DEPARTMENT OF CHEMISTRY

SYLLABUS FOR FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)

(FIRST – EIGHT SEMESTER)

Approved by Academic Council vide Resolution no. AC – 03/2024/05 Dated: 04 – 05– 2024 and AC – 06/2026/03 dated 28 – 02 - 2026

ARYA VIDYAPEETH COLLEGE (AUTONOMOUS)

ARYA NAGAR, GUWAHATI – 16

CONTENT

PREFACE

"Education is not preparation for life; education is life itself." — John Dewey

The aim of imparting education is not only to increase the knowledge but also to create the possibilities fora student to invent and discover. The purpose of this syllabus is to establish minimum basic concepts for each course to meet the needs of all our students. All the elements in this syllabus amalgamate to bring out the best in every student and enable them to be on the path of continuous progress.

The syllabus is framed based on Learning Outcome Based Education (LOCF) – the spirit of NEP, 2020. The programmes offered by the college are:

i. Bachelor Degree in Arts
ii. Bachelor Degree in Science
iii. Bachelor Degree in Commerce

Under the above programme, the following courses are offered by the college:

i. Core Course
ii. Minor Course
iii. Skill Enhancement Course
iv. Interdisciplinary Course
v. Ability Enhancement Course
vi. Value Added Course
vii. Internship

Programme outcome of each programme and Programme Specific Outcomes of each discipline/subject offered by the college is mapped with course learning outcome of each course. Graduate attributes of students obtaining Undergraduate Degree from the college are also incorporated in the syllabus.

The syllabus includes eight semesters where there will be 23 Core Courses, 8 Minor Courses, 2 Value Added Courses, 3 SEC Courses, 3 IDC Courses, 4 AEC courses and internship. The total credit offered for eight semesters is160.

The syllabus framed takes into account the different styles of learning – audio, visual and experiential. The syllabus correlates academics to real life situations balancing social and emotional stimulation among the students and imbibe human values. Also, the syllabus gives the opportunity for the theoretical knowledge to be pursued ensuring maximum application of it.

Structure of Four Year Undergraduate Course

Semester	Type	Core	Minor	SEC	IDC	AEC	VAC/FC	IN
	Credit	4	4	3	3	2	4(2 + 2)	2
I		CE-1114	MN-1114	SE-1113	ID-1113	AE-1112	VL-1112 (Two Courses)	-
II		CE-2114	MN-2114	SE-2113	ID-2113	AE-2112	VL-2112 (Two Courses)	-
III		CE-3214 CE-3224	MN-3214	SE-3213	ID-3213	AE-3212	-	-
IV		CE-4214 CE-4224 CE-4234	MN-4214	-	-	AE-4212	-	IN-4212
V		CE-5314 CE-5324 CE-5334 CE-5344	MN-5214	-	-	-	-	-
VI		CE-6314 CE-6324 CE-6334 CE-6344	MN-6214	-	-	-	-	-
VII		CE-7414* CE-7424** CE-7434** CE-7444** CE-7454**	MN-7314	-	-	-	-	-
VIII		CE-8414# CE-8424# CE-8434# CE-8444# CE-8454#	MN-8314	-	-	-	-	-

***Compulsory for all students in the 7th semester.**

****Students are required to choose any three courses from the remaining four core courses in the 7th semesters.**

 # Students who wish to pursue a Bachelor Degree with Honours must choose any four of the five core courses in the 8th semester.

NOTE: Students who secure a minimum of 7.5 CGPA at the end of the 6th semester (without any arrears) may opt for a Bachelor Degree with Honours and Research. Those students shall have to choose one core course out of the given five courses in the 8th semester and have to complete a Research Dissertation of 12 credits.

Course code: **First two letters is the abbreviation of course component**

First digit implies semester number

Second digit implies course level

Third digit implies course number

Fourth digit implies credit points per course.

Digit	Course Level
1	100 - 199
2	200 - 299
3	300 - 399
4	400 - 499

Semester Wise Credit Distribution

Semester	CREDIT DISTRIBUTION							
	CORE	MINOR	SEC	AEC	IDC	VAC/FC	IN	TOTAL
FIRST	1 x 4	1 x 4	1 x 3	1 x 2	1 x 3	2x 2	--	20
SECOND	1 x 4	1 x 4	1 x 3	1 x 2	1 x 3	2x 2	--	20
THIRD	2x 4	1 x 4	1 x 3	1 x 2	1 x 3	--	--	20
FOURTH	3x 4	1 x 4	--	1 x 2	--	--	1 x 2	20
FIFTH	4x 4	1 x 4	--	--	--	--	--	20
SIXTH	4x 4	1 x 4	--	--	--	--	--	20
SEVENTH	4x 4	1 x 4	--	--	--	--	--	20
EIGHT	4x 4	1 x 4	--	--	--	--	--	20

SEC: SKILL ENHANCEMENT COURSE

AEC: ABILITY ENHANCEMENT COURSE

IDC: INTERDISCIPLINARY COURSE

VAC/FC: VALUE ADDED COURSE

IN: INTERNSHIP

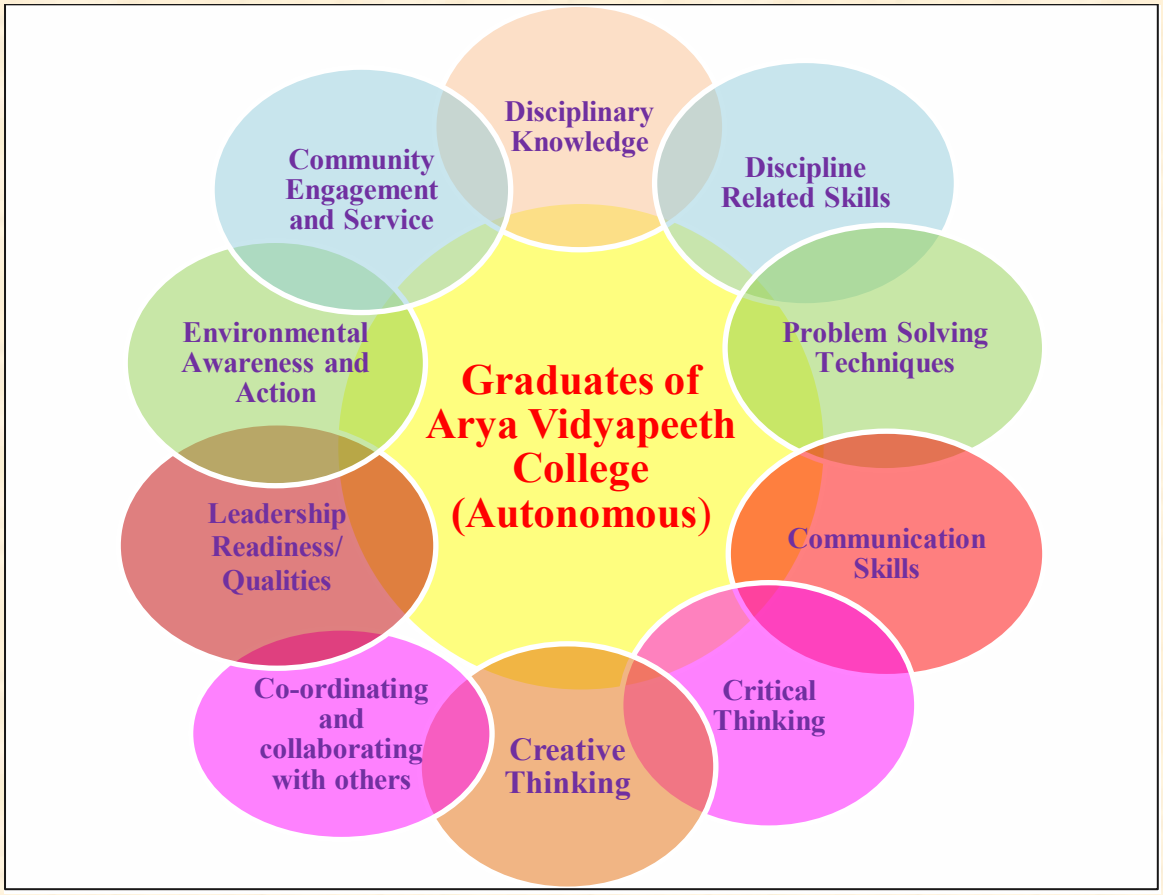
Abbreviation of Course Components:

CE (Core), MN (Minor), SE (Skill Enhancement Course), AE (Ability Enhancement Course), VL (Value added Course), ID (Interdisciplinary Course), IN (Internship)

GRADUATE ATTRIBUTES

Graduate Attributes:

Graduate Attributes are the qualities, skills and understandings that the students should develop during their time with the college. These attributes consequently shape the contribution they are able to make to their profession and society. They are the qualities that also prepare graduates as agents of social good in an unknown future. These attributes sets them apart from those without a degree. The graduate attributes of Arya Vidyapeeth College (Autonomous) are:



Model of Graduate Attributes

1. **Disciplinary knowledge:** Graduates shall acquire comprehensive knowledge and understanding of their subject area, the ability to engage with different traditions of thought, and the ability to apply their knowledge in practice including in multi-disciplinary or multi-professional contexts.
2. **Discipline related skills:** Skills in areas related to specialization in the chosen disciplinary/interdisciplinary/major/minor area(s) of learning in a broad multidisciplinary context. In addition, create, select, and apply appropriate modern techniques, resources and IT tools.
3. **Problem solving skills:** A capacity for problem identification, the collection of evidence, synthesis and dispassionate analysis and apply one's learning in real – life situations.

4. **Communication Skills:** Ability to recognize and value communication as the tool for negotiating and creating new understanding, collaborating with others, and furthering their own learning.
5. **Critical thinking:** Graduates acquire the capacity for problem identification, collection of evidence, synthesis and dispassionate analysis. They also acquire the capacity for attentive exchange, informed argument and reasoning.
6. **Creative Thinking:** The graduates acquire an ability to create, perform or think in different and diverse ways about the same objects or scenarios and also the ability to communicate effectively for different purposes and in different contexts. They should also be able to work independently and as part of a team.
7. **Co-ordinating and collaborating with others:** The graduates need to possess the ability to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings. They should also be able to work productively with others, no matter their culture, perspective or background, and complete joint projects and also to work in partnership.
8. **Leadership readiness/qualities:** The graduates should be able to lead and support others by inspiring them with a clear vision and motivating them to achieve goals. They also need to acquire ability to map out the tasks of a team or an organization and setting directions.
9. **Environmental Awareness and action:** The graduates shall earn the capacity to realize the individual's responsibility in protecting and conserving the environment. They need to gain the capacity to understand the impact of the professional solutions in societal and environmental contexts, and demonstrate the knowledge of need for sustainable development.
10. **Community engagement and service:** The graduates need to develop an understanding of social and civic responsibilities, and of the rights of individuals and groups. The graduates should be able to demonstrate the capability to participate in community-engaged services/ activities for promoting the wellbeing of the society which includes participation in NSS, NCC, adult literacy etc.

UNDERGRADUATE PROGRAMME OUTCOME (PO)

BACHELOR DEGREE INSCIENCE: (B.Sc.)

1. **SPO-1 Knowledge:** Learners are encouraged to apply the knowledge of mathematics and science fundamentals to various solutions of complex problems. As such, knowledge of the subject is the sole objective of any student learner. A student is exposed to a wide range of topics in various subjects and is given intensive training in each of the courses that have laboratory related work. The learner is encouraged to use various mathematical methods (analytical and numerical) and experimental methods as an application to the acquired concepts and principles that help in studying various branches of sciences. At the end of the program, students are able to gain thorough knowledge in key areas in the subjects offered.
2. **SPO-2Problem Analyses**: Well, equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyse results so obtained from experiments and draw suitable conclusions against their supported data acquired. At the end of the program, students will be able to identify, formulate and analyse scientific problems and reach concrete solutions using various principles of mathematics and sciences.
3. **SPO-3 Designing Solutions**: Having acquired knowledge of subjects, students are trained to think out of the box, design and conduct an experiment or a series of experiments that demonstrate their understanding of the methods and processes involved.
4. **SPO-4 Modern tool usage**: Learners are trained to create, select, and apply appropriate techniques, resources and IT tools in the analysis and synthesis of data within limitations. (Outcome of final year project).
5. **SPO-5 Effective Communication**: Proficiency in speaking, reading, writing and listening in English and one Indian language and find meaning of the world by connecting people, ideas, books, media and technology.
6. **SPO-6 Employability**: This programme enables the learners to perform the jobs in diverse fields such as science, engineering, industries, survey, education, banking, development-planning, business, public service, self-business etc. efficiently. They will also be able to appear for competitive examinations
7. **SPO-7 Ethics:** While it is necessary to instil the spirit of competitiveness among students in a world of increasing competition, it is equally vital to develop a strong sense of ethics among learners that will help them develop some positive attitudes and values. This includes appreciation of the various principles and theories that evolved in science, the impact that science has on social, economic and environmental issues. One of the main objectives of any academic exercise,

therefore, should be to produce well-groomed individuals who understand the significance of ethical values and abide by them even in the most pressing circumstances. In this programme, this process is enabled through courses and facilitators who integrate the teaching of ethics in everyday pedagogy. As such, at the end of this programme students will be able to develop, internalise and exercise ethics in their professional as well as personal practices.

8. **SPO-8Environment and Sustainability**: 'Environmental sustainability' has become the watchword of the 21st century. An increased engagement with environment related concerns is appearing tangibly on global fronts; academics cannot and should not remain quarantined from this massive development. Through classroom discussions and research projects, this programme facilitates active dialogues with factors which influence human-ecology interactions. As such, at the end of this programme students will be able to identify and analyse socio-political, cultural and economic problems which act as deterrents to environmental sustainability and provide creative solutions towards the same.

9. **SPO-9 Soft-Skill Development**: Apart from the attainment of knowledge and hands on skills in practical applicability of the subject, learners need to be equipped with soft-skills and values which will help them function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary groups. These soft skills include leadership, teamwork, project-management, positive outlook, innovative approaches and effective articulation. Several soft skill programs are organized for learners through various agencies that tie up with the state government. As such, at the end of this programme, students will be able to hone the soft-skills required in positively enhancing their academic, professional and personal pursuits towards self and societal advancement.

10. **SPO-10 Science and Society**: The learners are encouraged to apply logical reasoning based on the knowledge, skills, designing solutions to assess societal, health, safety issues and the responsibilities that go along with the scientific practice. As an extension activity to society, learners are encouraged to take up specific projects such as impact of salinity on fresh water wells in an adopted village, and provide effective solutions.

11. **SPO-11Life-long learning**: With the pursuit of knowledge for either personal or professional reasons, learners are also encouraged to volunteer and be self-motivated that not only enhances society values, active participation and personality development, but also enhances self-sustainability, competiveness and employability. As such, learners will be able to recognize the need for, and have the preparation and ability to engage in independent and life-long learning in every broad context of technological changes.

CORE

LIST OF COURSES:

Semester	Course Name	Course Code
1	General Chemistry-I	CH – CE – 1114
2	General Chemistry-II	CH – CE – 2114
3	General Chemistry-III	CH – CE – 3214
	General Chemistry-IV	CH – CE – 3224
4	Organic Chemistry-I	CH – CE – 4214
	Inorganic Chemistry-I	CH – CE – 4224
	Physical Chemistry-I	CH – CE – 4234
5	Organic Chemistry-II	CH – CE – 5314
	Inorganic Chemistry-II	CH – CE – 5324
	Physical Chemistry-II	CH – CE – 5334
	Analytical Chemistry	CH – CE – 5344
6	Organic Chemistry-III	CH – CE – 6314
	Inorganic Chemistry-III	CH – CE – 6324
	Physical Chemistry-III	CH – CE – 6334
	Industrial Chemistry	CH – CE – 6344

Semester	Course Name	Course Code
7	Research Methodology	CH – CE – 7414
	Organic Chemistry – IV	CH – CE – 7424
	Inorganic Chemistry – IV	CH – CE – 7434
	Physical Chemistry – IV	CH – CE – 7444
	Quantum Chemistry	CH – CE – 7454
8	Organic Chemistry – V	CH – CE - 8414
	Inorganic Chemistry – V	CH – CE - 8424
	Physical Chemistry – V	CH – CE - 8434
	Spectroscopy	CH – CE - 8444
	Green Chemistry	CH – CE – 8454
	Dissertation	CH – DT – 812

Programme Specific Outcome of Bachelor of Science – Chemistry Core (PSO)

PSO No.	Name	Outcome
PSO–1	Basic Understanding	The learner will able to gain basic ideas about different branches of chemistry viz. organic, inorganic, physical, analytical and quantum chemistry.
PSO–2	Critical Thinking	The learner will be to analyse, interpret, evaluate and make judgement about the various concepts encountered in Chemistry.
PSO–3	Skill Enhancement	The learner will develop practical skills to work/ or to develop start-ups in different industrial fields like chemical, pharmaceutical, polymer, glass blowing, agro industry and others related to chemical sciences.
PSO–4	Communication Skill	The learner will gain communication skill to present their knowledge/expertise/skill in Chemistry in the form of project work, seminar presentation, poster presentation, wall magazine and other modes.
PSO–5	Digital Efficiency	The learner will be able to imply digital learning through different software packages like Google forms, docs, excel, Chem draw, ISIS draw, Origin, Gaussian etc. They will also able to search scientific literatures in different digital mediums.
PSO–6	Collective Effort	The learner will learn to complete common tasks or achieve common goals in an effective way through collaborative manner.
PSO–7	Exposure to Research Activities	The learner will get exposures to diverse research fields through project work, interactions with scientists/ researchers/scholars, institutional/industrial visits students outreach programmes, etc. which will incubate research aptitude in the students.
PSO–8	Employability Prospects	The learner will be able to gain knowledge and expertise to pursue a career in educational institutions, R&D organizations, etc. across the country and abroad.
PSO–9	Competency for Competitive Examinations	The learners will gain the confident to face the competitive exams like CUET, PGUET, JAM, NET, GATE, SLET, GRE, TOEFL, Civil services, etc.
PSO–10	Ethical Analysis	The learner will learn to make legitimate evidence based-decision making in a particular context, especially through the concepts of IPR like Patent, copyright, plagiarism, etc.

Course Learning Outcome (CLO) – Core

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	General Chemistry-I CH – CE – 1114	CLO - 1	The students will get introduced to the foundations of organic, inorganic, as well as, physical chemistry concepts including atomic structure, periodicity of elements, redox reactions, ideals of organic reactions, aliphatic hydrocarbons, kinetic theory of gases, ionic equilibria, liquid state, etc.
		CLO - 2	The students will learn about the basic laboratory techniques and they are supposed to learn to perform introductory experiments viz. redox titrations, purification methods, pH measurements, etc.
2	General Chemistry-II CH – CE – 2114	CLO - 1	The students will learn about the fundamental's concepts of chemistry, including chemical bonding, transition elements, hydrocarbons, stereochemistry, solid state chemistry and chemical thermodynamics.
		CLO - 2	The students will learn to perform basic laboratory experiments like acid-base titrations, separation techniques, and thermochemical measurements.
3	General Chemistry-III CH – CE – 3214	CLO - 1	The students will familiarize themselves with the principles of atomic and molecular structure, chemical bonding, and introductory concepts in coordination chemistry, while also gaining practical experience in the preparation of double salts and inorganic coordinate complexes.
		CLO - 2	The students will get introduced to organic reaction mechanisms of elimination and addition reactions, as well as, learn about the stereochemistry of conformational isomers. The students are expected to perform detection of functional groups in organic compounds.
		CLO - 3	The students will be acquainted with the reaction rates and order, as well as, thermodynamic concepts of systems of variable compositions. They are further expected to develop expertise in performing reaction kinetics studies on chemical reactions.

3	General Chemistry-IV CH – CE – 3224	CLO - 1	The students will develop a comprehensive understanding of lattice energy equations, crystal field theory terms, and the reactivity of coordination compounds. They will also recognize trends in lanthanide and actinide properties and distinguish among periodic row elements, while acquiring skills in gravimetric analysis for metal ion quantification and chromatographic methods for metal ion separation.
		CLO - 2	The students will get introduced to organic reaction mechanisms of nucleophilic and electrophilic reactions of aliphatic and aromatic compounds, along with the chemistry of halogenated hydrocarbons. The students are expected to learn to perform selective elemental analysis of organic compounds and their functional group detection of *N*-containing compounds.
		CLO - 3	The students will be able to differentiate ideal and non-ideal solutions and understand different phenomena and properties pertinent to solutions.
4	Organic Chemistry-I CH – CE – 4214	CLO - 1	The students will be able to describe and classify different classes of organic compounds, including alcohols, phenols, ethers and epoxides, carbonyl compounds, and carboxylic acids, in terms of their functional groups and reactivity, along with analyze and design transformations between different functional groups using oxidizing and reducing agent
		CLO - 2	The students will learn to perform systematic analysis in order to identify organic compounds and prepare their derivatives.
	Inorganic Chemistry-I CH – CE – 4224	CLO - 1	The students will grasp the fundamentals of acid-base chemistry and the unique characteristics of noble gases, as well as recognize a range of s- and p-block compounds, understanding their preparation, structure, bonding, properties, and applications. Additionally, they will apply theoretical principles of redox chemistry to comprehend metallurgical processes effectively.

4	Inorganic Chemistry-I CH – CE – 4224	CLO - 2	The students will acquire proficiency in conducting iodo-/iodi-metric titrations as well as complexometric titrations, thereby enhancing their abilities in quantitative estimation.
	Physical Chemistry-I CH – CE – 4234	CLO - 1	The students will be able to interpret the physical and chemical transformations taking place during chemical reactions at molecular level.
		CLO - 2	The students will apprehend the electrical properties of atoms and molecules from concepts of ionic conductivity and spontaneous chemical reactions. Students will also gain hands-on training on operating electrochemical instruments and learn to determine conductance of acid-base solutions.
5	Organic Chemistry-II CH – CE – 5314	CLO - 1	The students are expected learn about different classes of organic compounds including heterocyclic compounds, polynuclear aromatic hydrocarbons, N-S-&P-containing compounds, organometallic compounds, explain their structure, bonding, reactivity, critically examine their synthesis and reactions mechanism. The students are expected to learn about different types of molecular rearrangements and write their mechanisms.
		CLO - 2	The students will learn about laboratory synthetic practices and be able to execute small scale organic preparations. Students will additionally learn to isolate organic mixtures using column chromatography.
	Inorganic Chemistry-II CH – CE – 5324	CLO - 1	The students will be equipped to recognize a range of s- and p-block compounds and understand their preparation, structure, bonding, properties, and applications. Additionally, they will gain insight into organometallic compounds, including their bonding, stability, reactivity, and uses, and become acquainted with various catalysts based on transition metals and their industrial applications. Furthermore, students will explore the mechanisms of ligandsubstitution and redox reactions in coordination complexes as part of their study.

