GANGADHAR MEHER UNIVERSITY
SAMBALPUR, ODISHA

UNDER GRADUATE PROGRAMME
IN
CHEMISTRY
(Three/Four Year Degree Course)
(With Multiple Entry/Exit Option)
Based on NEP-2020

APPLICABLE FOR THE UG STUDENTS REGISTERED IN THE ACADEMIC YEAR 2024-25 AND ONWARDS.

SCHOOL OF CHEMISTRY

VISION

Chemists are spearheading an extraordinary molecular revolution that will change science as a whole and the world as we know it. We may now "see and explore" these hitherto unobservable scientific frontiers with atomistic resolution thanks to chemistry, the fundamental molecular science. Modern technology allows for the creation, modification, simulation, and analysis of molecules that have existed for centuries. Additionally, we can create and research exciting new ideas. With this commitment to ensure quality education in Chemistry and allied fields, with a holistic approach towards a better life, environment, and society.

MISSION

M1: Promotes fundamentals of Chemistry through this 4-year UG course by usingstate-of-the-art laboratory, teaching, and research facilities.

M2: motivation towards innovation with quality research in chemical sciences.

M3: To provide excellent teachers, entrepreneurs, and innovative independent researchers.

M4: Become a nationally recognizedcentre for chemical sciences and establish state of art centralised research facility.

VALUES

- **Employability**
- **Collaboration**
- **Creativity**
- **Diverse perspective**
- **Entrepreneurship**
- **Informed practices**
- **Professionalism**

PROGRAM OUTCOMES

[PO.1]. Fundamental knowledge of chemical sciences and connected areas to compete in national/international level tests such as JAM, UGC-CSIR NET, and GATE.

[PO.2]. Exposure to high-end sophisticated instrument facilities with Hands-on Experience in research.

[PO.3]. With a skill set to become employable professionals while maintaining core human values like ethics, empathy, and the ultimate goal of becoming good citizens.

[PO.4]. Academic and Research skills including industry-oriented training

[PO.5]. Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

[PO.6]. Effective Communication: Speak, read, write, and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media, and technology.

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. Develop knowledge, understanding and expertise in their chosen field of chemical science.

[PSO.2]. Develop an understanding of eco-friendly chemical processes and impact of chemistry on health andenvironment.

[PSO.3]. Understand theoretical concepts of instruments that are commonly used in most chemistry fields as well asinterpret and use data generated in instrumental chemical analyses.

[PSO.4]. Provide opportunities to excel in academics, research or Industry

Table-I: Course structure

Semester	Course	Course Name	Credits	Total Marks
I	**Core-I(Paper-I)**	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	Core-I(Paper-II)	Fundamental Organic Chemistry	**04**	
	Core-II (Paper-I)*	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	MDC-I	Biochemistry	**03**	
	AEC	Odia	**04**	
	VAC	Environmental Studies and Disaster management	**03**	
			22	
II	**Core-I(Paper-III)**	States of matter, and Ionic equilibrium	**04**	
	Core-I(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Core-III(Paper-I)*	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	MDC-II	Environmental Chemistry	**03**	
	AEC	English	**04**	
	SEC-I	Computational Chemistry and Molecular Modelling	**03**	
			22	

Table-II: Course structure

Semester	Course	Course Name	Credits	Total Marks
I	**Core-I(Paper-I)**	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	Core-I(Paper-II)	Fundamental Organic Chemistry	**04**	
	Core-II (Paper-I)*	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	MDC-I	Biochemistry	**03**	
	AEC	Odia	**04**	
	VAC	Environmental Studies and Disaster management	**03**	
			22	
II	**Core-I(Paper-III)**	States of matter, and Ionic equilibrium	**04**	
	Core-I(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	

