analysis for forensic purposes, Apply instrumental analysis to various types of forensic evidence.

UNIT-III

Forensic Analysis of Specific Evidence Types: Chemical principles and instrumental techniques to analyze specific types of forensic evidence, Interpretation of analytical results for evidential value and draw conclusions, Forensic chemical analysis aids in crime scene reconstruction and suspect identification.

Practical Skills:

- Video illustration of on crime scenes for forensic analysis.
- Knowledge of proper sample preparation techniques to extract and isolate analytes from different types of evidence, such as blood, hair, fibers, and drugs.
- Visit of forensic laboratory and learn necessary analysis technics.

Suggested books:

1. Forensic Science: An Introduction to Scientific and Investigative Techniques, Stuart H. James, Jon J. Nordby, Suzanne Bell, 2014, CRC Press.
2. Forensic Chemistry (Advanced Forensic Science Series) by Max M. Houck, 2015, Academic Press.
3. Forensic Science: Modern Methods of Solving Crime, Max M. Houck, 2007, Praeger