5	Inorganic Chemistry-II CH – CE – 5324	CLO - 2	The students will gain an appreciation for utilizing concepts such as solubility product, common ion effect, pH, etc., in the analysis of ions, and understand how through strategic reaction design, it becomes feasible to identify components within a mixture.
	Physical Chemistry-II CH – CE – 5334	CLO - 1	The students are expected to learn phase rule and its application in some specific systems. They will also learn about equilibrium in chemical systems from thermodynamic viewpoint. Further, students will gain practical knowledge on phase transitions in selected systems, depending on the conditions and also comprehend different surface adsorption phenomena.
		CLO - 2	The students are expected to develop an understanding of the interaction of surfaces and explore concepts of surface adsorption. In addition, students can have practical understanding on different surface adsorption phenomena.
	Analytical Chemistry CH – CE – 5344	CLO - 1	The students will gain theoretical understanding about the choice of various analytical techniques used in analytical chemistry for qualitative and quantitative characterization of samples.
		CLO - 2	The students will get hands-on experience of operating spectrophotometric, pH-metric and polarimetric instrumental techniques and also be to solve or interpret instrumental data for sample analysis.
6	Organic Chemistry-III CH – CE – 6314	CLO - 1	The students will be get introduced to the chemistry of natural products viz. carbohydrates, nucleic acids, amino acids, lipids, terpenes, and alkaloids, describe their importance, as well as, examine their properties, applications, etc.
		CLO - 2	The students will learn to perform titrimetric estimations of organic compounds like amino acids, sugars and oils, along with be able to isolate naturally occurring compounds from plants and fruits.
	Inorganic Chemistry-III	CLO - 1	The students will explore the beneficial and detrimental effects of various metals and non-metals in biological systems,

6	CH – CE – 6324		alongside delving into organometallic compounds to understand their bonding, stability, reactivity, and applications. Additionally, they will gain familiarity with a diverse range of transition metal-based catalysts and their industrial utilization.
		CLO - 2	The students will acquire the skills to synthesize specific coordination complexes tailored for various applications. Moreover, they will gain expertise in the synthesis of metal oxide and metal sulfide nanoparticles.
	Physical Chemistry-III CH – CE – 6334	CLO - 1	The students are expected to understand the application of quantum mechanics in some simple chemical systems such as hydrogen atom or hydrogen like ions.
		CLO - 2	The students will also be able to understand the basics of light- matter interactions and various kinds of spectroscopic techniques and applications. The students will learn about to characterize and analyze diverse molecules using UV-Vis spectroscopic techniques.
	Industrial Chemistry CH – CE – 6344	CLO - 1	The students will be acquainted with the various materials of industrial importance and their advanced and current applications.
		CLO - 2	The students will learn to conduct quantitative and qualitative chemical analysis of some industrially important materials that are manufactured in chemical industries.
7	Research Methodology CH-CE-7414	CLO-1	The objectives of this course are to make the students aware of fundamental but mandatory ethical practices in chemistry, to introduce the concept of data analysis, to learn to perform literature survey in different modes, to make the students aware of safety handling and safe storage of chemicals, to make students aware about plagiarism and how to avoid it, and

			to teach the use of different e-resources.
7		CLO-2	Student can have hands on training on various aspect of research including collecting journal articles and writing literature survey, preparing poster presentation, etc.
	Organic Chemistry-IV CH-CE-7424	CLO-1	The students will be able to critically analyze organic reaction mechanisms through a detailed understanding of kinetic and thermodynamic principles, including reaction profiles, isotope effects, and linear free energy relationships. They will gain in-depth knowledge of reactive intermediates. Additionally, students will develop a solid foundation in stereochemical principles.
		CLO-2	The students will be able to systematically analyze and identify components in a binary organic mixture using classical separation and identification techniques. They will also acquire practical experience in the extraction of natural products, specifically carotenoids, from plant sources.
	Inorganic Chemistry-IV CH-CE-7434	CLO-1	The students will be able to apply advanced concepts of inorganic, organometallic, and solid-state chemistry to explain the structure, bonding, synthesis, and reactivity of main group and transition metal compounds.
		CLO-2	The students will be able to interpret molecular structures and chemical behavior using principles

			of symmetry, group theory, and spectroscopic characterization.
7	Physical Chemistry-IV CH-CE-7444	CLO-1	The objective of this course is to aware students on the detail of equillibrium, non-equillibrium and statistical thermodynamics. Also, to familiarize students with significance of polymer chemistry and data analysis. Moreover, the present course also enables students towards chemistry of natural products and basics of quantum chemistry.
		CLO-2	Student can perform hands-on training of various data analysis using MS Excel/origin. Student can also learn practically to determine the molecular weight of a polymer and various aspects of thermodynamics and phase equilibria.
	Quantum Chemistry CH-CE-7454	CLO-1	Upon completion of this course, students will be able to understand fundamental quantum concepts, operator theory, and the Schrödinger equation to describe atomic and molecular systems.
		CLO-2	The students will be able to apply quantum mechanical models and approximation methods (perturbation theory, Born-Oppenheimer approximation, MO theory) to solve atomic and molecular problems.
8	Organic Chemistry-V CH-CE-8414	CLO-1	The students will be able to analyse and predict the outcomes of key organic photochemical, oxidation-reduction and pericyclic reactions.

8		CLO-2	The students will be able to carry out basic organic syntheses, including multi-step and multicomponent reactions. They will gain hands-on experience in natural product extraction, analysis, and biodiesel preparation. Additionally, students will develop skills in quantitative analysis using titrimetric and spectroscopic methods.
	Inorganic Chemistry-V CH-CE-8424	CLO-1	Apply group theory to analyse molecular symmetry, vibrations, and spectral transitions, Explain bonding and electronic spectra of transition metal complexes using crystal field and molecular orbital theories
		CLO-2	The students can have practical experience on advanced inorganic quantitative analysis
	Physical Chemistry-V CH-CE-8434	CLO-1	By studying this course student can able to: Apply steady-state approximation method toward various reaction, understand the kinetics of fast reaction, also understand the theory of molecular dynamics including transition state theory and its applications, Understand the electrochemical application for energy storage and energy conversion.
		CLO-2	Student can able to comprehend with advanced practical aspect of chemical kinetics and application of electrochemistry.
	Spectroscopy CH-CE-8444	CLO-1	By studying this course student can able to understand the various concepts used in the analysis of organic and inorganic molecules via various spectroscopic and spectrometric techniques.

8		CLO-2	Student can get hands-on training on using NMR or IR or UV techniques to differentiate between organic molecules.
	Green Chemistry CH-CE-8454	CLO-1	Apart from introducing learners to the principles of green chemistry, this course will make them conversant with applications of green chemistry to organic synthesis. Students will be prepared for taking up entry level jobs in the chemical industry. They also will have the option of studying further in the area.
		CLO-2	The student will be able to apply the principles of green chemistry in organic synthesis and preparation of value-added chemicals.

MAPPING OF PROGRAMME OUTCOME (PO) AND COURSE LEARNING OUTCOME (CLO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	PROGRAMME OUTCOME										
		SPO1	SPO2	SPO3	SPO4	SPO5	SPO6	SPO7	SPO8	SPO9	SPO10	SPO11
CH-CE-1114	CLO-1	3	3	3	1	3	3	1	2	-	3	3
	CLO-2	3	3	3	3	2	3	1	1	1	3	3
CH-CE-2114	CLO-1	3	3	3	1	3	3	1	3	1	3	3
	CLO-2	3	3	3	2	1	3	1	1	-	3	3
CH-CE-3214	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	1	3	3	1	2	-	3	3
	CLO-3	3	3	3	3	3	3	2	3	3	3	3
CH-CE-3224	CLO-1	3	3	3	3	3	3	2	3	3	3	3
	CLO-2	3	3	3	1	3	3	2	2	-	3	3
	CLO-3	3	3	3	3	3	3	3	3	3	3	3
CH-CE-4214	CLO-1	3	3	3	1	3	3	2	3	-	3	3
	CLO-2	3	3	3	1	1	3	2	1	-	3	3
CH-CE-4224	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	2	3	3	3
CH-CE-4234	CLO-1	3	3	3	2	3	3	3	2	3	3	3
	CLO-2	3	3	3	3	3	3	3	3	3	3	3
CH-CE-5314	CLO-1	3	3	3	1	3	3	3	3	-	3	3
	CLO-2	3	3	3	3	2	3	2	3	-	3	3
CH-CE-5324	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	3	3	3	3
CH-CE-5334	CLO-1	3	3	3	3	3	3	3	2	3	3	3
	CLO-2	3	3	3	3	3	3	3	2	3	3	3
CH-CE-5344	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	2	3	3	3
CH-CE-6314	CLO-1	3	3	3	1	3	3	3	3		3	3
	CLO-2	3	3	3	2	3	3	2	3		3	3
CH-CE-6324	CLO-1	3	3	3	3	3	3	2	3	3	3	3
	CLO-2	3	3	3	3	3	3	3	3	3	3	3
CH-CE-6334	CLO-1	3	3	3	3	3	3	3	3	3	3	3
	CLO-2	3	3	3	3	3	3	3	3	3	3	3
CH-CE-6344	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	2	3	3	3
CH-CE-7414	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	3	3	3	3
CH-CE-7424	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	3	3	3	3
CH-CE-7434	CLO-1	3	3	3	3	3	3	3	2	3	3	3
	CLO-2	3	3	3	3	3	3	3	2	3	3	3

Course Code	CLO	PROGRAMME OUTCOME										
		SPO1	SPO2	SPO3	SPO4	SPO5	SPO6	SPO7	SPO8	SPO9	SPO10	SPO11
CH-CE-7444	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	2	3	3	3
CH-CE-7445	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	2	3	3	3
CH-CE-8414	CLO-1	3	3	3	1	3	3	3	3	3	3	3
	CLO-2	3	3	3	2	3	3	2	3	3	3	3
CH-CE-8424	CLO-1	3	3	3	3	3	3	2	3	3	3	3
	CLO-2	3	3	3	3	3	3	3	3	3	3	3
CH-CE-8434	CLO-1	3	3	3	3	3	3	3	3	3	3	3
	CLO-2	3	3	3	3	3	3	3	3	3	3	3
CH-CE-8444	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	2	3	3	3
CH-CE-8454	CLO-1	3	3	3	3	3	3	2	2	3	3	3
	CLO-2	3	3	3	3	3	3	2	2	3	3	3

MAPPING OF PROGRAMME SPECIFIC OUTCOME (PSO) AND COURSE LEARNING OUTCOME (CLO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	PROGRAMME SPECIFIC OUTCOME									
		PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
CH-CE-1114	CLO-1	3	3	3	2	2	3	1	3	3	-
	CLO-2	3	3	3	2	2	3	1	3	3	-
CH-CE-2114	CLO-1	3	3	3	2	1	3	1	3	3	-
	CLO-2	3	3	3	2	1	3	1	3	3	-
CH-CE-3214	CLO-1	3	3	3	2	2	3	1	3	3	1
	CLO-2	3	3	3	3	2	3	1	3	3	1
	CLO-3	3	1	3	2	1	3	1	2	3	-
CH-CE-3224	CLO-1	3	3	3	2	2	3	1	3	3	1
	CLO-2	3	3	3	3	2	3	1	3	3	1
	CLO-3	3	1	3	2	1	3	1	2	3	-
CH-CE-4214	CLO-1	3	3	3	3	2	3	1	3	3	1
	CLO-2	3	3	3	2	2	3	1	3	3	1
CH-CE-4224	CLO-1	3	3	2	2	3	3	2	3	3	1
	CLO-2	3	3	3	2	3	3	3	3	3	1
CH-CE-4234	CLO-1	3	2	3	1	1	1	1	1	3	-
	CLO-2	3	3	3	1	1	3	3	2	3	-
CH-CE-5314	CLO-1	3	3	3	2	2	3	2	3	3	1
	CLO-2	3	3	3	2	2	3	2	3	3	1
CH-CE-5324	CLO-1	3	3	2	2	3	3	2	3	3	1
	CLO-2	3	3	3	2	3	3	3	3	3	1
CH-CE-5334	CLO-1	3	3	2	2	1	3	2	2	3	1
	CLO-2	3	3	2	2	1	3	2	2	3	1
CH-CE-5344	CLO-1	3	3	2	2	3	3	3	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2
CH-CE-6314	CLO-1	3	3	3	2	3	3	2	3	3	1
	CLO-2	3	3	3	2	3	3	2	3	3	1
CH-CE-6324	CLO-1	3	3	2	2	3	3	2	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2
CH-CE-6334	CLO-1	3	3	1	2	3	3	3	2	3	1
	CLO-2	3	3	3	2	3	3	3	3	3	1
CH-CE-6344	CLO-1	3	3	2	2	3	3	2	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2
CH-CE-7414	CLO-1	3	3	2	2	3	3	2	3	3	1
	CLO-2	3	3	3	2	3	3	3	3	3	1
CH-CE-7424	CLO-1	3	3	2	2	3	3	2	3	3	1
	CLO-2	3	3	3	2	3	3	3	3	3	1
CH-CE-7434	CLO-1	3	3	2	2	1	3	2	2	3	1
	CLO-2	3	3	2	2	1	3	2	2	3	1

CH-CE-7444	CLO-1	3	3	2	2	3	3	3	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2
CH-CE-7454	CLO-1	3	3	2	2	3	3	3	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2
CH-CE-8414	CLO-1	3	3	3	2	3	3	2	3	3	1
	CLO-2	3	3	3	2	3	3	2	3	3	1
CH-CE-8424	CLO-1	3	3	2	2	3	3	2	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2
CH-CE-8434	CLO-1	3	3	1	2	3	3	3	2	3	1
	CLO-2	3	3	3	2	3	3	3	3	3	1
CH-CE-8444	CLO-1	3	3	2	2	3	3	2	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2
CH-CE-8454	CLO-1	3	3	2	2	3	3	2	3	3	2
	CLO-2	3	3	3	2	3	3	3	3	3	2

COURSE NAME: General Chemistry-I
COURSE CODE: CH – CE – 1114
Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

This course aims at giving students understanding about the basic constituents of matter – atoms, ions and molecules in terms of their electronic structure and reactivity. Structure and bonding are to be dealt with basic quantum chemistry treatment. Further, periodic classification of elements in the periodic table and changes in properties along the periods and groups to be studied in detail. The students are introduced to the principles of redox titrations in context of volumetric analysis of common metal ions. The course also apprises students with introduction to organic compounds, electron displacement, type of reagents and reaction intermediates. The chemistry of aliphatic and aromatic hydrocarbon is also included. Further, the course strives to educate the students on fundamental topics states of matter-gaseous and liquid along with ionic equilibria.

Course Learning Outcome:

CLO-01: *The students will get introduced to the foundations of organic, inorganic, as well as, physical chemistry concepts including atomic structure, periodicity of elements, redox reactions, ideals of organic reactions, aliphatic hydrocarbons, kinetic theory of gases, ionic equilibria, liquid state, etc.*

CLO-02: *The students will learn about the basic laboratory techniques and they are supposed to learn to perform introductory experiments viz. redox titrations, purification methods, pH measurements, etc.*

Unit 1: Inorganic Chemistry

Atomic Structure-I (5 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and $|\psi|^2$. Quantum numbers and their significance.

Periodicity of Elements (7 Lectures)

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* &*p*-block.

a. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

b. Atomic radii (van der Waals), Ionic and crystal radii, Covalent radii.

c. Ionization enthalpy, factors affecting ionization energy.

d. Electron gain enthalpy, trends of electron gain enthalpy.

e. Electro negativity, Pauling's/ Mulliken's/ Alfred Rochow's electro negativity scales. Variation of electro negativity with bond order, partial charge, hybridization, group electro negativity.

f. Inert pair effect, diagonal relationship.

Oxidation-Reduction: (3 Lectures)

Principles involved in volumetric analysis of metal ion Fe2+ with the help of standard $KMnO_4$ and$K_2Cr_2O_7$ solution

Unit 2: Organic Chemistry

Organic Compounds: (2 Lectures)

Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: (3 Lectures)

Inductive, electromeric, resonance and mesomeric effects, hyper conjugation and their applications; Dipole moment; Hydrogen bonding and its effect on the properties of organic molecules; Organic acids and bases – their relative strength.

Cleavage of Bonds: (3 Lectures)

Homolysis and Heterolysis. Curly arrow rules, Drawing electron movement with arrows and half-headed arrows. Structure and shape of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Aliphatic Hydrocarbons (7 Lectures)

a. Alkanes: Preparation - Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions - Free radical Substitution: Halogenation.

b. Alkenes: Preparation - Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis-alkenes (Partial catalytic hydrogenation) and trans-alkenes (Birch reduction). Reactions-cis-addition (alkaline $KMnO_4$) and trans-addition (Br_2), Addition of hydrogen halides (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

c. Alkynes: Preparation - Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra-halides and dehydrohalogenation of vicinal-dihalides. Reactions-formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$. Vali International, New Delhi.

Unit 3: Physical Chemistry

Kinetic Theory of Gases:(6 Lectures)

Postulates of Kinetic theory of gases and derivation of the kinetic gas equation. Behaviour of real gases: Deviation from ideal behaviour, compressibility factor, causes of deviation from ideal behaviour, Vander Waals equaton of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from Vander Waals equation. Andrew isotherms of CO_2.

Ionic Equilibrium:(5 Lectures)

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. Buffer solutions. Solubility and solubility product of sparingly soluble salts-applications of solubility product principle.

Liquids: (4 Lectures)

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

Practical:

Total Lectures: 30

Oxidation-Reduction Titrimetry:

1. Preparation of solutions of different Molarity/Normality of titrants.
2. Estimation of $Fe^{2+}$and Fe^{3+} ions with the help of $K_2Cr_2O_7$ and standardized $KMnO_4$ solutions.

Purification methods:

1. Purification of organic compounds by crystallization using the following solvents: a) Water b) Alcohol c) Alcohol-Water
2. Determination of the melting points of recrystallized compounds and unknown organic Compounds.

pH measurements:

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps using pH meter.
2. Preparation of buffer solutions:

(i) Sodium acetate-acetic acid.

(ii) Ammonium chloride-ammonium hydroxide.

Surface tension measurement: (in aqueous solutions only)

1. Determination of the surface tension of a dilute solution using astalagmometer.
2. Study of the variation of surface tension of a detergent solution with concentration.

Viscosity measurement: (in aqueous solutions only)

1. Determination of the relative and absolute viscosity of dilute solution using an Ostwald's viscometer.
2. Study of the variation of viscosity of an aqueous solution with concentration of solute

RECOMMENDED BOOKS:

THEORY:

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley Atkins, P., Overton, T., Rourke, J., Weller, M. and Armstrong, F., Shriver and Atkins
3. Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, 9 th Ed., Oxford University Press.

5. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.
6. Negi, A.S., Anand, S.C. A Textbook of Physical Chemistry, 3 rd Ed. New Age International Publishers
7. Silbey, R. J., Alberty, R. A., Bawendi, M. G. Physical Chemistry, 4 th Ed., John Wiley & amp; Sons.
8. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, 2 nd Ed., Oxford University Press.
9. Bruice, P. Y. Organic Chemistry, 7 th Ed., Pearson Education.
10. Morrison, R. N., Boyd, R. N. & Bhattacharjee, S. K. Organic Chemistry, 7 th Ed. Pearson Education.

PRACTICAL:

1. Yadav, J.B. Advanced Practical Physical Chemistry, Krishna Prakashan.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi.
3. Mendham, J., Denney, R.C., Barnes, J. D., Thomas, M. and Sivasankar, S. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed., Pearson Education.
4. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, Pearson Education

COURSE NAME: General Chemistry-II

COURSE CODE: CH – CE – 2114

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 Credits

TOTAL LECTURES: 45

COURSE OBJECTIVE:

This course aims at giving students theoretical understanding about the structure and bonding of molecules, with important concepts like Valence Bond theory and Molecular Orbital theory. The students are introduced to the chemistry of the d-block transition elements including their properties and reactivities. The course also apprises students with introduction to aromatic organic compounds, with special focus on benzene, its properties and reactivity. The students are also introduced to the stereochemistry of organic compounds. Further, the course strives to educate the students on fundamental topic of states of matter- solid state and the important concept of chemical thermodynamics and thermo chemistry.

Course Learning Outcome:

CLO-01: *The students will learn about the fundamental's concepts of chemistry, including chemical bonding, transition elements, hydrocarbons, stereochemistry, solid state chemistry and chemical thermodynamics*.

CLO-02: *The students will learn to perform basic laboratory experiments like acid-base titrations, separation techniques, and thermochemical measurements*

Unit 1: Inorganic Chemistry

Chemical Bonding – I: (3 Lectures)

i. Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals.

ii. Covalent bond: Lewis's structure, Formal charge.

iii. Concepts of hybridization involving *s, p &d* orbitals, equivalent and non-equivalent hybrid orbitals. Bent's rule.

Chemical Bonding – II (6 Lectures)

i. 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.

ii. Molecular orbital theory, Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions.

Transition Elements (3d series) (6 Lectures)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Unit 2: Organic Chemistry

Aromatic Hydrocarbons (5 Lectures)

Structure and Bonding (Benzene); Hückel's rule of aromaticity, Aromatic character of arenes and heterocyclic compounds with suitable examples. Preparation (of benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid; Reactivity (of benzene): Electrophilic aromatic substitution – nitration, halogenation and sulphonation; Directing effects of the groups. Friedel-Craft's reaction (alkylation and acylation).

Stereo chemistry of Organic Compounds (10 Lectures)

Concept of isomerism, Elementary idea of structural projections: Flying wedge, Newmann, Sawhorse and Fischer representations.

Configurational isomers: Optical isomerism – Optical activity, Concept of chirality; Enantiomers, Diastereomers and Meso compounds; Optically active molecules without chiral centre, Atropisomerism. Racemic Mixtures and Resolution. Geometrical isomerism–*cis-trans* and *syn-anti* isomerism. Relative and absolute configuration with CIP rules: D/L and R/S designations (for upto 2 chiral carbon atoms) and E/Z designations (for up to two C = C systems).

Unit 3: Physical Chemistry:

Solids: (4Lectures)

Symmetry elements, unit cells, crystal systems, Bravais Lattice types and identification of lattice planes. Structure of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Thermodynamics (6 Lectures)

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.

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

Thermochemistry (5 Lectures)

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. A diabatic flame temperature, explosion.

Practical:

Total lectures: 30

Acid – Base Titrations

1. Estimation of carbonate and hydroxide present together in mixture
2. Estimation of carbonate and bicarbonate present together in a mixture
3. Estimation of free alkali present in different soaps/detergents.

Separation techniques

1. Separation of a binary mixture of organic compounds by thin layer chromatography (TLC) like ortho-/para-nitrophenols, ortho-/para-nitroaniline, etc.
2. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography

Heat Capacity & Enthalpy measurements

1. Determination of heat capacity of a calorimeter using hot and cold water.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of hydration of copper sulphate.
4. Study of the solubility of benzoic acid in water and determination of ΔH

RECOMMENDED BOOKS:

THEORY:

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley Atkins, P., Overton, T., Rourke, J., Weller, M. and Armstrong, F., Shriver and Atkins
3. Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, 9 th Ed., Oxford University Press.
5. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.
6. Negi, A.S., Anand, S.C. A Textbook of Physical Chemistry, 3 rd Ed. New Age International Publishers
7. Silbey, R. J., Alberty, R. A., Bawendi, M. G. Physical Chemistry, 4 th Ed., John Wiley & amp; Sons.
8. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, 2 nd Ed., Oxford University Press.
9. Bruice, P. Y. Organic Chemistry, 7 th Ed., Pearson Education.

10. Morrison, R. N., Boyd, R. N. & Bhattacharjee, S. K. Organic Chemistry, 7 th Ed. Pearson Education.

PRACTICAL:

1. Yadav, J.B. Advanced Practical Physical Chemistry, Krishna Prakashan.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi.
3. Mendham, J., Denney, R.C., Barnes, J. D., Thomas, M. and Sivasankar, S. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed., Pearson Education.
4. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, Pearson Education

COURSE NAME: General Chemistry-III

COURSE CODE: CH- CE - 3214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

This course aims at providing the students with further insights into the electronic structure and bonding of atoms, ions and molecules, in terms of basic quantum chemistry treatment. The course also introduces students to coordination chemistry and its various aspects like nomenclature, structure, bonding, variety and reactivity of the coordination compounds for the students to appreciate. The course also attempts to educate the students with fundamental aspects of a chemical reaction and introduce them to different types of organic reactions mechanisms. The study of conformational isomers is included to enlighten the students about stereochemistry. Lastly, the course is integrated with the study of chemical kinetics to acquaint the students with reaction rates and order, as well as, thermodynamic concepts of systems of variable compositions.

Course Learning Outcome:

CLO 1: *The students will familiarize themselves with the principles of atomic and molecular structure, chemical bonding, and introductory concepts in coordination chemistry, while also gaining practical experience in the preparation of double salts and inorganic coordinate complexes.*

CLO 2: *The students will get introduced to organic reaction mechanisms of elimination and addition reactions, as well as, learn about the stereochemistry of conformational isomers. The students are expected to perform detection of functional groups in organic compounds.*

CLO 3: *The students will be acquainted with the reaction rates and order, as well as, thermodynamic concepts of systems of variable compositions. They are further expected to develop expertise in performing reaction kinetics studies on chemical reactions.*

Unit 1: Inorganic Chemistry

Atomic Structure – II (6 Lectures)

Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wavefunctions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number and electronic configuration.

Chemical Bonding – III (4 Lectures)

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Coordination Chemistry – I (5 Lectures)

Coordination compounds, types of ligands, Werner's theory, IUPAC nomenclature and isomerism in coordination compounds. Stereochemistry of complexes with 4- and 6-coordination numbers.

Drawbacks of VBT. Basic idea of Crystal field theory (CFT) of octahedral and tetrahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields, pairing energy.

Unit 2: Organic Chemistry

Stereochemistry of Organic Compounds - II (5 lectures)

Conformational isomers: Conformers, Conformational analysis of simple alkanes (ethane and butane) & relative stability with energy diagrams. Types of cycloalkanes and their relative stability. Conformational analysis of cyclohexane: Chair, Boat and Twist boat forms, relative stability with energy diagrams.

Introduction to Organic Reaction Mechanisms - I (10 lectures)

Idea of driving force, activation energy, transition state, energy profile diagrams, concept of kinetic and thermodynamic control of reactions; Classification of organic reactions.

Addition reactions: Electrophilic additions of alkenes and their mechanisms – addition of hydrogen halide (Markownikoff/ Anti-Markownikoff addition), addition of halides (X2), hydroboration-oxidation and ozonolysis.

Electrophilic additions of alkynes and their mechanisms – addition of hydrogen halide, addition of halides (X2) and hydration.

Elimination reactions: β-elimination reaction (base-catalysed) – Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Pyrolyticelimination reactions of esters.

Unit 3: Physical Chemistry

Chemical Kinetics - I (8 Lectures)

Concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rate. Order and molecularity of a reaction. Derivation of differential and integrated form of rate expressions of zero, first and second order reactions, experimental methods of the determination of rate laws. Half-life of a reaction.