	Core-III(Paper-I)*	Atomic Structure, Periodicity of elements and Chemical Bonding	04	
	MDC-II	Environmental Chemistry	03	
	AEC	English	**04**	
	SEC-I	Computational Chemistry and Molecular Modelling	**03**	
			22	
III	**Core-I(Paper-V)**	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-I(Paper-VI)	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	Core-I(Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	Core-II (Paper-II)	Fundamental Organic Chemistry	**04**	
	MDC-III	Biophysical chemistry	**03**	
	VAC-I	Basic Nutrition & Food Chemistry	**03**	
			22	
IV	**Core-I(Paper-VIII)**	Coordination Chemistry, Chemistry of d- and f- block elements, Inorganic Reaction Mechanism and electron transfer reactions	**04**	
	Core-I(Paper-IX)	Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons	**04**	
	Core-I(Paper-X)	Conductance, electrochemistry, electrical properties of atoms and molecules	**04**	
	Core-III(Paper-II)	Fundamental Organic Chemistry	**04**	
	Community Engagement & Services/ Field work /Internship	CE/IP/FW	**04**	
			20	

Table-III:Course structure for Three Year Degree Course with Single Major and Two Minor

Semester	Course	Course Name	Credits	Total Marks
I	**Core-I(Paper-I)**	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	Core-I(Paper-II)	Fundamental Organic Chemistry	**04**	

	Core-II (Paper-I)	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	MDC-I	Biochemistry	**03**	
	AEC	Odia	**04**	
	VAC	Environmental Studies and Disaster management	**03**	
			22	
II	**Core-I(Paper-III)**	States of matter, and Ionic equilibrium	**04**	
	Core-I(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Core-III(Paper-I)	Atomic Structure, Periodicity of elements and Chemical Bonding	04	
	MDC-II	Environmental Chemistry	03	
	AEC	English	**04**	
	SEC-I	Computational Chemistry and Molecular Modelling	**03**	
			22	
III	**Core-I(Paper-V)**	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-I(Paper-VI)	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	Core-I(Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	Core-II (Paper-II)	Fundamental Organic Chemistry	**04**	
	MDC-III	Biophysical chemistry	**03**	
	VAC-I	Basic Nutrition & Food Chemistry	**03**	
			22	
IV	**Core-I(Paper-VIII)**	Coordination Chemistry, Chemistry of d- and f- block elements, Inorganic Reaction Mechanism and electron transfer reactions	**04**	
	Core-I(Paper-IX)	Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons	**04**	
	Core-I(Paper-X)	Conductance, electrochemistry, electrical properties of atoms and molecules	**04**	
	Core-III(Paper-II)	Fundamental Organic Chemistry	**04**	
	Community Engagement & Services/ Field work /Internship	CE/IP/FW	**04**	

			20	
V	**Core-I(Paper-XI)**	Organic Spectroscopy	**04**	
	Core-I(Paper-XII)	Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry	**04**	
	Core-I(Paper-XIII)	Chemistry of Organometallic compounds	**04**	
	Core-II(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	SEC-II	Cosmetic and pharmacological chemistry	**03**	
	VAC-II	Nanoscience and Nanotechnology	**03**	
			22	
VI	**Core-I(Paper-XIV)**	Analytical Methods of Chemistry	**04**	
	Core-I(Paper-XV)	Solid and porous materials, and magnetochemistry and power cells	**04**	
	Core-III(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	SEC-III	Corrosion and Prevention	**03**	
	VAC-III	Surfactant and detergents	**03**	
			18	

Table-IV: Course structure for Three Year Degree Course with Double Major

Semester	Course	Course Name	Credits	Total Marks
I	**Core-I(Paper-I)**	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	Core-I(Paper-II)	Fundamental Organic Chemistry	**04**	
	Core-II(Paper-I)	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	Core-II(Paper-II)	Fundamental Organic Chemistry	**04**	
	MDC-I	Biochemistry	**03**	
	AEC	Odia	**04**	
	VAC	Environmental Studies and Disaster management	**03**	
			26	
II	**Core-I(Paper-III)**	States of matter, and Ionic equilibrium	**04**	
	Core-I(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative	**04**	

