DEPARTMENT OF CHEMISTRY

SYLLABUS FOR FOUR YEAR UNDERGRADUATE PROGRAMME (FYUGP)

(FIRST– SIXTH SEMESTER)

Approved by Academic Council vide Resolution no. AC – 03/2024/05 Dated: 04 – 05 – 24

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 for a 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 is 160.

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	MN-3214	SE-3213	ID-3213	AE-3212	-	-
		CE-3224						
IV		CE-4214	MN-4214	-	-	AE-4212	-	IN-4212
		CE-4224						
		CE-4234						
V		CE-5314	MN-5214	-	-	-	-	-
		CE-5324						
		CE-5334						
		CE-5344						
VI		CE-6314	MN-6214	-	-	-	-	-
		CE-6324						
		CE-6334						
		CE-6344						
VII		CE-7414	MN-7314	-	-	-	-	-
		CE-7424						
		CE-7434						
		CE-7444						
VIII		CE-8414	MN-8314	-	-	-	-	-
		CE-8424**						
		CE-8434**						
		CE-8444**						

****Students who secure more than 7.5 CGPA at the end of third year (6th semester) may opt for a research dissertation of 12 credits instead of the three core papers.**

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
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	2 x 2	--	20
SECOND	1 x 4	1 x 4	1 x 3	1 x 2	1 x 3	2 x 2	--	20
THIRD	2 x 4	1 x 4	1 x 3	1 x 2	1 x 3	--	--	20
FOURTH	3 x 4	1 x 4	--	1 x 2	--	--	1 x 2	20
FIFTH	4 x 4	1 x 4	--	--	--	--	--	20
SIXTH	4 x 4	1 x 4	--	--	--	--	--	20
SEVENTH	4 x 4	1 x 4	--	--	--	--	--	20
EIGHT	4 x 4	1 x 4	--	--	--	--	--	20

SEC: SKILL ENHANCEMENT COURSE

AEC: ABILITY ENHANCEMENT COURSE

IDC: INTERDISCIPLINARY COURSE

VAC/FC: VALUE ADDED COURSE

IN: INTERNSHIP

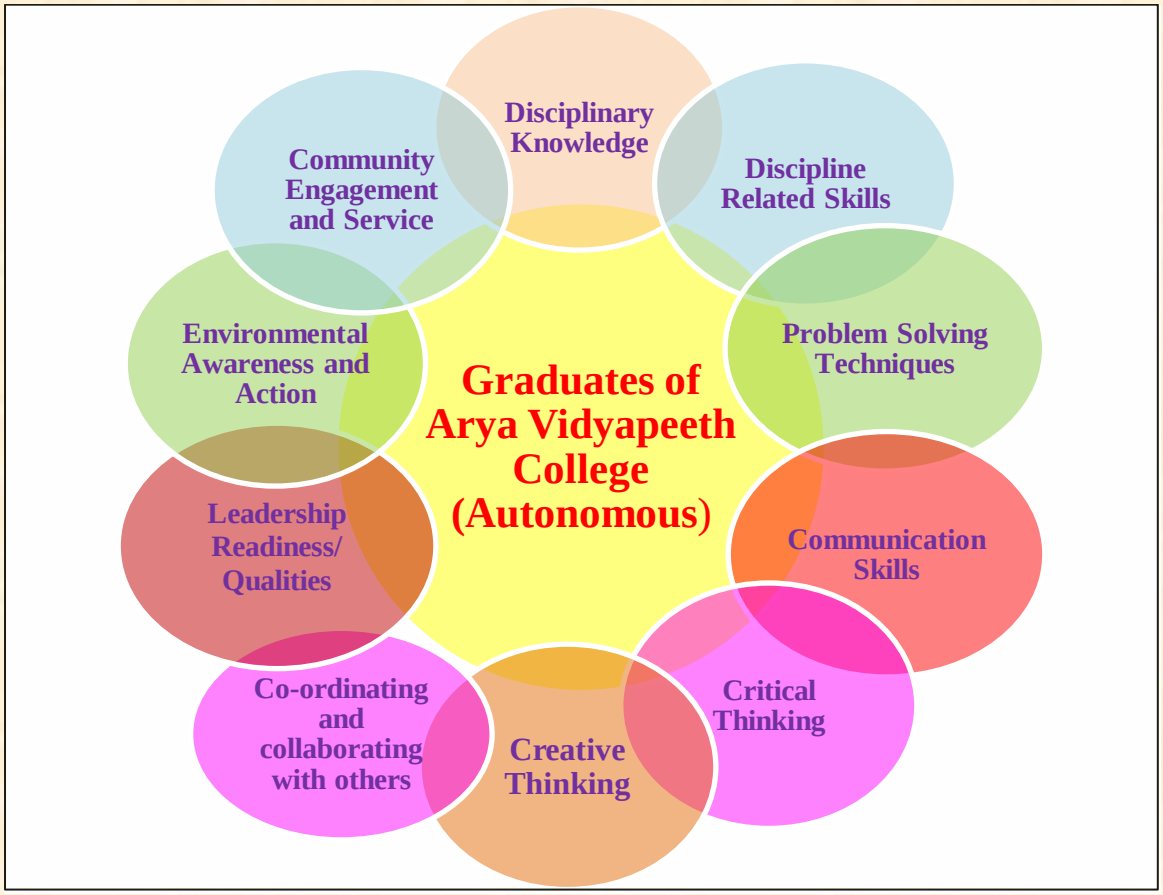
Abbreviation of Course Components:

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-2 Problem Analyses**: Well equipped with an understanding of the analytical methods involved, they are in a position to interpret and analyze 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 analyze 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,

economical 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-8 Environment 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 analyze 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-11 Life-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

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 analyze, 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 fundamentals 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, organo metallic 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 ligand substitution 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.

MAPPING OF PROGRAME 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

MAPPING OF PROGRAME 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

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 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 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 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*

Unit 1: Inorganic Chemistry

Chemical Bonding – I: (3 Lectures)

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

ii. Covalent bond: Lewis structure, Formal charge.

iii. Concepts of hybridization involving *s, p* &*d* orbitals, equivalent and non-equivalent hybridorbitals. 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 oxidationstates (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).

Stereochemistry 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 upto two C=C systems).

Unit 3: Physical Chemistry:

Solids: (4 Lectures)

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 thermo chemistry. 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 thermo chemical data. Variation of enthalpy of a reaction with temperature–Kirchhoff's equation. Adiabatic 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 wave functions 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, conceptof 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. An 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.; 47th Ed., 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. *AnGuide 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 analyze 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*, 5th Ed.,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 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 iodometrically.

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 & Atkins Inorganic 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 weak and 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*, 5th Ed.,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 rule, 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- and t-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 p$K_a$values of indicators using spectrophotometry.

iii. Determination of a mixture of Co and Ni from UV-Vis 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, 9th Ed., 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'sPrinciples 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 of Practical 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 myoblobin.

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.

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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 analyze 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 thermosoftening (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 & AtkinsInorganic 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 andRiegel's Handbook of Industrial Chemistry and Biotechnology*, 11th Ed., Springer, 2007.
7. Sharma, B. K. *Industrial Chemistry includingChemical 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.

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

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.

Mapping of Programe 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

Mapping of Programe 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

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 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
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 & 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

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 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*

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 structure, Formal charge.

iii. Concepts of hybridization involving *s, p* &*d* orbitals, equivalent and non-equivalent hybridorbitals. 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 oxidationstates (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).

Stereochemistry 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 upto two C=C systems).

Unit 3: Physical Chemistry:

Solids: (4 Lectures)

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 thermo chemistry. 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 thermo chemical data. Variation of enthalpy of a reaction with temperature–Kirchhoff's equation. Adiabatic 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 - 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 between Gibbs free energy of reaction and reaction quotient. 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 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. 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. 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 inter halogens, 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)

Inter halogen compounds, noble gas compounds- xenon oxides and fluorides.

Inorganic Chain, Rings and Cage Compounds (7 Lectures)

Alumino silicates, 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 boundarymethods. Ionic mobility. Applications of conductance measurements: determination of degreeof 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 rule, 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.

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	CLO 1	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	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-SE-3213	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 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

Course CODE: CH-SE-1113

Total Credits: 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 andadulteration.

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. Spectro photometric 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* 7th Ed., Prentice Hall.
2. Vogel, A. I. Vogel's *Quantitative Chemical Analysis* 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 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:

This course aims to educate students on various chromatographic separation technique 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 ($Fe^{3+}$and Al^{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:

Total Lectures: 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's Qualitative Inorganic Analysis* 7th Ed., Prentice Hall.
2. Vogel, A. I. Vogel's *Quantitative Chemical Analysis* 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 Cengage Learning.

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 enzyme action, effect of pH, temperature on enzyme activity, enzyme inhibitors, coenzymes and cofactors.

Lipids: Classification, biological importance of triglycerides, phosphoglycerides and cholesterol, 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'sPrinciples 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 University Press, 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 to pH-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 today life(Sodium, Silver, Gold, Platinum, Copper, Tin, Magnesium, Iron etc.), Adverse effect of someelements (Arsenic, Fluorine, Cadmium, Lead etc.)

Unit 4: Hydrocarbon (7 Lectures)

Introduction to Alkane, Alkene, Alkyne.Aromatic hydrocarbon-benzene, Introduction topetrol, diesel, kersone, naptha, 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, Green house 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.