Systems of Variable Composition (7 Lectures)

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

Practical:

Total Lectures: 30

Inorganic Preparations

i. Aluminium potash sulphate, $KAl(SO_4)_2 12H_2O$ (Potash alum)

ii. Chrome alum $K_2SO_4Cr_2(SO_4)_3 24H_2O$

iii. Manganese (III)phosphate $MnPO_4H_2O$

iv. Tetra ammine copper (II)sulphate, $Cu(NH_3)4SO_4H_2O$

v. Potassium tris (oxalato) ferrate (III), $K_3[Fe(C_2O_4)_3]$

vi. Potassium tris (oxalato) chromate (III), $K_3[Cr(C_2O_4)_3]$

vii. bis (glycinato) copper (II), $[Cu(glycinate)_2(H_2O)]$

viii. Hexa ammine nickel (II)chloride, $[Ni(NH_3)_6]Cl_2$

Qualitative Organic Analysis

Analysis of an organic compound: Test for carboxylic acid, phenolic and carbonyl groups.

Identification of acidic functional groups of a given organic sample (acetic acid, oxalic acid) and determination of equivalent mass by titrimetric methods.

Chemical Kinetic Studies

Study the kinetics of the following reactions:

i. Initial rate method: Iodide-persulphate reaction.

ii. Iodine-Clock reaction

iii. Integrated rate method:

   a. Acid hydrolysis of methyl acetate with hydrochloric acid.

   b. Saponification of ethyl acetate.

RECOMMENDED BOOKS:

Theory:

1. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed., Pearson Education, 2006.
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley, 2007.
3. Miessler, G. L. &Tarr, D. A., Inorganic Chemistry, 4th Ed., Pearson Education, 2010.
4. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, 2nd Ed., Oxford University Press.
5. Nasipuri, D. Stereochemistry of Organic Compounds: Principles and Applications, 4th Ed., New Age International Publishers.
6. March, J. Advanced Organic Chemistry, 4th Ed., Wiley, 2006.
7. Sykes, P. A Guide Book to Mechanism in Organic Chemistry, 6th Ed., Pearson Education, 2006.
8. Atkins, P.W. & Paula, J. Physical Chemistry, 11th Ed., Oxford University Press, 2018.
9. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.; 47thEd., 2017.
10. Kapoor, K. L. A Textbook of Physical Chemistry (Volume 2&5), McGraw Hill Education,6th Ed., 2019.

Practical:

1. Marr, G. &Rockett, R. W. Practical Inorganic Chemistry, Van Nostrand Reinhold Co., 1972.
2. Mann, F. G. & Saunders, B. C. Practical Organic Chemistry, Pearson Education, 2009.
3. Khosla, B. D., Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., 2011.
4. Barua, S. A Textbook of Practical Chemistry, Kalyani Publishers, 2016.

COURSE NAME: General Chemistry-IV

COURSE CODE: CH- CE - 3224

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course aims at giving students understanding about the concepts of lattice energy and different equations related to lattice energy in ionic compounds. This course also introduces students to coordination chemistry with emphasis on various ligand field effects and chelate effects. The chemistry of lanthanides and actinides is included for insights into characteristics and properties of f-block elements. The course attempts to educate the students on various substitution reactions of aliphatic and aromatic compounds with their mechanism; the chemistry of halogenated hydrocarbons are also included for students to learn about organic compounds. The course is further designed to enlighten students about the physical aspects of solutions and colligative properties.

Course Learning Outcome

CLO 1: *The students will develop a comprehensive understanding of lattice energy equations, crystal field theory terms, and the reactivity of coordination compounds. They will also recognize trends in lanthanide and actinide properties and distinguish among periodic row elements, while acquiring skills in gravimetric analysis for metal ion quantification and chromatographic methods for metal ion separation.*

CLO 2: *The students will get introduced to organic reaction mechanisms of nucleophilic and electrophilic reactions of aliphatic and aromatic compounds, along with the chemistry of halogenated hydrocarbons. The students are expected to learn to perform selective elemental analysis of organic compounds and their functional group detection of N-containing compounds.*

CLO 3: *The students will be able to differentiate ideal and non-ideal solutions and understand different phenomena and properties pertinent to solutions.*

Unit 1: Inorganic Chemistry

Ionic Bonding (5 Lectures)

Born Lande equation with derivation and importance of Kapustinskii expression for lattice energy, Madelung constant, Born-Haber cycle and its application, solvation energy

Coordination Chemistry – II (6 Lectures)

Factors affecting the magnitude of Δ_0, Spectrochemical series, Octahedral vs tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry, qualitative aspects of ligand field and molecular orbital theory, chelate effect, polynuclear complexes, labile and inert complexes.

Lanthanides and Actinides (4 Lectures)

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit 2: Organic Chemistry

Introduction to Organic Reaction Mechanisms-II: (9 Lectures)

Aliphatic substitution reactions: Free radical substitution mechanism of alkyl halides – Halogenation. Nucleophilic substitution reactions of alkyl halides– S_N1, S_N2 &S_Ni mechanisms with stereochemical aspects and solvent effects. Nucleophilic substitution vs. elimination.

Electrophilic aromatic substitutions: General mechanism (benzene as substrate) with evidences, formation of π-complex and σ-complex, Ortho-para ratio. Ipso substitution.

Nucleophilic aromatic substitutions: S_NAr mechanism (benzene as substrate) with evidences, Benzyne mechanism with evidences, methods of trapping benzyne intermediate, Directive influences in benzyne mechanism, Cine substitution.

Chemistry of Organic Compounds-I (6 Lectures)

Alkyl Halides: Methods of preparation: from alkenes and alcohols, physical properties, Reactivity – Hydrolysis, ether formation, amine formation, nitro formation, nitrile & isonitrile formation.

Aryl Halides: Methods of preparation (Chloro-, bromo- and iodo-benzene case): from phenol, Sandmayer & Gattermann reaction, physical properties, Reactivity (Chlorobenzene case)– Halogenation, nitration, sulphonation, Friedal Crafts reaction, Wurtz-Fittig reaction.

Unit 3: Physical Chemistry

Solutions (7 Lectures)

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law- non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule.

Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids.

Colligative Properties (8 Lectures)

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

Practical:
Total Lectures: 30

Quantitative Inorganic Analysis

i. Gravimetric analysis of Ni(II) using dimethylglyoxime (DMG).
ii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$, SO_4^{2-} ion as $BaSO_4$.

Chromatographic Separations

Chromatography of metal ions: Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni(II), Mn(II), Zn(II) and Co(II)
ii. Cu(II), Cd(II) and Hg(II)

Qualitative Organic Analysis:

Analysis of an organic compound (containing elements N, S and halogens):

i. Test for detection of elements N, S and X (halogens).

ii. Test for nitro, amine and amide groups

RECOMMENDED BOOKS:

Theory:

1. Cotton, F.A., Wilkinson, G. and Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley, 2007.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Ed., Pearson Education, 2006.
3. Miessler, G. L. &Tarr, D. A., *Inorganic Chemistry*, 4th Ed., Pearson Education, 2010.
4. March, J. *Advanced Organic Chemistry*, 4th Ed., Wiley, 2006.
5. Sykes, P. *A Guide Book to Mechanism in Organic Chemistry*, 6th Ed., Pearson Education, 2006.
6. Finar, I. L., *Organic Chemistry (Volume 1)*, 6th Ed., Pearson Education, 2009.
7. Atkins, P.W. & Paula, J. *Physical Chemistry*, 11th Ed., Oxford University Press, 2018.
8. Puri, B. R.; Sharma, L. R.; Pathania, M. S. *Principles of Physical Chemistry*, Vishal Publishing Co.; 47thEd., 2017.
9. Kapoor, K. L. *A Textbook of Physical Chemistry* (Volume 2&5), McGraw Hill Education,6th Ed., 2019.

Practical:

1. Mendham, J. et al.: *Vogel's Text Book of Quantitative Chemical Analysis*; 6th Ed. Pearson Education, 2009.
2. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press, 2000.
3. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: Organic Chemistry-I

COURSE CODE: CH- CE - 4214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course is intended to apprise students about different classes of organic compounds, including alcohols, phenols, ethers and epoxides, carbonyl compounds, carboxylic acids and their derivatives. Students are also expected to learn about various oxidizing and reducing reagents and their use in carrying out functional group transformations in organic compounds.

Course Learning Outcome:

CLO 1: *The students will be able to describe and classify different classes of organic compounds, including alcohols, phenols, ethers and epoxides, carbonyl compounds, and carboxylic acids, in terms of their functional groups and reactivity, along with analyse and design transformations between different functional groups using oxidizing and reducing agents.*

CLO 2: *The students will learn to perform systematic analysis in order to identify organic compounds and prepare their derivatives.*

Unit 1: Chemistry of Organic Compounds - II (30 lectures)

Alcohols: Preparation, properties and relative reactivity of 1°, 2°, 3° alcohols; Bouveault-Blanc Reduction; Preparation and reactions of diols: Oxidation by periodic acid and lead tetraacetate.

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions (electrophilic), Reimer–Tiemann reaction and Kolbe's–Schmidt reaction.

Ethers and Epoxides: Preparation and reactions with halo acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

Carbonyl Compounds: Preparation and physical properties; Reactivity – Nucleophilic addition to carbonyl groups, Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Cannizzaro and Wittig reaction. Haloform reaction and, oxidation-reduction reactions (Clemmensen, Wolff-Kishner, Merwein-Pondorff-Verley), Addition reactions of unsaturated carbonyl compounds - Michael addition.

Active methylene compounds: Keto-enol tautomerism, Preparation and synthetic applications of Ethylacetoacetate and diethylmalonate.

Carboxylic acid and their derivatives: Preparation, physical properties and reactions of monocarboxylic acids with mechanisms – Esterification, amide formation and Hell-Volhard-Zelinsky reaction; Introduction to dicarboxylic acids and unsaturated acids: Typical reactions of succinic, phthalic, maleic and fumaric acids.

Preparation of acid chlorides, acid anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group – Mechanism of acidic and alkaline hydrolysis of esters, Dieckmann and Reformatsky reactions, Hofmann-bromamide degradation.

Unit 2: Oxidation & Reduction Reactions (15 lectures)

Common oxidizing agents and their use in functional group transformations: Chromium trioxide, Jones reagent, PDC, PCC, Potassium permanganate, Osmium tetroxide.

Common reducing agents and their use in functional group transformations: Catalytic hydrogenation (Raney Ni, Pd & Pt), Reduction by LAH and $NaBH_4$, Reduction by metals (Li, Na).

Practical:

Total Lectures: 30

Qualitative Organic Analysis

Systematic qualitative analysis of an organic compound (containing simple mono-functional and bi-functional groups) and its identification by melting point determination and derivative preparation: Carboxylic acids, phenols, ketones, aldehydes, nitro compounds, amines, amides and aromatic hydrocarbons.

RECOMMENDED BOOKS:

Theory:

1. Carruthers, W. & Coldhaim, I. *Modern Methods of Organic Synthesis*, 4th Ed., Cambridge, 2013 (Reprint).
2. Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry,* 2nd Ed., Oxford University Press, 2012.
3. Solomons, T. W. G., Fryhle, C. B., Snyder, S. A. *Organic Chemistry*, 12th Ed., Wiley, 2016.
4. Smith, M. B. *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 8th Ed. Wiley, 2020.
5. Morrison, R. T., Boyd, R. N. & Bhattacharjee, S. K. *Organic Chemistry*, 7th Ed., Pearson Education India, 2011.
6. Finar, I. L., *Organic Chemistry (Volume 1)*, 6th Ed., Pearson Education, 2009.

Practical:

1. Ahluwalia, V. K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press, 2000.
2. Vogel, A. I. *Elementary Practical Organic Chemistry: Qualitative Organic Analysis Part 2*, 2nd Ed., Pearson, 2010.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education, 2009.
4. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A. R. *Vogel's Textbook ofPractical Organic Chemistry,* 5thEd., Pearson Education, 2012.
5. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: Inorganic Chemistry-I

COURSE CODE: CH- CE - 4224

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course aims to educate the students with the concepts of protonic and non-protonic acids-bases to appreciate different types of chemical reactions. Periodic behavior of s- and p- block elements related to their electronic structure and their reactivity is included to acquaint students with the principles governing their reactivity. This course further intend to apprise students about the variety of compounds of the main group elements including oxides, hydrides, nitrides, interhalogens and noble gases. The basic principles of metallurgy are discussed so as to acquaint the students with the application of the redox chemistry they have learnt in the earlier course on inorganic chemistry.

Course Learning Outcome:

CLO 1: *The students will grasp the fundamentals of acid-base chemistry and the unique characteristics of noble gases, as well as recognize a range of s- and p-block compounds, understanding their preparation, structure, bonding, properties, and applications. Additionally, they will apply theoretical principles of redox chemistry to comprehend metallurgical processes effectively.*

CLO 2: *The students will acquire proficiency in conducting iodo-/iodi-metric titrations as well as complexometric titrations, thereby enhancing their abilities in quantitative estimation.*

Unit 1: Acids and Bases (10 Lectures)

Bronsted-Lowry Concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis's acid-base concept, classification of lewis acid, hard and soft acid and bases (HSAB), application of HSAB principle.

Unit 2: Noble Gases (8 Lectures)

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).

Unit 3: Chemistry of *s*- and *p*-block elements-I (18 Lectures)

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour 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.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrogen compounds.

Unit 4: General Principles of Metallurgy (9 Lectures)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

Practical
Total Lectures: 30

Iodo- /Iodi-metric Titrations

i. Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).

ii. Estimation of (a) arsenite and (b) antimony in tartar-emetic iodimetrically.

iii. Estimation of available chlorine in bleaching powder iodimetrically.

Complexometric Titrations

Estimation of metal ions: Zn^{2+}, Ca^{2+} and Mg^{2+} by complexometric titrations using metal ion indicators.

RECOMMENDED BOOKS:

Theory:

1. Lee, J. D., *Concise Inorganic Chemistry*, 5th Ed., Oxford University Press, 2008.
2. Greenwood, N.N. & Earnshaw, A., *Chemistry of the Elements*, 2nd Ed., Elsevier India, 2010.
3. Cotton, F. A., Wilkinson, G. and Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley, 2007.
4. Cotton, F. A. & Wilkinson, G. *Advanced Inorganic Chemistry*, 6th Ed., Wiley-VCH, 2007.
5. Miessler, G. L. &Tarr, D. A. *Inorganic Chemistry*, 4th Ed., Pearson Education, 2010.
6. Weller, M., Armstrong, F., Rourke, J. & Overton, T. *Shriver & AtkinsInorganic Chemistry*, 6th Ed. Oxford University Press, 2015.

Practical:

1. Mendham, J. et al.: *Vogel's Text Book of Quantitative Chemical Analysis*; 6th Ed. Pearson Education, 2009.
2. Marr, G. and Rockett, R.W. *Practical Inorganic Chemistry,* Van Nostrand Reinhold. 1972.
3. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: Physical Chemistry-I

COURSE CODE: CH- CE - 4234

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course aims to educate the students with the advanced concepts of chemical kinetics and molecular reaction dynamics. The course also introduces with two particular topics of physical chemistry – electrochemistry and ionic conductance.

Course Learning Outcome:

CLO 1: *The students will be able to interpret the physical and chemical transformations taking place during chemical reactions at molecular level.*

CLO 2: *The students will apprehend the electrical properties of atoms and molecules from concepts of ionic conductivity and spontaneous chemical reactions. Students will also gain hands-on training on operating electrochemical instruments and learn to determine conductance of acid-base solutions.*

Unit 1: Chemical Kinetics-II and Reaction Dynamics (15 Lectures)

Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, the transition state theory (TST) of bimolecular gaseous reactions, thermodynamic formulations. Comparison between TST and hard sphere collision theory. Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates. Reaction mechanism- steady-state approximation and rate determining step approximation methods.

Unit 2: Conductance (15 Lectures)

Conductivity, equivalent and molar conductivity and their variation with dilution for weakand strong electrolytes. Kohlrausch law of independent migration of ions. Debye- Huckel-Onsager equation, Wein effect, Debye-Falkenhagen effect, Walden's rules. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit 3: Electrochemistry (15 Lectures)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen

electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Practical:

Total Lectures:30

Potentiometric

i. Strong acid vs strong base
ii. Weak acid vs strong base
iii. Dibasic acid vs strong base

Conductometry

i. Determination of cell constant.
ii. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
iii. Perform the following conductometric titrations:
    a. Strong acid vs. strong base
    b. Weak acid vs. strong base
    c. Mixture of strong acid and weak acid vs. strong base
    d. Strong acid vs. weak base.

RECOMMENDED BOOKS:

Theory:

1. Atkins, P. W & Paula, J. D. *Physical Chemistry*, 9th Ed., Oxford University Press, 2011.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.
3. Mortimer, R. G. *Physical Chemistry*, 3rd Ed., Elsevier, 2009.
4. Barrow, G. M. *Physical Chemistry*, 5th Ed., Tata McGraw Hill, 2006.
5. Engel, T. & Reid, P. *Physical Chemistry*, 3rd Ed., Prentice-Hall, 2012.
6. Silbey, R. J., Alberty, R. A. &Bawendi, M. G. *Physical Chemistry*, 4th Ed., John Wiley & Sons, 2005.
7. Puri, B. R., Sharma, L. R., Pathania, M. S. *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing Co., 2017.
8. Kapoor, K. L. *A Textbook of Physical Chemistry (Volume 1 & 5)*, 6th Ed., McGraw Hill Education, 2019.

Practical:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co., 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8th Ed.; McGraw-Hill, 2003.
3. Yadav, J. B. *Advanced Practical Physical Chemistry*, 36th Ed., Krishna Prakashan, 2016.

COURSE NAME: Organic Chemistry-II

COURSE CODE: CH- CE - 5314

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course is designed to explain students about different classes of organic compounds, including heterocyclic compounds, polynuclear aromatic hydrocarbons, nitrogen-containing compounds, sulfur-containing compounds, phosphorus-containing compounds, and organometallic compounds of lithium, copper and magnesium. The course is also intended to provide the students with an insight into molecular rearrangement reactions and their mechanisms

Course Learning Outcome:

CLO 1: *The students are expected learn about different classes of organic compounds including heterocyclic compounds, polynuclear aromatic hydrocarbons, N-, S-, P-containing compounds, organometallic compounds, explain their structure, bonding, reactivity, critically examine their synthesis and reactions mechanism. The students are expected to learn about different types of molecular rearrangements and write their mechanisms.*

CLO 2: *The students will learn about laboratory synthetic practices and be able to execute small scale organic preparations. Students will additionally learn to isolate organic mixtures using column chromatography.*

Unit 1: Molecular Rearrangements & their mechanisms (8 Lectures)

Nucleophilic or anionotropic: Whitmore-1,2 Shift, Wagner-Meerwein, Wolff, Hofmann, Lossen, Curtius, Schmidt, Beckmann, Favorskii, Benzil-benzilic acid, Baeyer-Villiger.

Free radical: Wittig

Electrophilic or cationotropic: Pinacol-pinacolone

Special: Fries rearrangement (aromatic electrophilic substitution), Stevens (ion pairs in solvent cage/ radical pair)

Unit 2: Chemistry of Organic Compounds-II (25 Lectures)

Polynuclear aromatic hydrocarbons: Structure, preparation, structure elucidation and important derivatives of naphthalene and anthracene; Reactions of naphthalene and anthracene.

Nitrogen-containing compounds: Preparation and important reactions of nitro compounds and nitriles. Amines: Effect of substituent and solvent on basicity; Preparation, properties and reactivity: 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 their synthetic applications.

Organometallic compounds: Synthetic applications of organometallic compounds of Li (methyl lithium, n-butyllithium), Mg (Grignard's reagent) & Cu (Gilman's reagent).

Sulfur-containing compounds: Preparation and reactions of thiols, thioethers and sulphonic acids. *Phosphorus-containing compounds:* Preparation and reactions of phosphorus ylides-Wittig reaction.

Unit 3: Heterocyclic compounds (12 Lectures)

Classification and nomenclature (upto 5-and 6-membered rings containing one heteroatom), Synthesis, structure and bonding, properties (basicity, aromaticity); selected reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Indole (Fischer indole synthesis, Madelung synthesis).

Practical:

Total Lectures: 30

Organic Preparations

Preparation of organic compounds, percentage yield calculation, product recrystallization and purity determination by melting point:

i. Benzoylation of the organic compounds: amines (aniline, toluidine and anisidine) and phenols (phenol, *β*-naphthol, salicylic acid) by conventional or green methods.

ii. Aldol condensation by conventional or green methods.

iii. Benzil-benzilic acid rearrangement by conventional methods.

iv. Nitration of nitrobenzene to *m*-dinitrobenzene by conventional methods.

v. Biginelli reaction by multi-component reaction (MCR) strategy.

Aqueous work up and solvent extractions to be performed, if necessary.

Column Chromatographic Separations

Separation of a binary mixture of organic compounds by solid-liquid column chromatography (in micro/millimole scale): *ortho*- and *para*-nitrophenol, *ortho*- and *para*-aminophenol, *ortho*- and *para*-nitroaniline.

RECOMMENDED BOOKS:

Theory:

1. Rojas, C. M. *Molecular Rearrangements in Organic Synthesis*, 1st Ed., Wiley, 2015.
2. Carruthers, W. &Coldhaim, I. *Modern Methods of Organic Synthesis*, 4th Ed., Cambridge, 2013 (Reprint).
3. Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry,* 2nd Ed., Oxford University Press, 2012.
4. Solomons, T. W. G., Fryhle, C. B. & Snyder, S. A. *Organic Chemistry*, 12th Ed., Wiley, 2016.
5. Norman, R. O. C &Coxon, J. M. *Principles of Organic Synthesis*, 3rd Ed., CRC Press, 1993.
6. Finar, I. L. *Organic Chemistry (Volume 2)*, 6th Ed., Pearson Education, 2009.
7. Morrison, R. T., Boyd, R. N. & Bhattacharjee, S. K. *Organic Chemistry*, 7th Ed., Pearson Education India, 2011.
8. Bruice, P. Y. *Organic Chemistry*, 8th Ed., Pearson Education, 2015.

Practical:

1. Vogel, A. I. *Elementary Practical Organic Chemistry: Small Scale Preparations Part 1*, 2nd Ed., Pearson, 2010.
2. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A. R. *Practical Organic Chemistry,* 5thEd., Pearson Education, 2012.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education, 2009.
4. Ahluwalia, V. K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press, 2000.

COURSE NAME: Inorganic Chemistry-II

COURSE CODE: CH- CE - 5324

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course starts with the periodic behavior of s and p block elements related to their electronic structure and their reactivity is included to acquaint students with the principles governing their reactivity. This course further intends to apprise students about the variety of compounds of the main group elements including oxides, hydrides, nitrides and interhalogens. Organometallic compounds are introduced so as to apprise students about the importance of metal carbon bond to form complexes and their application as catalysts. Students are expected to learn factors leading to stability of organometallic compounds, their synthesis, reactivity and uses. The unit on reaction mechanism is included for the students to get acquainted with the kinetic and thermodynamic factors governing the reaction path and stability of inorganic compounds.

Course Learning Outcome:

CLO 1: *The students will be equipped to recognize a range of s- and p-block compounds and understand their preparation, structure, bonding, properties, and applications. Additionally, they will gain insight into organometallic compounds, including their bonding, stability, reactivity, and uses, and become acquainted with various catalysts based on transition metals and their industrial applications. Furthermore, students will explore the mechanisms of ligand substitution and redox reactions in coordination complexes as part of their study.*

CLO 2: *The students will gain an appreciation for utilizing concepts such as solubility product, common ion effect, pH, etc., in the analysis of ions, and understand how through strategic reaction design, it becomes feasible to identify components within a mixture.*

Unit 1: Chemistry of *s*- and *p*–block elements - II (12 Lectures)

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. boranes, carboranes and graphitic compounds, silanes, oxides and oxoacids of nitrogen, phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Unit 2: Organometallic Chemistry - I (8 Lectures)

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rules, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.

Unit 3: Theoretical Principles in Qualitative Inorganic Analysis (8 Lectures)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

Unit 4: Mechanism of Inorganic reaction (17 Lectures)

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes. Electron transfer reactions.

Practical:

Total Lectures: 30

Inorganic Qualitative Analysis

i. Qualitative semi-micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: NO_2^-, S^{2-}, SO_3^{2-}, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+} and Mg^{2+}.

ii. Mixtures should preferably contain 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^-.

iii. Spot tests should be done whenever possible.

RECOMMENDED BOOKS:

Theory:

1. Cotton, F.A., Wilkinson, G. and Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley, 2007.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry*. 6th Ed., Wiley-VCH, 2007.
3. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Ed., Pearson Education, 2006.
4. Miessler, G. L. &Tarr, D. A., *Inorganic Chemistry* 4th Ed., Pearson, 2010.
5. Weller, M., Armstrong, F., Rourke, J. & Overton, T., *Inorganic Chemistry* 6th Ed. 2015.
6. Greenwood, N. N. & Earnshaw, A., *Chemistry of the Elements*, 2nd Ed., Elsevier India, 2010.
7. Bochmann, M. *Oxford Chemistry Primers: Organometallics (Volume 1 & 2)*, Oxford University Press, 1994.
8. Crabtree, R.H. *The Organometallic Chemistry of Transition Metals*, 1st Ed., John Wiley & Sons, 2014.
9. Vogel, A. I. *A Text-book of Macro and Semimicro Qualitative Inorganic Analysis*, Longmans, 1968.