		property		
	Core-II(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	Core-II(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	MDC-II	Environmental Chemistry	**03**	
	AEC	English	**04**	
	SEC-I	Computational Chemistry and Molecular Modelling	**03**	
			26	
III	**Core-I(Paper-V)**	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-I(Paper-VI)	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	Core-I(Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	Core-II(Paper-V)	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-II(Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	MDC-III	Biophysical chemistry	**03**	
	VAC-I	Basic Nutrition & Food Chemistry	**03**	
			26	
IV	**Core-I(Paper-VIII)**	Coordination Chemistry, Chemistry of d- and f- block elements, Inorganic Reaction Mechanism and electron transfer reactions	**04**	
	Core-I(Paper-IX)	Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons	**04**	
	Core-I(Paper-X)	Conductance, electrochemistry, electrical properties of atoms and molecules	**04**	
	Core-II(Paper-VIII)	Coordination Chemistry, Chemistry of d- and f- block elements, Inorganic Reaction Mechanism and electron transfer reactions	**04**	
	Core-II(Paper-X)	Conductance, electrochemistry, electrical properties of atoms and molecules	**04**	
	Community	CE/IP/FW	**04**	

	Engagement & Services/ Field work /Internship			
			24	
V	**Core-I(Paper-XI)**	Organic Spectroscopy	**04**	
	Core-I(Paper-XII)	Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry	**04**	
	Core-I(Paper-XIII)	Chemistry of Organometallic compounds	**04**	
	Core-II(Paper-XI)	Organic Spectroscopy	**04**	
	Core-II(Paper-XII)	Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry	**04**	
	SEC-II	Cosmetic and pharmacological chemistry	**03**	
	VAC-II	Nanoscience and Nanotechnology	**03**	
			26	
VI	**Core-I(Paper-XIV)**	Analytical Methods of Chemistry	**04**	
	Core-I(Paper-XV)	Solid and porous materials, and magnetochemistry and power cells	**04**	
	Core-II(Paper-XIV)	Analytical Methods of Chemistry	**04**	
	Core-II(Paper-XV)	Solid and porous materials, and magnetochemistry and power cells	**04**	
	SEC-III	Corrosion and Prevention	**03**	
	VAC-III	Surfactant and detergents	**03**	
			22	

Table-V: Course structure for 3 Year Degree Course with Three Core without Major

Semester	Course	Course Name	Credits	Total Marks
I	**Core-I(Paper-I)**	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	Core-II(Paper-I)	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	Core-III(Paper-I)	Atomic Structure, Periodicity of elements and Chemical Bonding	**04**	
	MDC-I	Biochemistry	**03**	
	AEC	Odia	**04**	

	VAC	Environmental Studies and Disaster management	**03**	
			22	
II	**Core-I(Paper-II)**	Fundamental Organic Chemistry	**04**	
	Core-II(Paper-II)	Fundamental Organic Chemistry	**04**	
	Core-III(Paper-II)	Fundamental Organic Chemistry	**04**	
	MDC-II	Environmental Chemistry	**03**	
	AEC	English	**04**	
	SEC-I	Computational Chemistry and Molecular Modelling	**03**	
			22	
III	**Core-I(Paper-III)**	States of matter, and Ionic equilibrium	**04**	
	Core-I(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Core-II(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	Core-III(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	MDC-III	Biophysical chemistry	**03**	
	VAC-I	Basic Nutrition and Food Chemistry	**03**	
			22	
IV	**Core-I(Paper-V)**	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-II(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Core-II(Paper-V)	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-III(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Community Engagement & Services/ Field work /Internship	CE/IP/FW	**04**	
			20	
V	**Core-I(Paper-VI)**	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	Core-II(Paper-VI)	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	Core-III(Paper-V)	Acids and Bases, Metallurgy,	**04**	

		Chemistry of main group elements		
	Core-III(Paper-VI)	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	SEC-II	Cosmetic and pharmacological chemistry	**03**	
	VAC-II	Nanoscience and Nanotechnology	**03**	
			22	
VI	**Core-I(Paper-VII)**	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	Core-II(Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	Core-III(Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	SEC-III	Corrosion and Prevention	**03**	
	VAC-III	Surfactants and Detergents	**03**	
			18	