10. Svelha, G. *Vogel's Qualitative Inorganic Analysis*, 7th Ed., Pearson Education, 2008. (Revised)

Practical:

1. Svelha, G. *Vogel's Qualitative Inorganic Analysis*, 7th Ed., Pearson Education, 2008. (Revised)
2. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: Physical Chemistry-II

COURSE CODE: CH- CE - 5334

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The aim of this course is to educate the students on three important topics of physical chemistry – chemical equilibria, phase equilibria and surface chemistry in a detailed manner.

Course Learning Outcome:

CLO 1: *The students are expected to learn phase rule and its application in some specific systems. They will also learn about equilibrium in chemical systems from thermodynamic viewpoint. Further, students will gain practical knowledge on phase transitions in selected systems, depending on the conditions and also comprehend different surface adsorption phenomena.*

CLO 2: *The students are expected to develop an understanding of the interaction of surfaces and explore concepts of surface adsorption. In addition, students can have practical understanding on different surface adsorption phenomena.*

Unit 1: Chemical Equilibrium (12 Lectures)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier's principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

Unit 2: Phase Equilibrium (18 Lectures)

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius–Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

Binary Solutions: Gibbs-Duhem Margules equation, applications to fractional distilation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, critical solution temperature, miscible pairs, steam distillation.

Nernst distribution law: Its derivation and applications.

Unit 3: Surface Chemistry (15 Lectures)

Surface area of solids, structure and chemical nature of solid surfaces, adsorption of gases and vapours on solids, Langmuir adsorption isotherm, the BET and related isotherms, isotherms based on equation of

state of the adsorbed films, thermodynamics of adsorption, critical comparison of various models for adsorption.

Physical adsorption on heterogeneous surfaces, rate of adsorption, adsorption on porous solids: hysteresis, Chemisorption and catalysis, chemisorption isotherms, kinetics of chemisorption, chemisorption bond, catalytic activity and strength of chemisorption, Langmuir-Hinshelwood and Eley-Rideal mechanism.

Practical:

Total Lectures: 30

Phase Equilibria

i. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

ii. Study the variation of mutual solubility temperature with concentration for thephenol water system and determination of the critical solution temperature.

iii. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

Adsorption

Verify the Freundlich and Langmuir isotherms for adsorption of various solutes onto different solid surfaces.

RECOMMENDED BOOKS:

Theory:

1. Atkins, P. W & Paula, J. D. *Physical Chemistry*, 9th Ed., Oxford University Press, 2011.
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa, 2004.
3. McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics*, Viva Books Pvt. Ltd., 2004.
4. Engel, T. & Reid, P. *Physical Chemistry*, 3rd Ed., Prentice-Hall, 2012.
5. Zundhal, S. S. *Chemistry concepts and applications*, Cengage India, 2011.
6. Ball, D. W. *Physical Chemistry*, Cengage India, 2012.
7. Mortimer, R. G. *Physical Chemistry*, 3rd Ed., Elsevier, 2009.
8. Levine, I. N. *Physical Chemistry*, 6th Ed., Tata McGraw-Hill, 2011.
9. Kapoor, K. L. *A Textbook of Physical Chemistry (Volume 2&5)*, McGraw Hill Education; 5th Ed., 2017.
10. Puri, B. R., Sharma, L. R., Pathania, M. S. *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing Co., 2017.

Practical:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co., 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8th Ed.; McGraw-Hill, 2003.
3. Yadav, J. B. *Advanced Practical Physical Chemistry*, 36th Ed., Krishna Prakashan, 2016.

COURSE NAME: Analytical Chemistry

COURSE CODE: CH- CE - 5344

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This is an advanced course designed to complement the needs of students who wish to learn about the qualitative and quantitative characterization techniques. The content of this course aims to cover some of the widely used instrumental techniques employed for characterization of samples in analytical chemistry.

Course Learning Outcome:

CLO 1: *The students will gain theoretical understanding about the choice of various analytical techniques used in analytical chemistry for qualitative and quantitative characterization of samples.*

CLO 2: *The students will get hands-on experience of operating spectrophotometric, pH-metric and polarimetric instrumental techniques and also be to solve or interpret instrumental data for sample analysis.*

Unit 1: Qualitative and quantitative aspects of analysis (7 lectures)

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution of indeterminate errors, statistical test of data; F-, Q- andt-test, rejection of data, and confidence intervals.

Unit 2: Optical methods of analysis (15 lectures)

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument.

Basic principles of quantitative analysis: Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of metal complex composition using Job's method of continuous variation and mole ratio method.

Infrared Spectroscopy: Basic principles of instrumentation (choice of source, monochromator & detector) for continuous wave and Fourier transform spectrometers; sampling techniques. Structure elucidation through interpretation of data. Effect and importance of isotope substitution.

Unit 3: Thermal methods of analysis (5 lectures)

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Unit 4: Electroanalytical techniques (12 lectures)

Classification of electroanalytical techniques. Instrumentation, Types of electrodes, standard electrode potential, cell reactions, glass electrodes and membrane-bound electrodes, liquid junction potential and salt bridge, pH determination using hydrogen electrode and quinhydrone electrode, potentiometric titrations-qualitative treatment (acid-base, and oxidation-reduction only). Conductance measurements; EMF and cell reactions. Conductometric titrations-qualitative treatment (only acid-base and acid base mixtures).

Unit 5: Diffraction techniques (5 lectures)

Packing of solids and how solids diffract (reflection view and scattering view) Bragg's Law, Miller indices and reciprocal lattices. Laws of crystallography. Basics of X-ray diffraction (powder and single crystal).

Practical:

Total Lectures: 30

i. Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method of continuous variation.

ii. Determination of pK_a values of indicators using spectrophotometry.

iii. Determination of a mixture of Co and Ni from UV-V is absorption spectra.

iv. Study of stretching frequencies of aldehydes and ketones from IR absorption spectra.

v. Determine the pH of the given aerated drinks, fruit juices, shampoos and soaps.

vi. Verify Beer-Lambert's law and determine the concentration of organic dyes like methylene blue, rhodamine B, etc. in a solution of unknown concentration.

vii. Determine the specific rotation of an optically active substance by polarimetric method.

RECOMMENDED BOOKS:

Theory:

1. Mendham, J., Denney, R.C., Barnes, J. D., Thomas, M. and Sivasankar, S. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed., Pearson Education, 2009.
2. Skoog, D. A., Holler, F. J. & Crouch, S.R. Principles of Instrumental Analysis, 6th Ed., Cengage Learning, 2017.
3. Skoog, D. A., West, D. M., Holler, F. J. & Crouch, S.R. Fundamentals of Analytical Chemistry, 9thEd., Brooks/Cole Cengage Learning, 2014.
4. Willard, Hobert H. et al. Instrumental Methods of Analysis, 7th Ed., CBS Publishers& Distributors, 2004.
5. Christian, G. D. Analytical Chemistry, 6th Ed. John Wiley & Sons, 2004.
6. Srivastava, B.B.L & Mishra, A. Fundamental of Analytical Chemistry, IP Innovative Publication, 1st Ed., 2016.

Practical:

1. Mendham, J., Denney, R.C., Barnes, J. D., Thomas, M. and Sivasankar, S. *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Ed., Pearson Education, 2009.
2. Skoog, D. A., Holler, F. J. & Crouch, S.R. *Principles of Instrumental Analysis*, 6th Ed., Cengage Learning, 2017.
3. Willard, Hobert H. et al. *Instrumental Methods of Analysis*, 7th Ed., CBS Publishers & Distributors, 2004.
4. Pavia, D. L., Lampman, G. M., Kriz, G. S., Vyvyan, J. A. *Introduction to Spectroscopy*, 4th Ed., Cengage Learing, 2008.

COURSE NAME: Organic Chemistry-III

COURSE CODE: CH- CE - 6314

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course intends to introduce students to the chemistry of natural products viz. carbohydrates, nucleic acids, amino acids, lipids, terpenes and alkaloids.

Course Learning Outcome:

CLO 1: *The students will be get introduced to the chemistry of natural products viz. carbohydrates, nucleic acids, amino acids, lipids, terpenes, and alkaloids, describe their importance, as well as, examine their properties, applications, etc.*

CLO 2: *The students will learn to perform titrimetric estimations of organic compounds like amino acids, sugars and oils, along with be able to isolate naturally occurring compounds from plants and fruits.*

Unit 1: Carbohydrates (14 Lectures)

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation.

Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

Unit 2: Nucleic Acids (5 Lectures)

Components of nucleic acids; Nucleosides and nucleotides; Synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Polynucleotides: DNA and RNA.

Unit 3: Amino Acids & Peptides (10 Lectures)

Amino acids, Peptides and their classification.

α-Amino acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a values, isoelectric point and electrophoresis.

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups – Solid-phase synthesis.

Unit 4: Lipids (5 Lectures)

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, saponification value, acid value, iodine number, rancidity.

Unit 5: Terpenes (5 Lectures)

Occurrence, classification, isoprene rule, special isoprene rule. Structure elucidation and synthesis of citral and α-terpineol. Biosynthesis of limonene, pinene and carvone (*via.* isopentenyl pyrophosphate).

Unit 6: Alkaloids (6 Lectures)

Natural occurrence, General structural features, Isolation and their physiological action, Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Nicotine. Medicinal importance of nicotine, hygrine, quinine, morphine, cocaine, and reserpine.

Practical:

Total Lectures:30

Quantitative Organic Estimations

i. Estimation of amino acids using titrimetric methods: Glycine

ii. Estimation of sugars using titrimetric (redox) methods: Glucose, Sucrose

iii. Determination of saponification value of an oil or triglyceride.

Natural Product Extractions

i. Extraction of lycopene from tomato peel

ii. Extraction of nicotine from tobacco leaves.

iii. Extraction of caffeine from tea leaves.

RECOMMENDED BOOKS:

Theory:

1. Morrison, R. T., Boyd, R. N. & Bhattacharjee, S. K. *Organic Chemistry*, 7th Ed., Pearson Education India, 2011.
2. Finar, I. L. *Organic Chemistry (Volume 2)*, 6th Ed., Pearson Education, 2009.
3. Bruice, P. Y. *Organic Chemistry*, 8th Ed., Pearson Education, 2015.
4. Nelson, D. L. and Cox, M. M., *Lehninger's Principles of Biochemistry*, Macmillan Higher Education, 2017.

Practical:

1. Ahluwalia, V. K. & Aggarwal R. *Comprehensive Practical Organic Chemistry: Preparation & Quantitative Analysis,* University Press, 2000.
2. Singh, J., et. al. *Advanced Practical Chemistry*, Pragati Prakashan, 9th Ed., 2019.
3. Furniss, B. S., Hannaford, A. J., Smith, P.W.G., Tatchell, A. R. *Vogel's Textbook ofPractical Organic Chemistry,* 5th Ed., Pearson Education, 2012.
4. Pavia, D. L., Lampman, G. M., Kriz, G. S., Engel, R. G. *Organic Chemistry A Lab Manual*, , Cengage Learing, 2009. (Reprint)
5. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: Inorganic Chemistry-III

COURSE CODE: CH- CE - 6324

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course introduces students to bioinorganic chemistry is included in this course to acquaint students on the useful and harmful aspects of metals in biological systems. Organometallic compounds are introduced so as to apprise students about the importance of metal carbon bond to form complexes and their application as catalysts. Students are expected to learn factors leading to stability of organometallic compounds, their synthesis, reactivity and uses. This course further expected to gain their knowledge about inorganic polymers.

Course Learning Outcome:

CLO 1: *The students will explore the beneficial and detrimental effects of various metals and non-metals in biological systems, alongside delving into organometallic compounds to understand their bonding, stability, reactivity, and applications. Additionally, they will gain familiarity with a diverse range of transition metal-based catalysts and their industrial utilization.*

CLO 2: *The students will acquire the skills to synthesize specific coordination complexes tailored for various applications. Moreover, they will gain expertise in the synthesis of metal oxide and metal sulfide nanoparticles.*

Unit 1: Bioinorganic Chemistry (15 Lectures)

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Na/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Role of metal ions in biology.

Iron management in biological system – siderophores, storage and transfer of iron, haemoglobin and myoglobin.

Unit 2: Organometallic Chemistry - II (15 Lectures)

Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkylaluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler–Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich condensation), Structure and aromaticity, Comparison of aromaticity and reactivity with that of benzene.

Unit 3: Transition Metal in Catalysis (8 Lectures)

Study of the following industrial processes and their mechanism: Alkene hydrogenation (Wilkinson's Catalyst), Hydroformylation (Co catalysts), Wacker Process, Synthetic gasoline (Fischer Tropsch

reaction), Synthesis gas by metal carbonyl complexes.

Unit 4: Inorganic Polymers (7 Lectures)

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Silicates – clays and zeolites, polyphosphazenes, metal-organic framework compounds (MOFs).

Practical:

Total Lectures: 30

Inorganic Preparations:

1. Solution phase synthesis of coordination compounds: characterization, properties and application (e.g. catalysis):
    a. Vanadyl acetylacetonate
    b. Potassium trisoxalatoferrate (III)
    c. Potassium trisoxalatochromate (III)
    d. Potassium trisoxalatoaluminate (III)
2. Synthesis and characterization of nanocrystals:
    a. ZnO
    b. ZnS
    c. CdS
    d. NiO
    e. Ag

RECOMMENDED BOOKS:

Theory:

1. Lippard, S. J. & Berg, J. M. Principles of Bioinorganic Chemistry, Panima Publishing Company, 1994.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed., Pearson Education, 2006.
3. Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry. 6th Ed., Wiley-VCH,2007.
4. Bochmann, M. Oxford Chemistry Primers: Organometallics (Volume 1 & 2), Oxford University Press, 1994.
5. Crabtree, R.H. The Organometallic Chemistry of Transition Metals, 1st Ed., John Wiley & Sons, 2014.
6. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
7. Miessler, G. L. &Tarr, D. A., Inorganic Chemistry 4th Ed., Pearson, 2010.
8. Weller, M., Armstrong, F., Rourke, J. & Overton, T., Inorganic Chemistry 6th Ed.2015.
9. Greenwood, N. N. & Earnshaw, A., Chemistry of the Elements, 2nd Ed., Elsevier India,2010.
10. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.

Practical:

1. Marr, G. &Rockett, R. W. Practical Inorganic Chemistry, Van Nostrand Reinhold Co., 1972.
2. Gulati, S., Sharma, J. L. &Manocha, S. Practical Inorganic Chemistry, CBS Publishers & Distributors., 2nd Ed., 2017.
3. Raj, G. Advanced Practical Inorganic Chemistry, Krishna Prakashan, 2013.
4. Fahlman, B.D. Material Chemistry, Springer, 2nd Ed., 2007.

.

COURSE NAME: Physical Chemistry-III

COURSE CODE: CH- CE - 6334

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

The aim of this course is to introduce the students with three important topics- quantum chemistry, molecular spectroscopy and photochemistry. Through this course, the students are introduced to the postulates of quantum mechanics and the application of quantum mechanical ideas in some simple systems such as particle in a box, rigid rotor, simple harmonic oscillator etc. Students are also introduced to the different aspects of molecular spectroscopy viz. rotational, vibrational, Raman & electronic spectroscopy and the basics of photochemistry.

Course Learning Outcome:

CLO 1: *The students are expected to understand the application of quantum mechanics in some simple chemical systems such as hydrogen atom or hydrogen like ions.*

CLO 2: *The students will also be able to understand the basics of light- matter interactions and various kinds of spectroscopic techniques and applications. The students will learn about to characterize and analyse diverse molecules using UV-Vis spectroscopic techniques.*

Unit 1: Quantum Chemistry – I (16 Lectures)

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy. Extension to two- and three-dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and *z*-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation-transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial wave equation, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li).

Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Unit 2: Molecular Spectroscopy (15 lectures)

Fundamental aspects of absorption and emission spectroscopy. Probability of transition, oscillator strength, dipole strength. Spontaneous and stimulated emission. Origin of selection rules using symmetry.

Rotation spectroscopy: Classification of molecules based on their moment of inertia, rotational energy levels, molecular geometry determination, stark effect, molecular dipole moment. Rotational spectroscopy of symmetric and asymmetric top molecules.

Vibrational spectroscopy: Harmonic and anharmonic oscillators. Morse potential, selection rules. The determination of anharmoncity constant and equilibrium vibrational frequency from fundamental and overtones. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches. Application of isotopic substitution.

Raman spectroscopy: Polarizability tensor, Stokes and anti-Stokes lines, rule of mutual exclusion.

Infrared and Raman spectroscopy of simple inorganic and organic molecules, predicting number of active modes of vibrations, organic functional group identification through IR spectroscopy, analysis of representative spectra of metal complexes with various functional groups at the coordination sites.

Unit 3: Electronic spectroscopy (5 lectures)

Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation, calculation of electronic transitions of polyenes using free electron model.

Unit 4: Photochemistry (9 lectures)

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

Practical:

Total Lectures: 30

UV/Visible spectroscopy

i. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV).

ii. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.

iii. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

RECOMMENDED BOOKS:

Theory:

1. McQuarrie, D. A. *Quantum Chemistry*, Viva Books, 2016.
2. Sen, B. K. Quantum Chemistry- Including Spectroscopy, Kalyani Publishers; 4th edition (2011)
3. Atkins, P. W. & Friedman, R. Molecular Quantum Mechanics, 5th Ed., Oxford University Press, 2010.
4. House, J. E. *Fundamentals of Quantum Chemistry*, 2nd Ed., Elsevier, 2004.
5. Lowe, J. P. & Peterson, K. *Quantum Chemistry*, 3rd Ed., Academic Press, 2005.

6. Chandra, A. K. *Introductory Quantum Chemistry*, 4th Ed., Tata McGraw-Hill, 2001.
7. Banwell, C. N. &McCash, E. M. *Fundamentals of Molecular Spectroscopy*, 4th Ed. Tata McGraw-Hill, 2013 (Reprint).
8. Kakkar, R. *Atomic & Molecular Spectroscopy*, 1st Ed., Cambridge University Press, 2015.
9. Kapoor, K. L. *A Textbook of Physical Chemistry (Volume 4)*, 5th Ed., McGraw Hill Education, 2017.

Practical:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co., 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8th Ed.; McGraw-Hill, 2003.
3. Yadav, J. B. *Advanced Practical Physical Chemistry*, 36th Ed., Krishna Prakashan, 2016.

COURSE NAME: Industrial Chemistry

COURSE CODE: CH- CE - 6344

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This is an advanced course intended to expose the students to the world of industrial chemistry and their applications. The content of this course aims to introduce the students to some industrially important materials, their synthetic process, properties and utilities

Course Learning Outcome:

CLO 1: *The students will be acquainted with the various materials of industrial importance and their advanced and current applications.*

CLO 2: *The students will learn to conduct quantitative and qualitative chemical analysis of some industrially important materials that are manufactured in chemical industries.*

Unit 1: Industrial Gases and Inorganic Chemicals (15 Lectures)

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

Unit 2: Fertilizers (8 Lectures)

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

Unit 3: Organic Polymers (10 Lectures)

Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermos softening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives. Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

Unit 4: Batteries (7 Lectures)

Primary and secondary batteries, battery components and their role, Characteristics of battery. Working of following batteries: Pb-acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

Unit 5: Catalysts (5 Lectures)

Catalysts and their industrial applications, deactivation or regeneration of catalysts. Phase transfer catalysts, zeolites and their application as catalysts.

Practical:

Total Lectures:30

Industrial Chemical Analysis

i. Determination of the percentage of available chlorine in bleaching powder.
ii. Estimation of total alkalinity of water samples (CO_3^-, HCO_3^-) using double titration method.
iii. Determination of free acidity in ammonium sulphate fertilizer.
iv. Estimation of calcium in calcium ammonium nitrate fertilizer.
v. Estimation of phosphoric acid in superphosphate fertilizer.
vi. Preparation of urea-formaldehyde resin.

RECOMMENDED BOOKS:

Theory:

1. Weller, M., Armstrong, F., Rourke, J. & Overton, T. *Shriver &Atkins Inorganic Chemistry*, 6th Ed. Oxford University Press, 2015.
2. Manahan, S. E. *Environmental Chemistry*, 8th Ed., CRC Press, 2005.
3. De, A. K. *Environmental Chemistry*, 8th Ed., New Age International, 2017.
4. Stocchi, E. *Industrial Chemistry Volume 1*, 1st Ed., Ellis Horwood, 1990.
5. Felder, R. M. & Rousseau, R. W. *Elementary Principles of Chemical Processes*, 3rd Ed., Wiley, 2005.
6. Kent, J.A. *Kent and Riegel's Handbook of Industrial Chemistry and Biotechnology*, 11th Ed., Springer, 2007.
7. Sharma, B. K. *Industrial Chemistry including Chemical Engineering*, 15th Ed., Krishna Prakashan, 2006.

Practical:

1. Mendham, J., Denney, R.C., Barnes, J. D., Thomas, M. and Sivasankar, S. *Vogel's Text Book of Quantitative Chemical Analysis*, 6th Ed., Pearson Education, 2009.
2. Skoog, D. A., West, D. M., Holler, F. J. & Crouch, S.R. *Fundamentals of Analytical Chemistry*, 9thEd., Brooks/Cole Cengage Learning, 2014.
3. Siddiqui, Z. *Practical Industrial Chemistry*, Anmol Publications, 2002.
4. Rogers, A. *Laboratory Guide of Industrial Chemistry*, Forgotten Books, 2019.

COURSE NAME: RESEARCH METHODOLOGY

Course Code: CH-CE-7414

Total Credits: 4 (Theory: 3+Practical/Practice: 1)

Theory: 3 credits

Total Lectures: 45

Course Objectives:

The objectives of this course are to make the students aware of fundamental but mandatory ethical practices in chemistry, to introduce the concept of data analysis, to learn to perform literature survey in different modes, to make the students aware of safety handling and safe storage of chemicals, to make students aware about plagiarism and how to avoid it, and to teach the use of different e-resources.

Couse Learning Outcomes:

CLO-1: *By studying this course, students will be able to follow ethical practices in chemistry, do Data analysis, and literature survey in different modes, use e-resources, avoid plagiarism, understand the consequences and how to avoid*

CLO-2: *Student can have hands on training on various aspect of research including collecting journal articles and writing literature survey, preparing poster presentation, etc.*

Unit I: Scope of Research (5 Lectures)

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

Unit II: Literature Survey, Databases and Research metrics (15 Lectures)

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, **Digital**: Databases and their responsible use: Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results. **Research metrics**: Impact factor of Journal, h-index, i10 index, Citation index. Author identifiers/or profiles: ORCID, Google Scholar, ResearchGate, VIDWAN.

Unit III: Research and Publication ethics (15 Lectures)

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkundetc), redundant publications Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and

vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals

IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

Unit IV: Statistical analysis for chemists (10 Lectures)

Types of data, data collection-Methods and tools, data processing, hypothesis testing, Normal and Binomial distribution, tests of significance: t-test, F-test, chi- square test, ANOVA, multiple range test, regression and correlation. Features of data analysis with computers and softwares -Microsoft Excel, Origin, SPSS.

Practical/Practice Credits: 01

Total Lectures: 15

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
4. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or ChemDraw or any other software.
5. Collection of chemical structure using ChemSpider and creating a database.
6. Curve fitting using freely available softwares/apps (any one)
7. Making of power point presentation
8. Experimental learning of safe storage hazardous chemicals
9. Experimental learning of handling of hazardous chemicals
10. Technical writing on topics assigned.
11. Demonstration for checking of plagiarism using recommended software
12. Preparation of poster presentation.

Essential/recommended readings:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.
4. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
5. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992. OSU safety manual 1.01

COURSE NAME: Organic Chemistry-IV

COURSE CODE: CH - CE - 7424

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective:

This course aims to provide students the with a detailed understanding of organic reaction mechanisms, including the structure, formation, and reactivity of key reactive intermediates such as carbanions, carbocations, carbenes, nitrenes, ylids, and radicals. It also aims to develop the ability to analyze kinetic and thermodynamic aspects of reactions, interpret linear free energy relationships, and apply stereochemical concepts in mechanistic contexts. The course emphasizes to develop practical skills of the students in qualitative analysis of binary organic mixtures and to introduce students to natural product chemistry through hands-on extraction techniques.

Course Learning Outcome:

CLO-1: *The students will be able to critically analyze organic reaction mechanisms through a detailed understanding of kinetic and thermodynamic principles, including reaction profiles, isotope effects, and linear free energy relationships. They will gain in-depth knowledge of reactive intermediates. Additionally, students will develop a solid foundation in stereochemical principles.*

CLO-2: *The students will be able to systematically analyze and identify components in a binary organic mixture using classical separation and identification techniques. They will also acquire practical experience in the extraction of natural products, specifically carotenoids, from plant sources.*

Unit I: Kinetics and Energetics of Reaction Mechanism (10 Lectures)

Reaction profiles for multistep reactions, Hammond postulate, Curtin-Hammett Principle; kinetic and thermodynamic control.

Linear free energy relationships (LFER): Hammett equation - substituent and reaction constants; kinetic isotope effects in organic reactions.

Unit II: Reaction Mechanisms & Intermediates: Structure & Reactivity I (13 Lectures)

Carbanions: enolates and enamines, Kinetic and thermodynamic enolates, lithium enolates in aldol and Michael reactions, alkylation and acylation of enolates; Name reactions under carbanion chemistry - Claisen, Dieckmann, Knoevenegal, Henry reaction, Nef reaction.

Ylids: Chemistry of phosphorous and sulfur ylids - Wittig and related reactions.

Carbocation: structure and stability of carbocations, classical and non-classical carbocations, neighbouring group participation and carbocation rearrangements, C-C bond formation involving carbocations, oxymercuration, halo-lactonisation.

Unit III: Reaction Mechanisms & Intermediates: Structure & Reactivity II (12 Lectures)

Carbenes and Nitrenes: Structure of carbenes, generation of carbenes, addition and insertion reactions. Structure of nitrene, generation and reactions of nitrene and related electron-deficient nitrogen intermediates, Tebbe olefination reactions.

Radicals: Generation of radical intermediates and its (a) addition to alkenes, alkynes (inter & intramolecular) for C-C bond formation and Baldwin‘s rules (b) fragmentation and rearrangements, McMurry coupling.

Unit IV: Stereochemistry (10 Lectures)

Classification of organic molecules into different Point Groups, R/S, E/Z nomenclature in C, N, S, P containing compounds; chirality in molecules devoid of chiral centers- allenes, spiranes and biphenyls (atropisomerism).

Concepts of stereogenic center – chirotopic and achirotopic center; homotopic and heterotopic ligands and faces (prostereoisomerism and prochirality, etc); optical purity and enantiomeric excess; conformations of cyclohexane and decalins.

Practical: 1 Credit

Total Lectures: 15

Qualitative analysis:

Binary mixture of organic compounds (solid-solid)

Experiments on Natural products:

Extraction of carotenoids from a natural source.

Books Recommended:

Theory:

1. F. A. Cary, R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edition, Springer, 2009.
2. R. O. C. Norman, J. M. Coxon, Principles of Organic Synthesis, 3rd Edition, CRC Press, 2000.
3. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Edition, Oxford University Press, 2012.
4. E. V. Anslyn, D. A. Dougherty, Modern Physical Organic Chemistry, University Science Books, 2005.
5. E.L. Eliel, S. H. Wilen, Stereochemistry of Organic Compounds, Wiley Student Edition, Wiley-India, 2008 (Reprint).

Practical:

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel‘s Textbook of Practical Organic Chemistry, Pearson, 2012.
2. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press.
3. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.

COURSE NAME: Inorganic Chemistry - IV

COURSE CODE: CH - CE – 7434

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective:

This course aims to provide an in-depth understanding of advanced inorganic and organometallic chemistry, focusing on the chemistry of s-, p-, d-, and f-block elements, their compounds, and applications in modern chemical systems. Students will gain knowledge of structure, bonding, reactivity, and synthetic strategies of main group and transition metal compounds, including their roles in catalysis and material science. The course also introduces concepts of solid-state chemistry and symmetry principles essential for interpreting molecular structures and bonding. The syllabus also includes advanced synthetic techniques of some important inorganic compounds.

Course Learning Outcomes:

CLO-1: *The students will be able to* apply advanced concepts of inorganic, organometallic, and solid-state chemistry to explain the structure, bonding, synthesis, and reactivity of main group and transition metal compounds.

CLO-2: *The students will be able to* interpret molecular structures and chemical behavior using principles of symmetry, group theory, and spectroscopic characterization.

Unit I: Chemistry of *s* and *p* block elements – III (12 Lectures)

Structure and bonding in metal borides, The hydroboration reaction, organoboranes including boronic acids, tetrahydridoborates – synthesis and synthetic use.

Preparation and reactivity of lithium aluminium hydride; alkyl aluminium compounds; chemistry of Al, Ga, In and Tl in +1 and +2 oxidation states.

Fullerenes and fullerides, nonmolecular compounds of carbon, organo compounds of Si, Ge, Sn and Pb; calixarenes, cryptands and crown ethers in complexation chemistry, metal chalcogenides, sulfur-nitrogen compounds

Organometallic compounds of Li, Be, Mg

Unit II: Transition elements (4*d* and 5*d* series) (8 Lectures)

Chemistry of the elements of the second and third transition series – general overview of compounds having the metals in their common oxidation states; halide containing clusters of niobium and tantalum; polyoxometallates of Mo and W; quadruple and quintuple M-M bonded compounds, the Creutz-Taube

complex; $RuCl_2(PPh_3)_3$; osmium tetroxide; Vaska's compound; palladium complexes in the oxidation state 0; Pt(II,IV) linear chain compounds.

Unit III: Introduction to solid chemistry (7 Lectures)

Structure of simple solids – metals, alloys and compounds; common structure types. Synthesis of solid-state compounds - ceramic method, hydrothermal synthesis, CVD and intercalation methods. Characterization of solids.

Unit IV: Organometallic Chemistry – III (12 Lectures)

Synthesis, structure, bonding and reactivity of mono and polynuclear metal carbonyls. Substituted metal carbonyls. Vibrational spectra of metal carbonyls.

Types of M-C bonds, synthesis and reactivity of metal alkyls, carbenes, alkenes, alkynes, and arene complexes; metallocenes and bent metallocenes.

Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination, insertion and deinsertion; ß – hydride elimination.

Unit V: Symmetry and Group Theory in Chemistry (6 Lectures)

Group and Matrices: Definitions and elements of group theory and matrix algebra

Molecular symmetry and symmetry groups: Symmetry elements and operations, classes of symmetry operations, symmetry and chirality, symmetry point groups, symmetry of the Platonic solids

Representation of Groups: Matrix notation for geometric transformations, reducible and irreducible representations, rules about irreducible representation as derived from great orthogonality theorem, relationship between reducible and irreducible groups, character tables.

Practical: 1 credit

Total Lecture: 15

Advanced Synthesis of Some Important Inorganic Compounds and their Isomers:

1. Synthesis of coordination compounds through ligand synthesis and spectroscopic characterization, *e.g.* preparation of bis (*N,N*-disalicylideneethylenediammine) (μ-aquadicobalt(II).
2. Solid phase synthesis of coordination compounds (*e.g.* Reinecke salt, trans-bisglycinatocopper (II)) and their properties.
3. Isomerism in coordination compounds. *e.g.* conversion of chloropentamminecobalt(III) chloride to nitro and nitroso isomers, *cis*- and *trans*-dichlorobis(ethylenediamine)cobalt(III) chloride etc.
4. Preparation of metal (II) isonicotinatetetrahydrates, characterization, use as precursors to metal oxides.
5. Synthesis of metal nanoparticles (Cu, Au, etc.), characterization and investigation of their optical properties.
6. Preparation of polyoxometallates (*e.g.*tetrabutylammoniumhexamolybdate(VI)), characterization.

Books Recommended:

Theory:

1. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6thed. Wiley, 1999

2. P.W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong; Shriver &Atkins' Inorganic Chemistry, 5th ed. Oxford University Press, 2010.

3. Fundamental Concepts of Inorganic Chemistry, Vols. 1-7, by A.K. Das and M. Das, CBS Publishers and Distributors, 2015

4. A. R. West, Solid State Chemistry and Its Application, Wiley Student Edition, John Wiley & Sons. 1998.

5. R. H. Crabtree, Organometallic Chemistry of the Transition Metals 2nd Ed., John Wiley, 1993.

6. F. A. Cotton, Chemical Applications of Group Theory, 3rdEdition, Willey India Pvt. Ltd. 2008.

Practical:

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th
Edition, Pearson, 2009.

2. G. Svehla, S. Mittal, Vogel's Qualitative Inorganic Analysis, Pearson Education, 7th Edition. 2013.

COURSE NAME: Physical Chemistry - IV

COURSE CODE: CH - CE - 7444

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective:

The objective of this course is to aware students on the detail of equillibrium, non-equillibrium and statistical thermodynamics. Also, to familiarize students with significance of polymer chemistry and data analysis. Moreover, the present course also enables students towards chemistry of natural products and basics of quantum chemistry.

Course Learning Outcome:

CLO-1: *By studying this course student can able to differentiate fundamental aspect between equilibrium and non-equillibrium thermodynamics, also understand the importance of statistical mechanics in chemistry and can be able to analyse data and its concept to solve problems.*

CLO-2: *Student can perform hands-on training of various data analysis using MS Excel/origin. Student can also learn practically to determine the molecular weight of a polymer and various aspects of thermodynamics and phase equilibria.*

Unit I: Equilibrium and Non-equilibrium Thermodynamics (18 Lectures)

Laws of thermodynamics, state and path functions and their applications, Maxwell's relations; spontaneity and equilibria; Le-Chatelier principle

Non-ideal system: thermodynamics of real gases and gas mixtures, fugacity and its determination, non-ideal solutions, activity and activity coefficient-different scales of activity coefficient, electronic activity coefficients

Phase equilibrium: thermodynamic criteria of phase equilibrium, Gibbs phase rule and its application to three component systems- triangular plots- water- acetic acid –chloroform system, ammonium chloride-ammonium sulphate-water system

Non-equilibrium thermodynamics: forced flows and entropy of production, coupled flows and phenomenological relations, Onsager reciprocal relations, thermodynamic effects- Seebeck and Peltier and Thomson effect

Unit II: Statistical Thermodynamics (15 Lectures)

Statistical mechanics of systems independent particles: Maxwell Boltzmann distribution, entropy and probability. calculation of thermodynamic properties for independent particles,- molecular partition functions- evaluation of translational, rotational and vibrational and nuclear partition functions

Thermodynamic properties of monatomic and diatomic gases (Suckur-Tetrode equation)- calculation of partition functions, thermodynamic function, principles of equipartition, heat capacities (Einstein model and Debyemodification), residual entropy, equilibrium constant

Unit III: Polymer Chemistry (6 Lectures)

Molecular weight of polymers, determination of molecular weight, kinetics of polymerization reaction, copolymerization, average dimension of polymer molecules, size exclusion chromatography

Unit IV: Sampling and Data Analysis: (6 Lectures)

Sampling of solid, liquid and gaseous samples, mean and standard deviation, absolute and relative errors, linear regression, covariance and correlation coefficient.

Practical: 1 Credit

Total Lecture: 15

(Students have to perform any five of the experiments mentioned below)

1. Least square fitting, linear and non-regression (Using Origin and MS Excel).
2. Boltzmann distribution plot.
3. Determination the molar mass of a polymer by viscometric method.
4. Study of the variation of surface tension of a solution of n-propyl alcohol/ethanol with concentration and determination of the limiting cross-sectional area of the alcohol molecule.
5. Determination of the partial molar volume of methanol/ethanol/formic acid by graphical method by determining the densities of solutions at different concentrations.
6. Study of the complex formation between Cu^{2+} ion and ammonia by distribution method and to find the composition of the complex.
7. To construct the phase diagram of 3 component system: triangular plots- water- acetic acid – chloroform system.

Books Recommended:

Theory:

1. P. Atkins, J. Paula, Physical Chemistry, 9th Edition, Oxford University Press, Oxford 2010.

2. I. R. Levine, Physical chemistry, 6th Edition, Mcgraw Hill Education, 2011.

3. D. A. McQuarrie, J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Student Edition, 1st Edition, 2011.

4. D. A. McQuarrie, Statistical Mechanics, University Science Books, California, 2005.

5. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6thEdition, Pearson, 2009.

6. V. R. Gowarikar, N. V. Viwanathan, J. Sreedhar, Polymer Science, 1st Edition, New age International Publishers, 1986.

7. G. Odian, Principles of Polymerization, 4th Edition, Willy Student Edition, 2004.

Practical:

1. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 27th Edison, 2008.

2. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry Experiments, PragatiPrakashan, 6th Edition, 2014.

3. M. Halpern, Experimental Physical Chemistry, 2nd Edition, Prentice Hall, Upper Saddle River, NJ 07458

COURSE NAME: Quantum Chemistry

COURSE CODE: CH - CE - 7454

Total Credits: 4 (Theory: 3+Tutorial:1)

Theory: 3 Credits

Total Lectures: 45

Course Objective:

This course aims to provide students with a fundamental understanding of quantum mechanics, focusing on key concepts such as operators, wavefunctions, and the mathematical framework underpinning quantum systems. They will learn to solve energy eigenvalue equations for systems like the rigid rotor, H-atom, and molecular compounds, applying techniques such as molecular orbital theory. The course also covers approximate methods, including perturbation theory and the variation theorem, alongside the Born-Oppenheimer approximation for multi-electron systems. By the end, students will be equipped to analyze and solve complex quantum mechanical problems, particularly in the context of molecular and atomic systems.

Course Learning Outcome:

CLO-1: *Upon completion of this course, students will be able to understand fundamental quantum concepts, operator theory, and the Schrödinger equation to describe atomic and molecular systems.*

CLO-2: *The students will be able to apply quantum mechanical models and approximation methods (perturbation theory, Born-Oppenheimer approximation, MO theory) to solve atomic and molecular problems.*

Unit I: Operators and Wavepackets (15 Lectures)

Black-body radiation, photoelectric and Compton effects, duality of matter, atomic spectra, Dirac bra-ket notation.

Hermitian operators, matrix elements, The diagonalization of the Hamiltonian, wave-packets, wave functions of one particle and many particles system, the equation for the wave function, the separation of the Schrodinger equation

Born interpretation, expectation values of observable properties, complementarity and complementary observable, uncertainty principle, general angular momentum operators, step-up and step-down operators, theoretical basis of the *L-S* and *j-j* coupling schemes.

Unit II: Solutions of Eigenvalue equations (10 Lectures)

Solutions of the energy eigenvalue equations for particles in a ring, particle on a sphere, Rigid Rotor, The angular momentum, QM treatment of H-atom, QM treatment of harmonic oscillator

Free electron MO theory of benzene; HMO treatment for unsaturated carbon compounds

Unit III: Approximate Methods (10 Lectures)

Time-independent perturbation theory of a two level system (up to second order), the first order correction to the energy and wave function, perturbation theory for degenerate states, the second order correction to the energy

The variation theorem, linear variation function-secular equation, the Rayleigh ratio

Unit IV: Born-Oppenheimer Approximation (10 Lectures)

Born-Oppenheimer approximation, product wave-functions, complete many electron wave functions including electron spin, Pauli's anti-symmetry and exclusion principles, Singlet and triplet states, central field model of many electron atoms (He atom), Slater type orbitals, splitting of term energies in presence of electric and magnetic field (Stark effect and Zeeman effect)

Tutorial:1 credit

Total Lectures: 15

Books Recommended:

1. D. McQuarrie, Quantum Chemistry, Viva Student Edition, University Science Books, 2020.
2. P. Atkins, R. Friedman, Molecular Quantum Mechanics, 4th Edition, Oxford University Press, Oxford 2008.
3. I. N. Levine, Quantum Chemistry, 7th Edition, PHI Learning Pvt. Ltd., 2014.
4. David J. Griffiths, Introduction to Quantum Mechanics, 2nd edition, Pearson Education Ltd., 2014.

COURSE NAME: Organic Chemistry-V

COURSE CODE: CH - CE - 8414

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective:

This course aims to provide students with an in-depth understanding of advanced organic reaction mechanisms, with a focus on photochemical processes, selective oxidation and reduction techniques, and pericyclic reactions. The course aims to educate students with the theoretical foundation and practical insight needed to analyze complex organic transformations, interpret reaction stereochemistry and selectivity, and apply molecular orbital theory to predict reactivity and reaction pathways in organic synthesis. The course also tries to provide students with hands-on experience in multistep organic synthesis, natural product extraction and analysis, and quantitative estimation techniques.

Course Learning Outcome:

CLO-1: *The students will be able to analyze and predict the outcomes of key organic photochemical, oxidation-reduction and pericyclic reactions.*

CLO-2: *The students will be able to carry out basic organic syntheses, including multi-step and multicomponent reactions. They will gain hands-on experience in natural product extraction, analysis, and biodiesel preparation. Additionally, students will develop skills in quantitative analysis using titrimetric and spectroscopic methods.*

Unit I: Organic Photochemistry (10 Lectures)

Photophysical processes (basic ideas), chemiluminescence, photosensitization

Photochemistry of carbonyl compounds: α-cleavage, β-cleavage, intramolecular H-abstraction, addition to π-systems- Paterno-Buchi reaction; Photochemistry of olefins –photostereomutation of cis-trans isomers, optical pumping, cycloaddition, photochemistry of conjugated polyenes, photochemistry of vision

Photochemistry of enones; Photo-rearrangement reactions, di-π-methane rearrangement

Unit II: Oxidation Reactions (9 Lectures)

Metal based and non-metal based oxidations (Al, Ag, Hg, Ru, Se, DMSO, hypervalent iodine and TEMPO based reagents)

Sharpless asymmetric epoxidation, Baeyer-Villiger oxidation, Wacker oxidation, hydroboration-oxidation, Prevost reaction and Woodward modification

Unit III: Reduction Reactions (12 Lectures)

Catalytic hydrogenation (Pd/Pt/Rh/Ni). Wilkinson catalyst

Metal based reductions using Li/Na/Ca in liquid ammonia, Sodium, Magnesium, and Samarium (Birch, Acyloin formation, Pinacol formation, dehalogenations and deoxygenations)

Hydride transfer reagents from Group III and Group IV in reductions (L-selectride and K-selectride, DIBAL-H, and Red-Al, Meerwein-Pondorff-Verley reduction)

Unit IV: Pericyclic Reactions (14 Lectures)

MO symmetry, FMO of conjugated polyenes, Woodward-Hoffmann principle of conservation of orbital symmetry, allowed and forbidden reactions, stereochemistry of pericyclic reactions, orbital symmetry.

Cycloaddition reactions: 2+2, 4+2, 6+2 cycloadditions, 3+2 and 4+3 dipolar cycloadditions; regioselectivity of 4+2 cycloaddition reaction.

Sigmatropic rearrangement: (m+n) sigmatropic rearrangement of hydrogen and chiral alkyl groups; Divinylcyclopropane rearrangement

Electrocyclic reactions and cycloreversions: Conrotatory and disrotatory process, Stereoselectivity of the reactions.

Ene reactions: of 1,7-dienes, carbonyl enophiles, simple problems. Claisen rearrangement and its variants.

Practical: Credit 1

Total Lectures: 15

Organic Synthesis (2-steps):

1. Benzoin – Benzil – Benzilic acid: Base catalysed, rearrangement
2. Multicomponent reaction of aldehyde, β-keto ester and ammonia for the synthesis of dihydro-pyridine derivatives (Hantzsch Pyridine Synthesis)

Experiments on Natural products:

1. Extraction and phytochemical screening/analysis of Natural Products (A case study).
2. Conversion of Vegetable Oil to Biodiesel.

Quantitative analysis:

1. Estimation of sugars by redox titrimetric methods.
2. Spectroscopic methods for estimation of functional groups.

Books Recommended:

Theory:

1. F. A. Cary, R. I. Sundberg, Advanced Organic Chemistry, Part A and B, 5th Edition, Springer, 2009.
2. W. Carruthers and I. Coldham, Modern Methods of Organic Synthesis, First South Asian Edition, Cambridge University Press, 2005.
3. M. B. Smith, Organic Synthesis, 2nd Edition, McGraw-Hill Education, 2001.
4. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Edition, Oxford University Press, 2012.
5. T. H. Lowry, K. S. Richardson, Mechanism and Theory in Organic Chemistry, International Student Edition, Addison-Wesley Publishing, 1998.

Practical:

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel‘s Textbook of Practical Organic Chemistry, Pearson, 2012.
2. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press.
3. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.

COURSE NAME: Inorganic Chemistry-V

COURSE CODE: CH - CE - 8424

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective:

The course aims to: Apply group theory to understand molecular symmetry, bonding, and spectroscopy, Explain electronic structures and spectra of transition metal complexes using CF and MO theories, Analyze magnetic properties of transition metal and lanthanide complexes, Understand principles and reactions in inorganic photochemistry, Explain nuclear reactions, radioactive decay, and applications of radiochemistry, Perform advanced inorganic analyses and apply computational tools to simple molecules

Course Learning Outcome:

CLO-1: *Apply group theory to analyze molecular symmetry, vibrations, and spectral transitions, Explain bonding and electronic spectra of transition metal complexes using crystal field and molecular orbital theories*

CLO-2: *The students can have practical experience on advanced inorganic quantitative analysis*.

Unit I: Symmetry and Group theory – II (10 Lectures)

Chemical application of group theory: Group Theory and Quantum Mechanics - wave functions as bases for irreducible representations, the direct product and its importance in predicting spectral transition probabilities.

Molecular vibrations - symmetry of normal vibrations, selection rules for fundamental vibrational (IR and Raman) transitions.

Symmetry properties of atomic orbitals, molecular orbitals for σ and π bonding in AB_4 molecules, MO treatment of the bonding in ferrocene. Ligand field states, construction of the correlation diagram for the d^2 configuration in an octahedral environment.

Crystallographic symmetry: Translational and point symmetry elements in crystal symmetry, glide planes and screw axes, the crystal systems, Bravais lattices, crystallographic point groups, space groups

Unit II: Binding and electronic spectra of transition metal complexes (10 Lectures)

Jahn-Teller distortion, CFSE, pairing energy, low-spin and high-spin complexes; and molecular orbital (MO) theory of selected octahedral, tetrahedral complexes and other geometries, Walsh Diagram.

d-d transition, charge transfer transition, color, intensity and origin of spectra, interpretation, term symbols and splitting of terms different geometries, selection rules for electronic transitions, correlation, Tanabe-Sugano and Orgel diagrams, calculation of Dq, B and C, nephelauxetic ratio.

Unit III:Magnetic property (10 Lectures)

Magnetic properties of free ions, types of magnetic behaviour: dia-, para-, ferro- and antiferro-magnetism, temperature independent paramagnetism, magnetic susceptibility - Van Vleck equation, experimental measurement, magnetic moment - orbital contribution, quenching of contribution, effect of spin orbit coupling, spincrossover. Temperature dependence of magnetic susceptibility, exchange coupling effects. Magnetic properties of second and third transition series and lanthanides.

Unit IV: Inorganic photochemistry (5 Lectures)

Photo substitution and photoredox reactions of chromium, cobalt and ruthenium compounds, Ligand field and charge transfer state (Thexi & DOSENCO states), *cis-trans* isomerization, photocatalysis and solar energy conversion by ruthenium complexes.

Unit V: Nuclear and radiochemistry (10 Lectures)

Radioactive decay processes, Fermi theory, half-lives, auger effect. Nuclear reactions - notations, comparison with chemical reaction: Types of nuclear reactions. Applications of radioisotopes as tracers (activation and isotope dilution analysis). Age determination, radiolysis of water, units for measuring radiation absorbed by matter, radiation dosimetry. Radiation induced chemistry–sources of radiation, chemical effects produced by the absorption of ionizing radiation and high energy ions and electrons from accelerators - radiation induced synthesis of materials.

Practical: Credit 1

Total Lecture: 15

Advanced Inorganic Analysis:

1. Qualitative analysis (tertiary mixture, alloy, ore) (semi-micro technique to be preferred)
2. Quantitative analysis (binary mixture, alloy, ore) - Ca-Mg ore, Cu-Zn alloy, Pb-Sn alloy, Ni in an alloy etc.
3. Quantitative determination of components in food (Fe, Zn, I, Ca, etc.)
4. Construction of 3D computational models of simple molecules (NH_3, H_2O, H_2O_2, CH_4, C_2H_6) using Avogadro or ArgusLab or chemcraft or any similar software.

Books Recommended:

Theory:

1. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999

2. P.W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong; Shriver &Atkins‘ Inorganic Chemistry, 5th ed. Oxford University Press, 2010.
3. Fundamental Concepts of Inorganic Chemistry, Vols. 1-7, by A.K. Das and M. Das, CBS Publishers and Distributors, 2015
4. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, 4th Ed. Pearson Education, 2006.
5. B. N. Figgis, M. A. Hitchman; Ligand Field theory and its Applications, Wiley India, 2010.
6. G. L. Miessler, D Tarr; Inorganic Chemistry. 3rd Ed., Pearson Education, 2004.
7. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong; Shriver &Atkins‘ Inorganic Chemistry, 5th Ed. OxfordUniversity Press, 2010.
8. F. A. Cotton, Chemical Applications of Group Theory, 3rdEdition, Willey India Pvt. Ltd. 2008.
9. R. L. Dutta, A. Syamal, Elements of Magnetochemistry, 2nd Ed. Affiliated East-West Press Pvt. Ltd.-New Delhi, 2004.
10. D. M. Roundhill, Photochemistry and Photophysics of Metal Complexes; Plenum: New York, 1994.

Practical:

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel‘s Textbook of Quantitative Chemical Analysis, 6thEdition, Pearson, 2009.
2. G. Svehla, S. Mittal, Vogel's Qualitative Inorganic Analysis,Pearson Education, 7th Edition. 2013.