Table-VI: Course structure for Fourth Year Hons. Without Research

Semester	Course	Course Name	Credits	Total Marks
I	**Core-I(Paper-I)**	Atomic Structure,Periodicity of elementsand Chemical Bonding	**04**	
	Core-I(Paper-II)	FundamentalOrganic Chemistry	**04**	
	Core-II (Paper-I)	Atomic Structure, Periodicity of elementsand Chemical Bonding	**04**	
	MDC-I	Biochemistry	**03**	
	AEC	Odia	**04**	
	VAC	Environmental Studies and Disaster management	**03**	
			22	
II	**Core-I (Paper-III)**	States of matter, and Ionic equilibrium	**04**	
	Core-I (Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Core-III (Paper-I)	Atomic Structure,Periodicity of elementsand Chemical Bonding	**04**	
	MDC-II	Environmental Chemistry	**03**	
	AEC	English	**04**	
	SEC-I	Computational Chemistry and Molecular Modelling	**03**	
			22	
III	**Core-I (Paper-V)**	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-I (Paper-VI)	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	Core-I (Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**03**	
	Core-II (Paper-II)	FundamentalOrganic Chemistry	**03**	
	MDC-III	Biophysical chemistry	**03**	
	VAC-I	Basic Nutrition and Food Chemistry	**03**	
			22	
IV	**Core-I(Paper-VIII)**	Coordination Chemistry, Chemistry of d- and f- block elements, Inorganic Reaction	**04**	

		Mechanism and electron transfer reactions		
	Core-I(Paper-IX)	Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons	**04**	
	Core-I(Paper-X)	Conductance, electrochemistry, electrical properties of atoms and molecules	**04**	
	Core-III(Paper-II)	FundamentalOrganic Chemistry	**04**	
	Community Engagement & Services/ Field work /Internship	CE/IP/FW	**04**	
			20	
V	**Core-I(Paper-XI)**	Organic Spectroscopy	**04**	
	Core-I(Paper-XII)	Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry	**04**	
	Core-I(Paper-XIII)	Chemistry of Organometallic compounds	**04**	
	Core-II(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	SEC-II	Cosmetic and pharmacological chemistry	**03**	
	VAC-II	Nanoscience and Nanotechnoogy	**03**	
			22	
VI	**Core-I(Paper-XIV)**	Analytical Methods of Chemistry	**04**	
	Core-I(Paper-XV)	Solid and porous materials, and magnetochemistry and power cells	**04**	
	Core-III(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	SEC-III	Cosmetic and pharmacological chemistry	**03**	
	VAC-III	Surfactant and detergents	**03**	
			18	
VII	**Core-I(Paper-XVI)**	Chemistry of Biomolecules	**04**	
	Core-I(Paper-XVII)	Polymer Chemistry	**04**	
	Core-I(Paper-XVIII)	Green Chemistry	**04**	

	Core-I(Paper-XIX)	Oxidation, Reduction, Reagents, Rearrangements and Name Reactions	**04**	
	Core-II(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
			20	
VIII	**Core-I(Paper-XX)**	Quantum chemistry & Statistical Thermodynamics	**04**	
	Core-I(Paper-XXI)	Chemical group theory, electronic spectra of metal complexes, and nuclear chemistry	**04**	
	Core-I(Paper-XXII)	Pericyclic reactions, Photochemistry and Retrosynthesis	**04**	
	Core-I(Paper-XXIII)	Research Methodology for Chemistry	**04**	
	Core-II(Paper-V)	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
			20	

Table-VII:Course structure for Fourth Year Hons. With Research

Semester	Course	Course Name	Credits	Total Marks
I	**Core-I(Paper-I)**	Atomic Structure,Periodicity of elementsand Chemical Bonding	**04**	
	Core-I(Paper-II)	FundamentalOrganic Chemistry	**04**	
	Core-II (Paper-I)	Atomic Structure, Periodicity of elementsand Chemical Bonding	**04**	
	MDC-I	Biochemistry	**03**	
	AEC	Odia	**04**	
	VAC	Environmental Studies and Disaster management	**3**	
			22	
II	**Core-I(Paper-III)**	States of matter, and Ionic equilibrium	**04**	
	Core-I(Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Core-III(Paper-I)	Atomic Structure, Periodicity of elementsand Chemical Bonding	**04**	
	MDC-II	Environmental Chemistry	**03**	
	AEC	English	**04**	