COURSE NAME: Physical Chemistry-V

COURSE CODE: CH - CE - 8434

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective: *The objective of this course is to aware students to the advancement in chemical kinetics, molecular reaction dynamics. Also, to familiarize students with dynamic electrochemistry and application of electrochemistry.*

Course Learning Outcome:

CLO-1: *By studying this course student can able to apply steady-state approximation method toward various reaction, understand the kinetics of fast reaction, also understand the theory of molecular dynamics including transition state theory and its application, understand the electrochemical application for energy storage and energy conversion.*

CLO-2: *Student can able to comprehend with advanced practical aspect of chemical kinetics and application of electrochemistry.*

Unit I: Chemical Kinetics (8 Lectures)

Steady state approximation and its applications, Oscillating reactions, chemical Chaos, Belousov-Zhabotinski reaction, straight-chain reaction-hydrogen halogen reactions, alkane pyrolysis, Branching-chain reactions- the hydrogen-oxygen reaction, explosion limits, Enzyme catalyzed reactions, Michaelis-Menten mechanism- Lineweaver-Burk and Eadie plots, enzyme inhibition.

Unit II: Molecular Reaction Dynamics (7 Lectures)

Collisions of real molecules- trajectory calculations, Laser techniques, reactions in molecular beam, - reaction dynamics, Estimation of activation energy and calculation of potential energy surface- the transition state theory (TST) of bimolecular gaseous reactions, statistical and thermodynamic formulations. Kinetics of reactions in solution diffusion controlled and chemically controlled reactions, TST of reactions in solution- Bronsted and Bjerrum equation, effect of ionic strength, kinetic salt effect.

Unit III: Study of Fast Reactions (8 Lectures)

Stopped flow technique, temperature and pressure jump methods, NMR studies in fast reactions, shock tube kinetics, relaxation kinetics, Linearized rate equation, relaxation time in single step fast reactions, determination of relaxation time.

Unit IV: Theories of Unimolecular Reactions (6 Lectures)

Theory of unimolecular reactions- Lindemann theory and its limitations, Drawbacks of Lindemann theory- Hinselwood modification, RRK theory, slaters treatment, RRKM theory.

Unit V: Dynamic Electrochemistry (10 Lectures)

Ion-solvent interaction- the Born model, Thermodynamic parameters of ion solvent interactions-structural treatment, the ion-dipole model-its modifications, ion-quadrupole and ion-induced dipole interactions, Primary solution- determination of hydration number, compressibility method and viscosity-mobility method, Debye-Huckel theory of ion-ion interactions-derivation, validity and limitations.

Unit VI: Systems for Electro-chemical Energy Storage & Conversion (6 Lectures)

Batteries: Types of Batteries, Lead- acid batteries, Nickel-cadmium batteries and Li-ion batteries, Supercapacitors: Electrical double layer capacitor, Pseudo-capacitor, Fuel Cells

Practical: Credit 1

Total Lectures: 15

(Students have to perform any five of the experiments mentioned below)

1. Study of the kinetics of reaction between iodine and acetone in acidic medium by half-life period method and determination of the order with respect to iodine and acetone.
2. Study of the autocatalytic reaction between oxalic acid and KMnO4 and determination of the order of the reaction.
3. Determination of the amount of each component of the following ternary mixture by conductometric titration. Hydrochloric acid, acetic acid and copper sulphate
4. Comparison of the relative strength of acetic acid and monochloroacetic acid by conductance measurement.
5. Determination of the degree of hydrolysis and hydrolysis constant of aniline hydrochloride /sodium acetate.
6. Determination of the dissociation constant of acetic acid by using Hendersen's equation
7. Finding the amount of the components of the following mixtures using pH metric titration: Hydrochloric acid + Acetic acid/oxalic acid

Books Recommended:

Theory:

1. P. Atkins and J. Paula, Physical Chemistry, 9th Edition, Oxford University Press, Oxford 2010.
2. I. R. Levine, Physical chemistry, 6th Edition, Mcgraw Hill Education, 2011.
3. K. J. Laidler, Chemical Kinetics,3rd Edition, Pearson, 2012.
4. J. O. Bockris, A. K. N. Reddy, Modern Electrochemistry Part 1, 2A and 2B, 2nd Edition, Springer
5. A. J. Bard, L. R. Faulkner, Electrochemical Methods Fundamentals and Applications, 2nd edition, Willy India, 2006.

Practical:

1. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 27th Edison, 2008.

2. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry Experiments, PragatiPrakashan, 6th Edition, 2014.

3. M. Halpern, Experimental Physical Chemistry, 2nd Edition, Prentice Hall, Upper Saddle River, NJ 07458

COURSE NAME: Spectroscopy

COURSE CODE: CH - CE - 8444

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective: *The objective of this course is to make students aware on the detail of NMR, EPR, Mossbauer Spectroscopy and Mass Spectrometry.*

Course Learning Outcome:

CLO-1: *By studying this course student can able to understand the various concepts used in the analysis of organic and inorganic molecules via various spectroscopic and spectrometric techniques.*

CLO-2: *Student can get hands-on training on using NMR or IR or UV techniques to differentiate between organic molecules.*

Unit I: NMR Spectroscopy (18 Lectures)

NMR phenomenon, Zeeman splitting, factors affecting sensitivity and resolution of a NMR spectrum, chemical shift tensor, spin-spin coupling, 1H NMR-inductive and anisotropic effects on chemical shifts (chemical and magnetic equivalence. First order patterns and J to structural correlations. Second order effects in AB, AX and ABX spin systems, simplification of second order spectrum using high magnetic field.

^{13}C NMR to structural correlations. Pulse and Fourier transformation in NMR. Dynamic processes by VT NMR- restricted rotation (DMF, annulenes and related systems), ring inversion (cyclohexane), degenerate rearrangement (bullvalene).

Unit II: ESR Spectroscopy (10 Lectures)

Its principle, hyperfine structure, ESR spectra of organic and inorganic compounds, ZFS, Kramer‘s degeneracy, determination of electronic structure, Zeeman splitting, g-values, hyperfine and super hyperfine coupling constants, practical considerations of measurements, and instrumentation.

Unit III: Mass Spectrometry (10 Lectures)

Mass spectrometry: basic principles, ionization techniques, isotope abundance, molecular ion, fragmentation processes of organic molecules, deduction of structure through mass spectral fragmentation. ESI-MS and MALDI-MS-applications in biomolecules. Studies of inorganic/coordination and organometallic representative compounds. Instrumentation

Unit IV: Mössbauer Spectroscopy (7 Lectures)

Principles, instrumentation and applications.

Practical: 1 credit

Total Lectures: 15

1. To determine the concentration of chromium and manganese in a mixture of dichromate and permanganate by spectrophotometric method.
2. Determination of the composition of iron salicylic acid complex spectrophotometrically by Job‘s method of continuous variation.
3. Investigation of the complex ion formation between Ni^{2+} and o-phenanthroline by Job‘s method.
4. Differentiation between of benzoic acid and cinnamic acid by UV spectroscopy (Spectra to be provided).
5. Differentiation between of *o*-/*p*-hydroxybenzaldehyde by IR spectroscopy (Spectra to be provided).
6. Structure elucidation from simple proton and 13C NMR and Mass Spectrometry.

Books Recommended:

1. D.L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to Spectroscopy, 4th Ed.,Cengage, 2001

2. R. S. Drago, Physical Methods in Chemistry, 1992

3. R. M Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, Spectrometric Identifications of Organic Compounds, 8th Edition, Wiley India Pvt. Ltd, 2015.

COURSE NAME: Green Chemistry

COURSE CODE: CH - CE - 8454

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 Credits

Total Lectures: 45

Course Objective: *The learners will be taught about the emerging discipline of green chemistry particularly to differentiate as to how the principles of green chemistry may be applied to organic synthesis.*

Course Learning Outcome:

CLO-1: *Apart from introducing learners to the principles of green chemistry, this course will make them conversant with applications of green chemistry to organic synthesis. Students will be prepared for taking up entry level jobs in the chemical industry. They also will have the option of studying further in the area.*

CLO-2: *The student will be able to apply the principles of green chemistry in organic synthesis and preparation of value-added chemicals.*

Unit I: Introduction to Green Chemistry (8 Lectures)

Introduction to Green Chemistry, some important environmental laws, pollution prevention Act of 1990, emergence of green chemistry, need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry. Green chemistry in sustainable development.

Unit II: Principles of Green Chemistry and Designing a Chemical synthesis (30 Lectures)

Twelve principles of Green Chemistry with their explanations and examples; 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); prevention/ minimization of hazardous/ toxic products; designing safer chemicals – different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions - use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Unit III: Future Trends in Green Chemistry (7 Lectures)

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Solventless reactions; Green chemistry in sustainable development.

Practical: 1 credit

Total Lectures: 15

(Students have to perform any five of the experiments mentioned below)

1. Preparation and characterization by UV-V is spectroscopy of nanoparticles of zinc using tea leaves/silvernano particles using plant extracts.
2. Preparation of biodiesel from commercial/waste cooking oil and characterization (TLC, pH, solubility).
3. Solid state synthesis of *N*-organophthalimide using phthalic anhydride and 3-amino benzoic acid.
4. Photochemical conversion of dimethyl maleate to dimethyl fumarate (*cis-trans* isomerisation)
5. Benzil- Benzilic acid rearrangement: Preparation of benzilic acid in solid state under solvent-free condition.
6. Preparation of dibenzalacetone by cross aldol condensation reaction using base catalysed green method.

Books Recommended

1. M. Lancaster, Green Chemistry: An Introductory Text, RSC, 2002
2. P.T. Anastas, J. C. Warner, Green Chemistry: Theory and Practice, Oxford University Press 2008
3. J. H. Clark, F. Deswarte, Introduction to Chemicals from Biomass, 2nd Edition, Wiley 2015

MINOR

Programme Specific Outcome of Bachelor of Science – Chemistry: Minor

PSO No.	Name	Outcome
PSO–1	Basic Understanding	The learner will able to gain basic ideas about the organic, inorganic and physical chemistry.
PSO–2	Collective Effort	The learner will learn to complete common tasks or achieve common goals in an effective way through collaborative manner.
PSO–3	Communication Skill	The learner will gain communication skill to present their knowledge/expertise/skill in Chemistry in the form of project work, seminar presentation, poster presentation, wall magazine and other modes.
PSO–4	Skill Enhancement	The learner will develop practical skills to work/ or to develop start-ups in different industrial fields like chemical, pharmaceutical, polymer, glass blowing, agro industry and others related to chemical sciences.
PSO–5	Competency for Competitive Examinations	The learners will gain the confident to face the competitive exams like CUET, PGUET, JAM, NET, GATE, SLET, GRE, TOEFL, Civil services, etc.
PSO–6	Ethical Analysis	The learner will learn to make legitimate evidence based-decision making in a particular context, especially through the concepts of IPR like Patent, copyright, plagiarism, etc.

LIST OF COURSES:

Semester	Course Name	Course Code
1	General Chemistry-I	CH – MN – 1114
2	General Chemistry-II	CH – MN – 2114
3	General Chemistry-III	CH – MN – 3214
4	General Chemistry-IV	CH – MN – 4214
5	General Chemistry-V	CH – MN – 5214
6	General Chemistry-VI	CH – MN – 6214
7	General Chemistry-VII	CH – MN – 7214
8	Organic Chemistry-V	CH – MN – 8214

Course Learning Outcome (CLO)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	General Chemistry-I CH – MN – 1114	CLO - 01	The students will get introduced to the foundations of organic, inorganic, as well as, physical chemistry concepts including atomic structure, periodicity of elements, redox reactions, aliphatic hydrocarbons, kinetic theory of gases, ionic equilibria, liquid state, etc.
		CLO - 02	The students will learn about the basic laboratory techniques and they are supposed to learn to perform introductory experiments viz. redox titrations, purification methods, pH measurements, etc.
2	General Chemistry-II CH – MN – 2114	CLO - 01	The students will learn about the fundamentals concepts of chemistry, including chemical bonding, transition elements, hydrocarbons, stereochemistry, solid state chemistry and chemical thermodynamics.
		CLO - 02	The students will learn to perform basic laboratory experiments like acid-base titrations, separation techniques and thermochemical measurements.
3	General Chemistry-III CH – MN – 3214	CLO-01	The students will develop a clear grasp of quantum chemistry concepts, encompassing atomic structure and chemical bonding, along with introductory knowledge of coordination chemistry, while also acquiring the skills to prepare double salts and inorganic coordinate complexes.
		CLO-02	The students will learn about preparation, properties and reactions of alkyl halides and aryl halides, as well as, become apprised with the stereochemistry of conformational isomers. The students will learn to perform detection and identification of various functional groups present in organic compounds.
		CLO-03	The students can learn about states of the reactants and products in chemical equilibrium and factors affecting them, along with the concept of phases, their stability and its applications to specific systems.They are further expected to develop expertise in performing phase equilibrium studies on simple homogeneous systems.

4	General Chemistry-IV CH – MN – 4214	CLO-01	The students will gain a comprehensive grasp of lattice energy equations, terminology associated with crystal field theory, and the reactivity patterns of coordination compounds. Additionally, they will be able to recognize the general trends in the properties of lanthanide and actinide elements within the periodic table, identifying distinctions among elements within each row. The students will develop skill to quantitatively estimate metal ions by gravimetric analysis and separate metal ions by chromatographic methods.
		CLO-02	The students will learn about organic compounds like alcohols, phenols and ethers with special reference to their preparation, physical properties, reactivity, etc. Students will also learn to perform elemental analysis to identify elements nitrogen, sulfur, halogens and nitrogenous functional groups present in organic compounds.
		CLO-03	The students are expected to learn about reaction rates, reaction orders, rate laws, experimental methods of rate law determination in chemical systems. The students will also learn to differentiate ideal and non-ideal solutions and understand different phenomena and properties pertinent to solutions. Students are further anticipated to develop expertise in performing reaction kinetics studies on select chemical reactions.
5	General Chemistry-V CH – MN – 5214	CLO-01	Students will gain insight into the chemistry of interhalogen compounds and noble gases, as well as understand the structures, bonding, and practical applications of chain, ring, and cage compounds. They will also employ theoretical principles of redox chemistry to comprehend metallurgical processes effectively. Furthermore, students will develop proficiency in conducting iodo-/iodi-metric titrations alongside complexometric titrations, enhancing their quantitative estimation abilities.
		CLO-02	The students are expected to learn the preparation and reactions of aldehydes, ketones and carboxylic acids. The students will further get acquainted with laboratory synthetic practices and be able to execute small scale organic preparations.

5	General Chemistry-V CH – MN – 5214	CLO-03	The students will be able to understand the electrical properties of ions and molecules from concepts of ionic conductivity and electrochemical reactions. The students will gain hands-on training on operating electrochemical instrument and learn to determine conductance of acid-base solutions.
6	General Chemistry-VI CH – MN – 6214	CLO-01	The students will grasp the concept of organometallic compounds and acquire knowledge of principles governing inorganic qualitative analysis. Through this course, they will develop skills in both qualitative and quantitative chemical analysis, enabling them to effectively identify and understand various inorganic salts.
		CLO-02	The students are expected to learn the preparation and reactions of organic compounds such as amines, diazonium salts, acid chlorides, esters, anhydrides and amides. The students will learn to conduct quantitative chemical analysis of organic compounds by titrimetric methods.
		CLO-03	The students will be able to understand various surface adsorptions process and learn about catalysis. The students will also understand the physical phenomena of surface tension & its effects on solutions and reaction kinetics of catalytic systems.
7	General Chemistry-VII CH-MN-7214	CLO-1	By studying this course student can able to determine the structure of metal-carbonyls, bond order of metal-carbonyls from IR spectra and also know about many important industrial transformations. They will also understand the various spectral analysis of inorganic compounds, know important synthetic methods and chemical reactions of terpenes and alkaloids and also get aware of various actions of therapeutic drug and understand the concept of basics of kinetics of polymer and nanotechnology.
		CLO-2	Students can able to have hands on training on various coordination complex preparations, synthesis of medicinally important compounds, nanoparticle synthesis its characterization and

			molecular weight determination of polymer.
8	General Chemistry-VIII CH-MN-8214	CLO-1	By studying this course student can able to understand various mechanistic pathways for inorganic reactions, also understand the importance of various metal ions in biological systems, can be able to know important synthetic methods and chemical reactions of amino acids and also become aware of various classification of proteins and structure determination. Students will understand the concept of quantization and various spectroscopic techniques and its corresponding selection rules for transitions.
		CLO-2	Students can able to have hands on training on quantitative determination of metals in alloys and various food sample, practical application of chromatography and UV-Vis spectroscopy for Lambert-Beer laws validation.

Mapping of Programme Outcome (PO) and Course Learning Outcome (CLO):

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	Programme Outcome (SPO)										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
CH-MN-1114	CLO–1	3	3	3	3	3	3	1	3	2	3	3
	CLO–2	3	3	3	3	3	3	1	3	2	3	3
CH-MN-2114	CLO–1	3	3	3	3	3	3	1	3	2	3	3
	CLO–2	3	3	3	3	3	3	1	3	2	3	3
CH-MN-3214	CLO–1	3	3	3	3	3	3	1	3	1	3	3
	CLO–2	3	3	3	3	3	3	1	3	1	3	3
	CLO – 3	3	3	3	3	3	3	1	3	1	3	3
CH-MN-4214	CLO–1	3	3	3	3	3	3	1	3	1	3	3
	CLO–2	3	3	3	3	3	3	1	3	1	3	3
	CLO – 3	3	3	3	3	3	3	1	3	2	3	3
CH-MN-5214	CLO–1	3	3	3	3	3	3	1	3	2	3	3
	CLO–2	3	3	3	3	3	3	2	3	2	3	3
	CLO – 3	3	3	3	3	3	3	2	3	2	3	3
CH-MN-6214	CLO–1	3	3	3	3	3	3	1	3	2	3	3
	CLO–2	3	3	3	3	3	3	1	3	2	3	3
	CLO – 3	3	3	3	3	3	3	1	3	2	3	3
CH-MN-7314	CLO-1	3	3	3	3	3	3	1	3	2	3	3
	CLO-2	3	3	3	3	3	3	1	3	2	3	3
CH-MN-8314	CLO-1	3	3	3	3	3	3	2	3	2	3	3
	CLO-2	3	3	3	3	3	3	2	3	2	3	3

Mapping of Programme Specific Outcome (PSO) and Course Learning Outcome (CLO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course code	CLO	Programme Specific Outcome						
		PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7
CH-MN-1114	CLO-1	3	3	2	3	3	1	3
	CLO-2	3	3	2	3	3	1	3
CH-MN-2114	CLO-1	3	3	2	3	3	1	3
	CLO-2	3	3	2	3	3	1	3
CH-MN-3214	CLO-1	3	3	2	3	3	1	3
	CLO-2	3	3	2	3	3	1	3
	CLO - 3	3	3	2	3	3	2	3
CH-MN-4214	CLO-1	3	3	2	3	3	2	3
	CLO-2	3	3	2	3	3	1	3
	CLO - 3	3	3	2	3	3	1	3
CH-MN-5214	CLO-1	3	3	2	3	3	1	3
	CLO-2	3	3	2	3	3	1	3
	CLO - 3	3	3	2	3	3	1	3
CH-MN-6214	CLO-1	3	3	2	3	3	1	3
	CLO-2	3	3	2	3	3	1	3
	CLO - 3	3	3	2	3	3	1	3
CH-MN-7314	CLO-1	3	3	2	3	3	1	-
	CLO-2	3	3	2	3	3	1	-
CH-MN-8314	CLO-1	3	3	2	3	3	1	-
	CLO-2	3	3	2	3	3	1	-

COURSE NAME: General Chemistry-I
COURSE CODE: CH – MN – 1114
Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY: 3 CREDITS

Total Lectures: 45

COURSE OBJECTIVE:

This course aims at giving students understanding about the basic constituents of matter – atoms, ions and molecules in terms of their electronic structure and reactivity. Structure and bonding are to be dealt with basic quantum chemistry treatment. Further, periodic classification of elements in the periodic table and changes in properties along the periods and groups to be studied in detail. The students are introduced to the principles of redox titrations in context of volumetric analysis of common metal ions. The course also apprises students with introduction to organic compounds, electron displacement, type of reagents and reaction intermediates. The chemistry of aliphatic and aromatic hydrocarbon are also included. Further, the course strives to educate the students on fundamental topics states of matter-gaseous and liquid along with ionic equilibria.

Course Learning Outcome:

CLO-01: *The students will get introduced to the foundations of organic, inorganic, as well as, physical chemistry concepts including atomic structure, periodicity of elements, redox reactions, ideals of organic reactions, aliphatic hydrocarbons, kinetic theory of gases, ionic equilibria, liquid state, etc.*

CLO-02: *The students will learn about the basic laboratory techniques and they are supposed to learn to perform introductory experiments viz. redox titrations, purification methods, pH measurements, etc.*

Unit 1: Inorganic Chemistry

Atomic Structure – I (5 Lectures)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and $|\psi|^2$. Quantum numbers and their significance.

Periodicity of Elements (7 Lectures)

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* &*p*-block.

a. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

b. Atomic radii (van der Waals), Ionic and crystal radii, Covalent radii.

c. Ionization enthalpy, factors affecting ionization energy.

d. Electron gain enthalpy, trends of electron gain enthalpy.

e. Electro negativity, Pauling's/ Mulliken's/ Alfred Rochow's electro negativity scales. Variation of electro negativity with bond order, partial charge, hybridization, group electro negativity.

f. Inert pair effect, diagonal relationship.

Oxidation-Reduction: (3 Lectures)

Principles involved in volumetric analysis of metal ion Fe2+ with the help of standard $KMnO_4$ and$K_2Cr_2O_7$ solution

Unit 2: Organic Chemistry

Organic Compounds (2 Lectures)

Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements (3 Lectures)

Inductive, electromeric, resonance and mesomeric effects, hyper conjugation and their applications; Dipole moment; Hydrogen bonding and its effect on the properties of organic molecules; Organic acids and bases – their relative strength.

Cleavage of Bonds (3 Lectures)

Homolysis and Heterolysis. Curly arrow rules, Drawing electron movement with arrows and half-headed arrows. Structure and shape of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Aliphatic Hydrocarbons (7 Lectures)

a. Alkanes: Preparation - Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions - Free radical Substitution: Halogenation.

b. Alkenes: Preparation - Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis-alkenes (Partial catalytic hydrogenation) and trans-alkenes (Birch reduction). Reactions-cis-addition (alkaline $KMnO_4$) and trans-addition (Br_2), Addition of hydrogen halides (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

c. Alkynes: Preparation - Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra-halides and dehydrohalogenation of vicinal-dihalides. Reactions-formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$. Vali International, New Delhi.

Unit 3: Physical Chemistry

Kinetic Theory of Gases (6 Lectures)

Postulates of Kinetic theory of gases and derivation of the kinetic gas equation. Behaviour of real gases: Deviation from ideal behaviour, compressibility factor, causes of deviation from ideal behaviour, Vander Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from Vander Waals equation. Andrew isotherms of CO_2.

Ionic Equilibrium:(5 Lectures)

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. Buffer solutions. Solubility and solubility product of sparingly soluble salts-applications of solubility product principle.

Liquids: (4 Lectures)

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

Practical:

Total Lectures: 30

Oxidation-Reduction Titrimetry:

1. Preparation of solutions of different Molarity/Normality of titrants.
2. Estimation of $Fe^{2+}$and Fe^{3+} ions with the help of $K_2Cr_2O_7$and standardized $KMnO_4$ solutions.

Purification methods:

1. Purification of organic compounds by crystallization using the following solvents: a) Water b) Alcohol c) Alcohol-Water
2. Determination of the melting points of recrystallized compounds and unknown organic Compounds.

pH measurements:

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps using pH meter.
2. Preparation of buffer solutions:

(i) Sodium acetate-acetic acid.

(ii) Ammonium chloride-ammonium hydroxide.

Surface tension measurement: (in aqueous solutions only)

1. Determination of the surface tension of a dilute solution using astalagmometer.
2. Study of the variation of surface tension of a detergent solution with concentration.

Viscosity measurement: (in aqueous solutions only)

1. Determination of the relative and absolute viscosity of dilute solution using an Ostwald's viscometer.
2. Study of the variation of viscosity of an aqueous solution with concentration of solute

RECOMMENDED BOOKS:

THEORY:

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley
3. Atkins, P., Overton, T., Rourke, J., Weller, M. and Armstrong, F., Shriver and Atkins

4. Inorganic Chemistry, 5th Edition, Oxford University Press.
5. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, 9 th Ed., Oxford University Press.
6. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.
7. Negi, A.S., Anand, S.C. A Textbook of Physical Chemistry, 3 rd Ed. New Age International Publishers
8. Silbey, R. J., Alberty, R. A., Bawendi, M. G. Physical Chemistry, 4 th Ed., John Wiley & amp; Sons.
9. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, 2 nd Ed., Oxford University Press.
10. Bruice, P. Y. Organic Chemistry, 7 th Ed., Pearson Education.
11. Morrison, R. N., Boyd, R. N. & Bhattacharjee, S. K. Organic Chemistry, 7 th Ed. Pearson Education.

Practical:

1. Yadav, J.B. Advanced Practical Physical Chemistry, Krishna Prakashan.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi.
3. Mendham, J., Denney, R.C., Barnes, J. D., Thomas, M. and Sivasankar, S. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed., Pearson Education.
4. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, Pearson Education

COURSE NAME: General Chemistry-II

COURSE CODE: CH – MN – 2114

TotalCredits:4(Theory:3+Practical/Tutorial:1)

THEORY: 3 Credits

TOTAL LECTURES: 45

COURSE OBJECTIVE:

This course aims at giving students theoretical understanding about the structure and bonding of molecules, with important concepts like Valence Bond theory and Molecular Orbital theory. The students are introduced to the chemistry of the d-block transition elements including their properties and reactivities. The course also apprises students with introduction to aromatic organic compounds, with special focus on benzene, its properties and reactivity. The students are also introduced to the stereochemistry of organic compounds. Further, the course strives to educate the students on fundamental topic of states of matter- solid state and the important concept of chemical thermodynamics and thermo chemistry.

Course Learning Outcome:

CLO-01: *The students will learn about the fundamental's concepts of chemistry, including chemical bonding, transition elements, hydrocarbons, stereochemistry, solid state chemistry and chemical thermodynamics*.

CLO-02: *The students will learn to perform basic laboratory experiments like acid-base titrations, separation techniques, and thermochemical measurements*

Unit 1: Inorganic Chemistry

Chemical Bonding – I: (3 Lectures)

i. Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals.

ii. Covalent bond: Lewis's structure, Formal charge.

iii. Concepts of hybridization involving *s, p &d* orbitals, equivalent and non-equivalent hybrid orbitals. Bent's rule.

Chemical Bonding – II (6 Lectures)

i. 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.

ii. Molecular orbital theory, Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions.

Transition Elements (3d series) (6Lectures)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Unit 2: Organic Chemistry

Aromatic Hydrocarbons (5 Lectures)

Structure and Bonding (Benzene); Hückel's rule of aromaticity, Aromatic character of arenes and heterocyclic compounds with suitable examples. Preparation (of benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid; Reactivity (of benzene): Electrophilic aromatic substitution – nitration, halogenation and sulphonation; Directing effects of the groups. Friedel-Craft's reaction (alkylation and acylation).

Stereo chemistry of Organic Compounds (10 Lectures)

Concept of isomerism, Elementary idea of structural projections: Flying wedge, Newmann, Sawhorse and Fischer representations.

Configurational isomers: Optical isomerism–Optical activity, Concept of chirality; Enantiomers, Diastereomers and Meso compounds; Optically active molecules without chiral centre, Atropisomerism. Racemic Mixtures and Resolution. Geometrical isomerism–*cis-trans* and *syn-anti* isomerism. Relative and absolute configuration with CIP rules: D/L and R/S designations (forupto2chiral carbon atoms) and E/Z designations (for upto two C = C systems).

Unit 3: Physical Chemistry

Solids: (4Lectures)

Symmetry elements, unit cells, crystal systems, Bravais Lattice types and identification of lattice planes. Structure of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Thermodynamics (6 Lectures)

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.

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

Thermochemistry (5 Lectures)

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Adiabatic flame temperature, explosion.

Practical:

TotalLectures:30

Acid – Base Titrations

1. Estimation of carbonate and hydroxide present together in mixture
2. Estimation of carbonate and bicarbonate present together in a mixture
3. Estimation of free alkali present in different soaps/detergents.

Separation techniques

1. Separation of a binary mixture of organic compounds by thin layer chromatography (TLC) like ortho-/para-nitrophenols, ortho-/para-nitroaniline, etc.
2. Separationofamixtureoftwoaminoacidsbyascendingandhorizontalpaperchromatography

Heat Capacity & Enthalpy measurements

1. Determination of heat capacity of a calorimeter using hot and cold water.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of hydration of copper sulphate.
4. Study of the solubility of benzoic acid in water and determination of ΔH

RECOMMENDED BOOKS:

Theory:

1. Lee, J. D. Concise Inorganic Chemistry, 5th Ed., Oxford University Press
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley Atkins, P., Overton, T., Rourke, J., Weller, M. and Armstrong, F., Shriver and Atkins
3. Inorganic Chemistry, 5th Edition, Oxford University Press.
4. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, 9 th Ed., Oxford University Press.
5. Puri, B. R.; Sharma, L. R.; Pathania, M. S. Principles of Physical Chemistry, Vishal Publishing Co.
6. Negi, A.S., Anand, S.C. A Textbook of Physical Chemistry, 3 rd Ed. New Age International Publishers
7. Silbey, R. J., Alberty, R. A., Bawendi, M. G. Physical Chemistry, 4 th Ed., John Wiley & amp; Sons.
8. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, 2 nd Ed., Oxford University Press.
9. Bruice, P. Y. Organic Chemistry, 7 th Ed., Pearson Education.
10. Morrison, R. N., Boyd, R. N. & Bhattacharjee, S. K. Organic Chemistry, 7 th Ed. Pearson Education.

Practical:

1. Yadav, J.B. Advanced Practical Physical Chemistry, Krishna Prakashan.
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi.
3. Mendham, J., Denney, R.C., Barnes, J. D., Thomas, M. and Sivasankar, S. Vogel's Text Book of Quantitative Chemical Analysis, 6th Ed., Pearson Education.
4. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, Pearson Education

COURSE NAME: General Chemistry-III

COURSE CODE: CH- MN - 3214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

This course aims at providing the students with further insights into the electronic structure and bonding of atoms, ions and molecules, in terms of basic quantum chemistry treatment. The course also introduces students to coordination chemistry and its various aspects like nomenclature, structure, bonding, variety and reactivity of the coordination compounds for the students to appreciate. The course attempts to educate the students about the organic compounds, starting with the chemistry of halogenated hydrocarbons. The study of conformational isomers is included to enlighten the students about stereochemistry. Lastly, the course is integrated with the study of chemical and phase equilibria to acquaint the students with states of various systems.

Course Learning Outcome:

CLO 1: *The students will develop a clear grasp of quantum chemistry concepts, encompassing atomic structure and chemical bonding, along with introductory knowledge of coordination chemistry, while also acquiring the skills to prepare double salts and inorganic coordinate complexes.*

CLO 2: *The students will learn about preparation, properties and reactions of alkyl halides and aryl halides, as well as, become apprised with the stereochemistry of conformational isomers. The students will learn to perform detection and identification of various functional groups present in organic compounds.*

CLO 3: *The students can learn about states of the reactants and products in chemical equilibrium and factors affecting them, along with the concept of phases, their stability and its applications to specific systems. They are further expected to develop expertise in performing phase equilibrium studies on simple homogeneous systems.*

Unit 1: Inorganic Chemistry

Atomic Structure–II (6 Lectures)

Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wavefunctions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number and electronic configuration.

Chemical Bonding–III (4 Lectures)

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Coordination Chemistry–I (5 Lectures)

Coordination compounds, types of ligands, Werner's theory, IUPAC nomenclature and isomerism in coordination compounds. Stereochemistry of complexes with 4- and 6-coordination numbers.

Drawbacks of VBT. Basic idea of Crystal field theory (CFT) of octahedral and tetrahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields, pairing energy.

Unit 2: Organic Chemistry

Stereochemistry of Organic Compounds-II (5 lectures)

Conformational isomers: Conformers, Conformational analysis of simple alkanes (ethane and butane) & relative stability with energy diagrams. Types of cycloalkanes and their relative stability. Conformational analysis of cyclohexane: Chair, Boat and Twist boat forms, relative stability with energy diagrams.

Chemistry of Alkyl Halides (5 lectures)

Types of Aliphatic Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions.

Preparation: From alkenes and alcohols.

Reactions: Hydrolysis, nitrite & nitro formation, nitrile &isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Chemistry of Aryl Halides (5 lectures)

Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene case): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit 3: Physical Chemistry

Chemical Equilibrium (8 Lectures)

Criteria of thermodynamic equilibrium, relation betweenGibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressureand concentration. Free energy of mixing and spontaneity; thermodynamic derivation ofrelations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (qualitative treatment).

Phase Equilibrium (7 Lectures)

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

Practical

Total Lectures: 30

Inorganic Preparations

i. Aluminium potash sulphate, $KAl(SO_4)_2 12H_2O$ (Potash alum)

ii. Chrome alum $K_2SO_4Cr_2(SO_4)_3 24H_2O$

iii. Manganese(III)phosphate $MnPO_4H_2O$

iv. Tetraamminecopper(II)sulphate, $Cu(NH_3)4SO_4H_2O$

v. Potassium tris(oxalato)ferrate(III), $K_3[Fe(C_2O_4)_3]$

vi. Potassium tris(oxalato)chromate(III), $K_3[Cr(C_2O_4)_3]$

vii. bis(glycinato)copper(II), [Cu(glycinate)2(H_2O)]

viii. Hexaamminenickel(II)chloride, $[Ni(NH_3)_6]Cl_2$

Qualitative Organic Analysis

i. Analysis of an organic compound: Test for carboxylic acid, phenolic and carbonyl groups.

ii. Identification of acidic functional groups of a given organic sample (acetic acid, oxalic acid) and determination of equivalent mass by titrimetric methods.

Phase Equilibria Studies

i. Study the variation of mutual solubility temperature with concentration for thephenol water system and determination of the critical solution temperature.

ii. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

RECOMMENDED BOOKS:

Theory:

1. Huheey, J. E., Keiter, E. A., Keiter, R. L., Medhi, O. K., *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Ed., Pearson Education, 2006.
2. Cotton, F.A., Wilkinson, G. and Gaus, P. L., *Basic Inorganic Chemistry*, 3rd Ed., Wiley, 2007.
3. Miessler, G. L. &Tarr, D. A., *Inorganic Chemistry*, 4th Ed., Pearson Education, 2010.
4. Nasipuri, D. *Stereochemistry of Organic Compounds: Principles and Applications*, 4th Ed., New Age International Publishers.
5. March, J. *Advanced Organic Chemistry*, 4th Ed., Wiley, 2006.
6. Finar, I. L., *Organic Chemistry (Volume 1)*, 6th Ed., Pearson Education, 2009.
7. Atkins, P.W. & Paula, J. *Physical Chemistry*, 9th Ed., Oxford University Press, 2010.
8. Puri, B. R.; Sharma, L. R.; Pathania, M. S. *Principles of Physical Chemistry*, Vishal Publishing Co.; 47thEd., 2017.
9. Kapoor, K. L. *A Textbook of Physical Chemistry* (Volume 2), McGraw Hill Education,5th Ed., 2017.

Practical:

1. Marr, G. &Rockett, R. W. *Practical Inorganic Chemistry,* Van Nostrand Reinhold Co., 1972.
2. Mann, F. G. & Saunders, B. C. *Practical Organic Chemistry,* Pearson Education, 2009.
3. Khosla, B. D., Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., 2011.
4. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: General Chemistry-IV

COURSE CODE: CH- MN - 4214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

This course aims at giving students understanding about the concepts of lattice energy and different equations related to lattice energy in ionic compounds. This course also introduces students to coordination chemistry with emphasis on various ligand field effects. The chemistry of lanthanides and actinides is included for insights into characteristics and properties of f-block elements. The course attempts to educate the students on certain classes of organic compounds, viz. alcohols, phenols, ethers. The course is further designed to enlighten students about chemical reaction kinetics and the physical aspects of solutions.

Course Learning Outcome:

CLO 1: *The students will gain a comprehensive grasp of lattice energy equations, terminology associated with crystal field theory, and the reactivity patterns of coordination compounds. Additionally, they will be able to recognize the general trends in the properties of lanthanide and actinide elements within the periodic table, identifying distinctions among elements within each row. The students will develop skill to quantitatively estimate metal ions by gravimetric analysis and separate metal ions by chromatographic methods.*

CLO 2: *The students will learn about organic compounds like alcohols, phenols and ethers with special reference to their preparation, physical properties, reactivity, etc. Students will also learn to perform elemental analysis to identify elements nitrogen, sulfur, halogens and nitrogenous functional groups present in organic compounds.*

CLO 3: *The students are expected to learn about reaction rates, reaction orders, rate laws, experimental methods of rate law determination in chemical systems. The students will also learn to differentiate ideal and non-ideal solutions and understand different phenomena and properties pertinent to solutions. Students are further anticipated to develop expertise in performing reaction kinetics studies on select chemical reactions.*

Unit 1: Inorganic Chemistry

Ionic Bonding (5 Lectures)

Lattice energy, Born Lande equation with derivation and importance of Kapustinskii expression for lattice energy, Madelung constant, Born-Haber cycle and its application.

Coordination Chemistry–II (6 Lectures)

Factors affecting the magnitude of Δ_0. Spectrochemical series. tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry, qualitative aspects of ligand field and molecular orbital theory.

Lanthanides and Actinides (4 Lectures)

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit 2: Organic Chemistry

Alcohols (8 Lectures)

Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: with Na metal, with halo acids (Lucas test), esterification, oxidation (alkaline KMnO4, acidic $K_2Cr_2O_7$, conc. HNO_3), Oppenauer oxidation. Diols: oxidation by periodic acid and lead tetraacetate. Pinacol-Pinacolone rearrangement.

Phenols (5 Lectures)

Preparation (Phenol case): Cumene hydroperoxide method, from diazonium salts.

Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Schotten–Baumann Reaction.

Ethers (aliphatic and aromatic) (2 Lectures)

Preparation: Williamson's ether synthesis.

Reactions: Cleavage of ethers with HI, Claisen rearrangement.

Unit 3: Physical Chemistry

Solutions (6 Lectures)

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law- non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Azeotropes. Partial miscibility of liquids: Critical solution temperature.

Chemical Kinetics (9 Lectures)

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). experimental methods of the determination of rate laws. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Practical:

Total Lectures: 30

Quantitative Inorganic Analysis

i. Gravimetric analysis of Ni(II) using dimethylglyoxime (DMG).

ii. Estimation of SO_4^{2-} ion as $BaSO_4$.

Chromatography of Metal Ions

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni(II), Mn(II), Zn(II) and Co(II)

ii. Cu(II), Cd(II) and Hg(II)

Qualitative Organic Analysis:

Analysis of an organic compound (containing elements N, S and halogens)

i. Test for detection of elements N, S and X (halogens).

ii. Test for nitro, amine and amide groups.

Chemical Kinetics Studies

i. Iodine-clock reaction

ii. Integrated rate method: Acid hydrolysis of methyl acetate with hydrochloric acid.

RECOMMENDED BOOKS:

Theory:

1. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Oxford University Press, 2008.
2. Miessler, G. L. &Tarr, D. A., *Inorganic Chemistry*, 4th Ed*.,* Pearson Education, 2010.
3. Solomons, T. W. G., Fryhle, C. B., Snyder, S. A. *Organic Chemistry*, 12th Ed., Wiley, 2016.
4. Bruice, P. Y. *Organic Chemistry*, 8th Ed., Pearson Education, 2015.
5. Puri, B. R.; Sharma, L. R.; Pathania, M. S. *Principles of Physical Chemistry*, Vishal Publishing Co.; 47th Ed., 2017.
6. Negi, A. S., Anand, S. C.*A Textbook of Physical Chemistry*, 2nd Ed.New Age International Publishers, 2007.

Practical:

1. Mendham, J. et al.: *Vogel's Text Book of Quantitative Chemical Analysis*; 6th Ed. Pearson Education, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co., 2011.
3. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: General Chemistry-V

COURSE CODE: CH- MN - 5214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objectives:

This course is aimed to apprise students about the variety of compounds of the main group elements like interhalogens, noble gases; inorganic ring, chain and cage compounds. The basic principles of metallurgy are discussed so as to acquaint the students with the application of the redox chemistry. This course is intended to teach students about two classes of organic compounds – carbonyl compounds and carboxylic acids. The course also introduces the students to two important topics of physical chemistry – ionic conductance and electrochemistry.

Course Learning Outcome:

CLO 1: *Students will gain insight into the chemistry of interhalogen compounds and noble gases, as well as understand the structures, bonding, and practical applications of chain, ring, and cage compounds. They will also employ theoretical principles of redox chemistry to comprehend metallurgical processes effectively. Furthermore, students will develop proficiency in conducting iodo-/iodi-metric titrations alongside complexometric titrations, enhancing their quantitative estimation abilities.*

CLO 2: *The students are expected to learn the preparation and reactions of aldehydes, ketones and carboxylic acids. The students will further get acquainted with laboratory synthetic practices and be able to execute small scale organic preparations.*

CLO 3: *The students will be able to understand the electrical properties of ions and molecules from concepts of ionic conductivity and electrochemical reactions. The students will gain hands-on training on operating electrochemical instrument and learn to determine conductance of acid-base solutions.*

Unit 1: Inorganic Chemistry

Chemistry of Non-Transition Elements (3 Lectures)

Interhalogen compounds, noble gas compounds- xenon oxides and fluorides.

Inorganic Chain, Rings and Cage Compounds (7 Lectures)

Aluminosilicates, Zeolites, borazine, phosphazine, S_4N_4, P_4, P_4O_6, P_4O_{10}, boron cage compounds

General Principles of Metallurgy (5 Lectures)

Concept of Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process.

Unit 2: Organic Chemistry

Aldehydes and ketones (aliphatic and aromatic) (8 Lectures)

(Case: Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions: Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemmensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

Carboxylic Acids (aliphatic and aromatic)(7 Lectures)

Preparation: Acidic and Alkaline hydrolysis of esters.

Reactions: Esterification, Amidation, Hell-Vohlard-Zelinsky Reaction.

Introduction to dicarboxylic acids, hydroxy acids and unsaturated acids and their typical reactions: succinic, phthalic, lactic, malic, tartaric, maleic and fumaric acids.

Unit 3: Physical Chemistry

Conductance (7 Lectures)

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, Conductometric titrations (only acid-base).

Electrochemistry (8 Lectures)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Practical:

Total Lectures: 30

Iodo-/Iodi-metric Titrations

i. Estimation of Cu(II) & $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).

ii. Estimation of available chlorine in bleaching powder iodometrically.

Complexometric Titrations

Estimation of metal ions: Zn^{2+}, Ca^{2+} and Mg^{2+} by complexometric titrations using metal ion indicators.

Organic Preparations

i. Benzoylation of amines (aniline, toluidine) and phenols (phenol, β-naphthol).

ii. Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone (benzaldehyde/acetone).

Percentage yield calculation, product recrystallization and purity determination by melting point to be carried out.

Conductometry

i. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

ii. Perform the following conductometric titrations:

   a. Strong acid vs. strong base

   b. Weak acid vs. strong base

RECOMMENDED BOOKS:

Theory:

1. Weller, M., Armstrong, F., Rourke, J. & Overton, T., *Inorganic Chemistry* 6th Ed. 2015.
2. Miessler, G. L. &Tarr, D. A., *Inorganic Chemistry* 4th Ed., Pearson, 2010.
3. Greenwood, N. N. & Earnshaw, A., *Chemistry of the Elements*, 2nd Ed., Elsevier India, 2010.
4. Bruice, P. Y. *Organic Chemistry*, 8th Ed., Pearson Education, 2015.
5. Solomons, T. W. G., Fryhle, C. B. & Snyder, S. A. *Organic Chemistry*, 12th Ed., Wiley, 2016.
6. Morrison, R. T., Boyd, R. N. & Bhattacharjee, S. K. *Organic Chemistry*, 7th Ed., Pearson Education India, 2011.
7. Atkins, P. W & Paula, J. D. *Physical Chemistry*, 9th Ed., Oxford University Press, 2011.
8. Kapoor, K. L. *A Textbook of Physical Chemistry (Volume 2&5)*, McGraw Hill Education; 5th Ed., 2017.
9. Puri, B. R., Sharma, L. R., Pathania, M. S. *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing Co., 2017.

Practical:

1. Mendham, J. et al.: *Vogel's Text Book of Quantitative Chemical Analysis*; 6th Ed. Pearson Education, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co., 2011.
3. Vogel, A. I. *Elementary Practical Organic Chemistry: Small Scale Preparations Part 1*, 2nd Ed., Pearson, 2010.
4. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: General Chemistry-VI

COURSE CODE: CH- MN - 6214

Total Credits: 4 (Theory: 3 + Practical/Tutorial: 1)

THEORY

Total Lectures: 45

Course Objective:

This course is aimed to introduce the students to the chemistry of organometallic compounds and learn the theoretical principles of qualitative inorganic analysis. This course is intended to enlighten the students about different classes of organic compounds like amines, diazonium salts, and derivatives of carboxylic acid. The course also introduces the students to physical aspects of surface phenomena and catalysis

Course Learning Outcome:

CLO 1: *The students will grasp the concept of organometallic compounds and acquire knowledge of principles governing inorganic qualitative analysis. Through this course, they will develop skills in both qualitative and quantitative chemical analysis, enabling them to effectively identify and understand various inorganic salts.*

CLO 2: *The students are expected to learn the preparation and reactions of organic compounds such as amines, diazonium salts, acid chlorides, esters, anhydrides and amides. The students will learn to conduct quantitative chemical analysis of organic compounds by titrimetric methods.*

CLO 3: *The students will be able to understand various surface adsorptions process and learn about catalysis. The students will also understand the physical phenomena of surface tension & its effects on solutions and reaction kinetics of catalytic systems.*

Unit 1: Inorganic Chemistry

Organometallic Chemistry – I (8 Lectures)

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rules, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.

Theoretical Concept of Qualitative Analysis (7 Lecture)

General idea about the qualitative analysis of ions; ionic product, solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents, interfering anions.

Unit 2: Organic Chemistry

Carboxylic acid derivatives (7 Lectures)

(Aliphatic: Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines (6 Lectures)

Aliphatic and aromatic amines: (Upto 5 carbons)

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, and Hofmann Bromamide reaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten-Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts (arene):(2 Lectures)

Preparation: from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

Unit 3: Physical Chemistry

Surface Chemistry (6 Lectures)

Physical adsorption, chemisorption, adsorption isotherms, nature of adsorbed state.

Catalysis (9 Lectures)

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.

Practical:

Total Lectures: 30

Inorganic Qualitative Analysis

i. Qualitative semimicro analysis of mixtures containing 2 anions and 2 cations. The following radicals are suggested: NO_2^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, PO_4^{3-}, K^+, Pb^{2+}, Cu^{2+}, Fe^{3+}, Al^{3+}, Zn^{2+}, Mn^{2+}, Ba^{2+}, Ca^{2+}, Mg^{2+}.

ii. Mixtures should preferably contain one interfering anion.

iii. Spot tests should be done whenever possible.

Organic Quantitative Analysis

i. Estimation of amino acids using titrimetric methods.

ii. Estimation of sugars using titrimetric (redox) methods.

iii. Determination of saponification value of an oil or triglyceride.

RECOMMENDED BOOKS:

Theory:

1. Svelha, G. *Vogel's Qualitative Inorganic Analysis*, 7th Ed., Pearson Education, 2008. (Revised)
2. Bochmann, M. *Oxford Chemistry Primers: Organometallics (Volume 1)*, Oxford University Press, 1994.
3. Weller, M., Armstrong, F., Rourke, J. & Overton, T., *Inorganic Chemistry* 6th Ed. 2015.
4. Morrison, R. T., Boyd, R. N. & Bhattacharjee, S. K. *Organic Chemistry*, 7th Ed., Pearson Education India, 2011.
5. Bruice, P. Y. *Organic Chemistry*, 8th Ed., Pearson Education, 2015.

6. Atkins, P. W & Paula, J. D. *Physical Chemistry*, 9th Ed., Oxford University Press, 2011.
7. Kapoor, K. L. *A Textbook of Physical Chemistry (Volume 5)*, McGraw Hill Education; 5th Ed., 2017.
8. Puri, B. R., Sharma, L. R., Pathania, M. S. *Principles of Physical Chemistry*, 47th Ed., Vishal Publishing Co., 2017.

Practical:

1. Svelha, G. *Vogel's Qualitative Inorganic Analysis*, 7th Ed., Pearson Education, 2008. (Revised)
2. Ahluwalia, V. K. & Aggarwal R. *Comprehensive Practical Organic Chemistry: Preparation & Quantitative Analysis,* University Press, 2000.
3. Yadav, J. B. *Advanced Practical Physical Chemistry*, 36th Ed., Krishna Prakashan, 2016.
4. Barua, S. *A Textbook of Practical Chemistry*, Kalyani Publishers, 2016.

COURSE NAME: General Chemistry-VII

Paper Code: CH-MN-7214 (Minor)

Total Credit: 4 (Theory: 3 + Practical: 1)

Theory: 3 credits

Total Lectures: 45

Course Objective:

The objective of this course is to aware students on the detail of organometallic chemistry and its industrial application and inorganic UV-Vis spectra. Moreover, the present course also enables students towards chemistry of natural products and basics of nanoscience and kinetics of polymers.

Course Learning Outcome:

CLO-1: *By studying this course student can able to determine the structure of metal-carbonyls, bond order of metal-carbonyls from IR spectra and also know about many important industrial transformations. They will also understand the various spectral analysis of inorganic compounds, know important synthetic methods and chemical reactions of terpenes and alkaloids and also get aware of various actions of therapeutic drug and understand the concept of basics of kinetics of polymer and nanotechnology.*

CLO-2: *Students can able to have hands on training on various coordination complex preparations, synthesis of medicinally important compounds, nanoparticle synthesis its characterization and molecular weight determination of polymer.*

Unit I: Coordination Chemistry–III (6 Lectures)

Molecular orbital (MO) theory of selected octahedral, tetrahedral complexes and other geometries.

d-d transition, charge transfer transition, color, intensity and origin of spectra, interpretation, term symbols and splitting of terms different geometries, selection rules for electronic transitions, correlation.

Unit II: Organometallic Compounds-II (5 Lectures)

Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni -acceptor behaviour of CO (MO diagram of CO to be discussed), synergicπusing VBT. effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Unit III: Transition Metals in Catalysis (4 Lectures)

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Wacker Process
3. Synthetic gasoline (Fischer-Tropsch reaction)

Unit IV: Chemistry of Natural Products (10 Lectures)

Terpenes: Occurrence, classifications, isoprene rule, special isoprene rule. Structure elucidation and synthesis of citral and α-terpeneol. Biosynthesis of limonene and pinene.

Alkaloids: Natural occurrence, general structural features, isolation and their physiological action, Hoffmann's exhaustive methylation, Emde's modification, structure elucidation and synthesis of nicotine.

Unit V: Medicinal Chemistry (5 Lectures)

Drugs and their classifications, Drug-Target interaction. Therapeutic action of antacids, antibiotics, analgesics, sulpha drugs, tranquilizers and antihistamines.

Unit VI: Polymer (8 Lectures)

Molecular weight of polymers, determination of molecular weights, kinetics of polymerization reaction, copolymerization, average dimension of polymer molecules.

Unit VII: Introduction to nanoscience and nanotechnology (7 Lectures)

History of nanoscience, definition and classification of nanomaterial, shape and structures of nanomaterials, synthesis of nanomaterials.

Practical: **1 Credit**

Total Lectures: 15

(Students have to perform any five of the experiments mentioned below)

1. Solid phase synthesis of coordination compounds (*e.g.* Reinecke salt, trans-bisglycinatocopper (II)) and their properties.
2. Isomerism in coordination compounds. *e.g.* conversion of chloropentamminecobalt(III) chloride to nitro and nitroso isomers, *cis*- and *trans*-dichlorobis(ethylenediamine)cobalt(III) chloride etc.
3. Preparation of Antacid.
4. Synthesis of paracetamol
5. Isolation and estimation of the content of aspirin in a commercial tablet.
6. Preparation and characterization by UV-Vis spectroscopy of nanoparticles of zinc using tea leaves/silver nanoparticles using plant extracts.
7. Determination the molar mass of a polymer by viscometric method.

Recommended Books:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, Fifth Edition, Pearson.
3. Finar, I.L., (2012), Organic Chemistry Volume 2, 6th Edition, Pearson Education.
4. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), Principles of Biochemistry. W.H.Freeman and Co., International Edition.
5. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition,Oxford University Press.
6. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India

COURSE NAME: General Chemistry-VIII

COURSE CODE: CH-MN-8214

Total Credits: 4 (Theory: 3 + Practical: 1)

Theory: 3 credits

Total Lectures: 45

Course Objective: *The objective of this course is to aware students on the detail of inorganic reaction mechanism and bioinorganic chemistry. Moreover, the present course also enables students towards chemistry of amino acids, proteins and carbohydrates and application of quantum chemistry toward spectroscopy.*

Course Learning Outcome:

CLO-1: *By studying this course student can able to understand various mechanistic pathways for inorganic reactions, also understand the importance of various metal ions in biological systems, can be able to know important synthetic methods and chemical reactions of amino acids and also become aware of various classification of proteins and structure determination. Students will understand the concept of quantization and various spectroscopic techniques and its corresponding selection rules for transitions.*

CLO-2: *Students can able to have hands on training on quantitative determination of metals in alloys and various food sample, practical application of chromatography and UV-Vis spectroscopy for Lambert-Beer laws validation.*

Unit I: Inorganic Reaction Mechanisms (7 Lectures)

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Kinetics of octahedral substitution, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes. Electron transfer reactions.

Unit II: Bioinorganic Chemistry (8 Lectures)

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

Unit III: Amino Acids, Peptides and Proteins (9 Lectures)

Strecker synthesis using Gabriel's phthalimide synthesis. Zwitter ion, Isoelectric point and electrophoresis. Reaction of Amino acids: ester of -COOH group, acetylation of $-NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides by degradation: Edman degradation (N-terminal), C-terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection and C-activation groups and Merrifield solid-phase synthesis.

Unit IV: Carbohydrates (6 Lectures)

Classification and General properties, Glucose and Fructose (open and cyclic structures), Determination of configuration of monosaccharides, absolute configuration of glucose and fructose, mutarotation. Structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose).

Unit V: Spectroscopy (15 Lectures)

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.

Rotation spectroscopy: Diatomic molecules, Selection rules, intensities of spectral lines, determination of bond lengths of diatomic molecules, isotopic substitution.

Infrared and Raman spectroscopy: Classical equation of vibration, vibrational energies of diatomic molecules, zero-point energy, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, effect of isotopic substitution, fundamental frequencies, overtones, hot bands.

Electronic spectroscopy: Frank-Condon Principle, electronic transitions, concept of singlet and triplet states, Selection rule for electronic transition in case of atomic spectroscopy and molecular spectroscopy, fluorescence and phosphorescence.

Practical: **1 credit**

Total Lecture: 15

1. Quantitative analysis (binary mixture, alloy, ore) - Ca-Mg ore, Cu-Zn alloy, Pb-Sn alloy, Ni in an alloy etc.
2. Estimation of glucose by using Fehling solution.
3. Estimation of glycine by volumetric analysis.
4. Separation and identification of mixture of Amino acids by paper chromatography.
5. Verify Lambert-Beer's law and determine the concentration of (i) $CuSO_4$ (ii) $KMnO_4$ (iii) $K_2Cr_2O_7$ in a solution of unknown concentration using UV-Vis Spectrophotometer

Recommended Books:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), Inorganic Chemistry, Fifth Edition, Pearson.
3. Finar, I.L., (2012), Organic Chemistry Volume 2, 6th Edition, Pearson Education.

4. Nelson, D.L., Cox, M.M., Lehninger, A.L. (2017), Principles of Biochemistry. W.H.Freeman and Co., International Edition.
5. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition,Oxford University Press.
6. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India

SKILL ENHANCEMENT COURSE (SEC)

Programme Specific Outcome of Bachelor of Science – Chemistry (Skill Enhancement Course)

PSO No.	Name	Outcome
PSO–1	Basic Understanding	The learner will able to gain basic ideas about the organic, inorganic, physical chemistry and analytical chemistry.
PSO–2	Collective Effort	The learner will learn to complete common tasks or achieve common goals in an effective way through collaborative manner.
PSO–3	Skill Enhancement	The learner will develop practical skills to work/ or to develop start-ups in different industrial fields like chemical, pharmaceutical, polymer, glass blowing, agro industry and others related to chemical sciences.
PSO–4	Competency for Competitive Examinations	The learners will gain the confident to face the competitive exams like CUET, PGUET, JAM, NET, GATE, SLET, GRE, TOEFL, Civil services, etc.
PSO–5	Ethical Analysis	The learner will learn to make legitimate evidence based-decision making in a particular context, especially through the concepts of IPR like Patent, copyright, plagiarism, etc.

Basic Syllabus Structure of SEC

Semester	Course Name	Course code
1	Basic Analytical Chemistry-I	CH – SE – 1113
2	Basic Analytical Chemistry-II	CH – SE – 2113
3	Analytical Bio-chemistry	CH – SE – 3213

Course Learning Outcome – Skill Enhancement Course (SEC)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	Basic Analytical Chemistry-I CH-SE-1113	CLO-01	The students will learn about the basic principles of chemical analysis, design/implement small-scale experiments and data analysis.
		CLO-02	The students are expected to develop skill in using spectrophotometric instruments and perform analysis of soil and edible items.
2	Basic Analytical Chemistry-II CH-SE-2113	CLO-01	The students will get the basic understanding of chromatographic techniques and learn about analysis of cosmetics.
		CLO-02	The students are expected to develop skill in performing chromatographic separations and special experiments like use of phenolphthalein in trap cases.
3	Analytical Biochemistry CH-SE-3213	CLO-01	The students will get apprised with various important biomolecules, their structures and physiological roles. Students will also gain knowledge about analysis of pathological samples (blood and urine). They will also be introduced to knowledge of drugs and identify various drugs used for treatments different ailments and their physiological processes
		CLO-02	Students will learn about the quantitative and qualitative analysis of biomolecules and be able to synthesize drug compounds in laboratory.

Mapping of Course Learning Outcome and Programme Outcome

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	PROGRAMME OUTCOME										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
CH-SE-1113	CLO1	3	3	3	3	3	3	2	3	3	3	3
	CLO 2	3	3	3	3	3	3	2	3	3	3	3
CH-SE-2113	CLO1	3	3	3	3	3	3	1	3	2	3	3
	CLO 2	3	3	3	3	3	3	1	3	2	3	3
CH-SE-3213	CLO1	3	3	3	3	3	3	2	3	2	3	3
	CLO 2	3	3	3	3	3	3	2	3	2	3	3

Mapping of Course Learning Outcome and Programme Specific Outcome

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course code	CLO	Programme Specific Outcome (PSO)				
		PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CH-SE-1113	CLO 1	3	3	3	3	2
	CLO 2	3	3	3	3	2
CH-SE-2113	CLO 1	3	3	3	3	2
	CLO 2	3	3	3	3	2
CH-SE-3213	CLO 1	3	3	3	3	3
	CLO 2	3	3	3	3	3

COURSE NAME: Basic Analytical Chemistry-I

CourseCODE:CH-SE-1113

TotalCredits:3(Theory:2+Practical/Tutorial: 1)

THEORY: 2 Credits

TOTAL LECTURES: 30

Course Objective:

This course aims to familiarize students with different micro and semi-micro analytical techniques and develop the ability to use modern analytical methods for chemical analysis of food, soil, and water.

Course Learning Outcome:

CLO–01: *The students will learn about the basic principles of chemical analysis, design/implement' small-scale experiments and data analysis*.

CLO–02: *The students are expected to develop skill in using spectrophotometric instruments and perform analysis of soil and edible items*

Unit 1: Introduction to Analytical Chemistry (7 Lectures)

Concept of sampling, Importance of accuracy, precision and sources of error in analytical measurements, Presentation of experimental data and results.

Unit 2: Analysis of soil (8 Lectures)

Composition of soil, Concept of pH and pH measurement, Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration, Chelation, Chelating agents, use of indicators.

Unit 3: Analysis of water (8 Lectures)

Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

a. Determination of pH, acidity and alkalinity of a water sample.
b. Determination of dissolved oxygen (DO) of a water sample.
c. Determination of salinity, hardness and conductivity of a water sample.

Unit 4: Analysis of food products (7 Lectures)

Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
b. Analysis of preservatives and colouring matter.

Practical:

Total Lectures:30

1. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples.
2. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.
3. Spectrophotometric determination of Iron in Vitamin/Dietary Tablets.

RECOMMENDED BOOKS:

1. Vogel, A.I. *Vogel's Qualitative Inorganic Analysis* 7thEd., Prentice Hall.
2. Vogel, A.I. Vogel's *Quantitative Chemical Analysis* 6thEd., Prentice Hall.
3. Khopkar, S. M. *Basic Concepts of Analytical Chemistry,* 2ndEd.
4. Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry*, 9thEd., Brooks/Cole Cengage Learning.

COURSE NAME: Basic Analytical Chemistry-II

COURSE CODE: CH-SE-2113

Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)

THEORY

Total Lectures: 30

Course Objectives:

Thiscourseaimstoeducatestudentsonvariouschromatographicseparationtechnique utilized during micro and semi-micro analysis. The students will also learn about advanced chromatographic techniques and modern analytical methods for chemical analysis of cosmetics.

Course Learning Outcome:

CLO – 01: *The students will get the basic understanding of chromatographic techniques and learn about analysis of cosmetics.*

CLO – 02: *The students are expected to develop skill in performing chromatographic separations and special experiments like use of phenolphthalein in trap cases.*

Unit 1: Chromatography (8 Lectures)

Definition, general introduction on principles of chromatography, paper chromatography, Thin layer chromatography, etc.

a. Paper chromatographic separation of mixture of metal ion (Fe^{3+}andAl^{3+}).
b. To compare paint samples by TLC method.

Unit 2: Ion-exchange (7 Lectures)

Column chromatography, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

Unit 3: Analysis of cosmetics (15 Lectures)

Major and minor constituents and their function

a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Practical:

TotalLectures:30

1. To study the use of phenolphthalein in traps cases.
2. Separation of a mixture of metal ions by paper chromatography.
3. Separation of a mixture of organic compounds by thin layer or column chromatography.
4. Estimation of constituents in cosmetics: Zinc, Calcium, Magnesium in talcum powder.

RECOMMENDED BOOKS:

1. Vogel, A. I.*Vogel'sQualitativeInorganicAnalysis*7th Ed., Prentice Hall.
2. Vogel, A. I. Vogel's*QuantitativeChemicalAnalysis*6th Ed., Prentice Hall.
3. Khopkar, S. M. *Basic Concepts of Analytical Chemistry,*2nd Ed.
4. Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry*, 9th Ed., Brooks/Cole CengageLearning.

COURSE NAME: Analytical Bio-chemistry

COURSE CODE: CH-SE-3213

Total Credits: 3 (Theory: 2 + Practical/Tutorial: 1)

THEORY

Total Lectures: 30

Course Objectives:

This course is intended to apprise students with various important biomolecules, their structures and physiological roles. Students are also expected to learn the basics of analysis of pathological samples (blood and urine), and get introduced to the drugs, drugs for various diseases available in market, their physiological response and side effects.

Course Learning Outcome:

CLO 1: *The students will get apprised with various important biomolecules, their structures and physiological roles. Students will also gain knowledge about analysis of pathological samples (blood and urine). They will also be introduced to knowledge of drugs and identify various drugs used for treatments different ailments and their physiological processes.*

CLO 2: *Students will learn about the quantitative and qualitative analysis of biomolecules and be able to synthesize drug compounds in laboratory.*

Unit 1: Biomolecules (15 Lectures)

Carbohydrates: Biological importance of carbohydrates, classification, metabolism (qualitative idea), glycolysis, alcohol fermentation and lactic acid fermentation.

Proteins: Classification, biological importance; amino acids: classification of amino acids, biological importance, primary secondary, tertiary and quaternary structures of proteins: α helix and β- pleated sheets; isolation, characterization and denaturation of proteins.

Enzymes: Nomenclature, characteristics, classification, active site, mechanism of enzymeaction, effect of pH, temperature on enzyme activity, enzyme inhibitors, coenzymes and cofactors.

Lipids: Classification, biological importance of triglycerides, phosphoglycerides andcholesterol, lipid membrane.

Vitamins: Classification, biological importance, deficiency diseases.

Nucleic acids: Nucleobases, Nucleotides, DNA structure (Watson-Crick model) and RNA, biological roles of DNA and RNA.

Unit 2: Biochemistry of disease (8 Lectures)

Blood: Composition and functions of blood, blood coagulation, blood collection and preservation of samples, anemia, regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.

Urine: Collection and preservation of samples, formation of urine, composition and estimation of constituents of normal and pathological urine.

Unit 3: Drugs & Pharmaceuticals (7 Lectures)

Drug discovery, drugs and their classification, synthesis and physiological response of representative drugs of the following classes: analgesics (aspirin), antipyretic (paracetamol), anti-inflammatory (ibuprofen), antibiotics (chloramphenicol), antibacterial and antifungal (sulphanethoxazol, sulphacetamide, trimethoprim).

Practical:

Total Lectures: 30

Identification and estimation of the following:

i. Detection of carbohydrates.
ii. Determination of iodine number of oil.
iii. Isolation of Casein from milk.
iv. Detection of protein by the Biuret reaction.
v. Isolation of DNA from onion.
vi. Synthesis of Aspirin, Paracetamol, magnesium bisilicate (antacid).
vii. Determination of pH of antacids.

RECOMMENDED BOOKS:

1. Nelson, D. L. and Cox, M. M., Lehninger's Principles of Biochemistry, Macmillan Higher Education, 2017.
2. T.G. Cooper: Tool of Biochemistry, Wiley, 2007.
3. Devlin, T. M., Textbook of Biochemistry with Clinical Correlations, John Wiley & Sons, 2010.
4. Talwar, G. P. and Srivastava, M., Textbook of Biochemistry and Human Biology, PHI Learning, 2002.
5. Patrick, G. L., An Introduction to Medicinal Chemistry, Oxford UniversityPress, 2009.
6. Thomas, G. Fundamentals of Medicinal Chemistry, Wiley, 2003.
7. Singh, H., Kapoor, V. K. Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, 1996

INTER-DISCIPLINARY COURSE (IDC)

Programme Specific Outcome of Bachelor of Science – Chemistry (IDC)

PSO No.	Name	Outcome
PSO–1	Basic Understanding	The learner will able to gain basics of chemistry.
PSO–2	Skill Enhancement	The learner will learn about skills to work/ or to develop start-ups in different industrial fields like chemical, pharmaceutical, polymer, glass blowing, agro industry and others related to chemical sciences.
PSO–3	Competency for Competitive Examinations	The learners will gain the confident to face the competitive exams like CUET, PGUET, JAM, NET, GATE, SLET, GRE, TOEFL, Civil services, etc.
PSO–4	Ethical Analysis	The learner will learn to make legitimate evidence based-decision making in a particular context.

Basic Syllabus Structure of IDC

Semester	Course Name	Course Code
1	Chemistry in Practical Life-I	CH-ID-1113
2	Chemistry in Practical Life-II	CH-ID-2113
3	Basic Concepts in Chemistry	CH-ID-3213

Course Learning Outcome (CLO)

Semester	Course Name & Code	Course Learning Outcome (CLO)	
1	Chemistry in Practical Life-I CH-ID-1113	CLO-01	Upon completing this course, students will gain an appreciation for the practical applications of chemistry.
		CLO-02	They will recognize how chemistry plays a crucial role in addressing numerous challenges and enhancing various aspects of daily life.
2	Chemistry in Practical Life-II CH-ID-2113	CLO-01	Upon finishing this course, students will develop an awareness of the practical significance of chemistry.
		CLO-02	They will discern how chemistry influences and enhances various aspects of everyday existence.
3	Basic Concepts in Chemistry CH-ID-3213	CLO-01	In this course, students will grasp the fundamental principles of chemistry while acquiring proficiency in basic analytical techniques.
		CLO-02	The understanding of green chemistry concepts empowers individuals to make informed decisions that prioritize environmental conservation and contribute to a more sustainable future.

Mapping of Course Learning Outcome (CLO) and Programme Outcome (PO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	Programme Outcome (PO)										
		SPO-1	SPO-2	SPO-3	SPO-4	SPO-5	SPO-6	SPO-7	SPO-8	SPO-9	SPO-10	SPO-11
CH-ID-1113	CLO - 1	3	2	2	1	3	3	3	3	2	3	3
	CLO - 2	3	3	2	1	3	3	2	3	2	3	3
CH-ID-2113	CLO - 1	3	3	3	2	3	3	3	3	2	3	3
	CLO - 2	3	3	3	2	3	3	3	3	2	3	3
CH-ID-3213	CLO - 1	3	3	3	2	3	3	3	3	3	3	3
	CLO - 2	3	3	3	2	3	3	3	3	3	3	3

Mapping of Course Learning Outcome (CLO) and Programme Specific Outcome (PSO)

Attributes: Co-relation Levels

"1" : Minimum Co-relation
"2" : Moderate Co-relation
"3" : Maximum Co-relation
"-" : No Co-relation

Course Code	CLO	Programme Specific Outcome (PSO)			
		PSO–1	PSO-2	PSO–3	PSO–4
CH-ID-1113	CLO-1	3	2	3	3
	CLO - 2	3	2	3	3
CH-ID-2113	CLO-1	3	2	3	3
	CLO - 2	3	2	3	3
CH-ID-3213	CLO-1	3	2	3	3
	CLO - 2	3	2	3	3

COURSE NAME: Chemistry in Practical Life-I

COURSE CODE: CH – ID – 1113

TOTAL CREDITS: 3 (Theory: 3)

THEORY

Total Lectures - 45

Course Objective:

This course aims to familiarize students with the relevance of chemistry in everyday life.

Course Learning Outcome:

CLO–01: *Upon completing this course, students will gain an appreciation for the practical applications of chemistry.*

CLO – 02: *They will recognize how chemistry plays a crucial role in addressing numerous challenges and enhancing various aspects of daily life*

Unit 1: Some basic concepts of Chemistry (5 Lectures)

Matter and its classification, Atomic and Molecular mass, Fundamental particles (electron, proton, neutron), Atomic number and Mass number, Isotope, Isobar, Isotone, Isotopes of hydrogen

Unit 2: Acid, base and salts (5 Lectures)

Strong and weak electrolytes, Theories of Acid, Introduction top H-scale, pH of some common fruits, soft drinks, etc.

Unit 3: Water (8 Lectures)

Water-Hard water and soft water, Removal of hardness of water, water pollution, water purification, Rain-water harvesting.

Unit 4: Energy sources (5 Lectures)

Primary and Secondary batteries (Lead-acid storage battery, Li-ion battery), Fuel cells, Biofuels

Unit 5: Molecules of Life (9 Lectures)

Carbohydrates, Proteins, Vitamins, Nucleic acid (DNA and RNA)

Unit 6: Polymers (8 Lectures)

Classification of polymers, Some important polymer and its uses-Polyethene, Teflon, PVC, Polyester, Nylon, Rubber, Bakelite, Biodegradable polymers.

Unit 7: Chemistry in Everyday Life (5 Lectures)

Drugs and it classification, Artificial sweeteners, Food preservatives, Soaps and detergents**.**

COURSE NAME: Chemistry in Practical Life-II

COURSE CODE: CH – ID – 2113

TOTAL CREDITS: 3 (Theory: 3)

THEORY

Total Lectures - 45

Course Objective:

This course aims to familiarize students with the relevance of chemistry in everyday life.

Course Learning Outcome:

CLO–01: *Upon finishing this course, students will develop an awareness of the practical significance of chemistry.*

CLO–02: *They will discern how chemistry influences and enhances various aspects of everyday existence.*

Unit 1: Enzymes and Catalysis (5 Lectures)

Homogeneous and Heterogeneous catalysis, Enzymes, Catalyst, Inhibitor, Poison.

Unit 2: Ores and Alloys (5 Lectures)

Ores and its types, Alloys and its uses.

Unit 3: Introduction to elements (7 Lectures)

Groups, Periods, Metals, Non-metals and Metalloids, Uses of some elements in day-to-day life (Sodium, Silver, Gold, Platinum, Copper, Tin, Magnesium, Iron etc.), Adverse effect of some elements (Arsenic, Fluorine, Cadmium, Lead, etc.)

Unit 4: Hydrocarbon (7 Lectures)

Introduction to Alkane, Alkene, Alkyne. Aromatic hydrocarbon-benzene, Introduction to petrol, diesel, kerosene, naphtha, coal tar, CNG, LPG, PNG etc.

Unit 5: Solid State (4 Lectures)

Crystalline and Amorphous, Conductor and Insulator, Magnetic properties (Diamagnetic and paramagnetic).

Unit 6: Solution (4 Lectures)

Types of solution-Homogeneous and Heterogeneous, Solubility of gas in liquid, Osmosis.

Unit 7: Environmental Chemistry (6 Lectures)

Ozone layer and ozone layer depletion, Greenhouse gases, fog, Acid rain, Air pollution.

Unit 8: Common Chemicals in Daily Life (7 Lectures)

Bleaching powder, baking soda, ammonium sulfate, plaster of Paris, washing soda, glass, cement, etc.

COURSE NAME: Basic Concepts in Chemistry

COURSE CODE: CH – ID – 3213

TOTAL CREDITS: 3 (Theory: 3)

THEORY

Total Lectures - 45

Course Objective:

This course aims to familiarize students with the basic chemistry ideals like atomic structure, mole concept, gaseous laws, and properties of solutions as well as some basic analytical techniques like chromatography and green chemistry concepts.

Course Learning Outcome:

CLO 1: *In this course, students will grasp the fundamental principles of chemistry while acquiring proficiency in basic analytical techniques.*

CLO 2: *The understanding of green chemistry concepts empowers individuals to make informed decisions that prioritize environmental conservation and contribute to a more sustainable future.*

Unit 1: Atomic Structure (10 Lectures)

Sub-atomic particles, Thomson's model, Rutherford's atomic model, Bohr's model of atom, Einstein's photoelectric effect, de Broglie relationship.

Unit 2: Mole concept (10 Lectures)

Mole and molar masses, Mass percent, Mole fraction, Molarity, Molality, Normality.

Unit 3: Gaseous laws (8 Lectures)

Charles's law, Boyle's law, Gay-Lussac's law, Avogadro's law, Ideal gas equation, Real gas equation (concept only).

Unit 4: Physical properties of solutions (7 Lectures)

Density, Surface tension, Viscosity, Conductivity, Refractive index.

Unit 5: Basic analytical techniques (6 Lectures)

Thin layer chromatography (TLC), Paper chromatography.

Unit 6: Green chemistry (4 Lectures)

Twelve Principles of green chemistry.

RECOMMENDED BOOKS:

1. Ball, D. W. *Introductory Chemistry*, Saylor Foundation, 2012**.**
2. Khopkar, S. M. *Basic Concepts of Analytical Chemistry*, 4th Ed. New Age International, 2020.
3. Dey, S. P. &Sepay, N. *A Textbook of Green Chemistry*, Techno World, 2022.