	SEC-I	Computational Chemistry and Molecular Modelling		
			22	
III	**Core-I(Paper-V)**	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
	Core-I(Paper-VI)	Chemistry of halogen, oxygen and sulphur containing organic compounds	**04**	
	Core-I(Paper-VII)	Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	**04**	
	Core-II (Paper-II)	FundamentalOrganic Chemistry	**04**	
	MDC-III	Biophysical chemistry	**03**	
	VAC-I	Basic Nutrition and Food Chemistry	**03**	
			22	
IV	**Core-I(Paper-VIII)**	Coordination Chemistry, Chemistry of d- and f- block elements, Inorganic Reaction Mechanism and electron transfer reactions	**04**	
	Core-I(Paper-IX)	Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons	**04**	
	Core-I(Paper-X)	Conductance, electrochemistry, electrical properties of atoms and molecules	**04**	
	Core-III(Paper-II)	FundamentalOrganic Chemistry	**04**	
	Community Engagement & Services/ Field work /Internship	CE/IP/FW	**04**	
			20	
V	**Core-I(Paper-XI)**	Organic Spectroscopy	**04**	
	Core-I(Paper-XII)	Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry	**04**	
	Core-I(Paper-XIII)	Chemistry of Organometallic compounds	**04**	
	Core-II(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	SEC-II	Cosmetic and pharmacological chemistry	**03**	
	VAC-II	NanoScience and Nanotechnology	**03**	

			22	
VI	**Core-I(Paper-XIV)**	Analytical Methods of Chemistry	**04**	
	Core-I(Paper-XV)	Solid and porous materials, and magnetochemistry and power cells	**04**	
	Core-III(Paper-III)	States of matter, and Ionic equilibrium	**04**	
	SEC-III	Corrosion and Prevention	**03**	
	VAC-III	Surfactant and Detergents	**03**	
			18	
VII	**Core-I(Paper-XVI)**	Chemistry of Biomolecules	**04**	
	Core-I(Paper-XX)	Quantum chemistry & Statistical Thermodynamics	**04**	
	Core-I(Paper-XXI)	Chemical group theory, electronic spectra of metal complexes, and nuclear chemistry	**04**	
	Core-II (Paper-IV)	Chemical thermodynamics, equilibrium, and Colligative property	**04**	
	Core-II (Paper-V)	Acids and Bases, Metallurgy, Chemistry of main group elements	**04**	
			20	
VIII	**Core-I(Paper-XXII)**	Pericyclic reactions, Photochemistry and Retrosynthesis	**04**	
	Core-I(Paper-XXIII)	Research Methodology for Chemistry	**04**	
	Community Engagement & Services/ Field work /Internship	**Research**	**12**	
			20	

<u>Table-I:</u> Structure for Certificate Courses: Exit after First Academic year

[(One academic year (First & Second Semesters and a Summer/ Vocational Course and Community Work)]

Semester	Core-I (credit)	Core-II (credit)	Core-III (credit)	MDC (credit)	AEC (credit)	SEC (credit)	VAC (credit)	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	Paper-I(4) Paper-II(4)	Paper-I(4)		Choose one from MDC basket (3)	Odia (4)		Environmental Studiesand Disastermanagement (3)		22
II	Paper-III(4) Paper-IV(4)		Paper-I(4)	Choose one from MDC basket (3)	English (4)	SEC-I (3)			22
Total	4x4=16	1X4=4	1X4=4	2x3=6	2x4=8	1X3=3	Choose one from VAC basket (3)		44
Vocational Course of 4 credits for Certificate									

Table-II: Structure for Diploma Certificate Course Exit after Second Academic year

[*Two academic years (First, Second, Third & Four Semesters and a Summer Vocational Course and Community Work)]*

Semester	Core-I (credit)	Core-II (credit)	Core-II I(credit)	MDC(credit)	AEC (credit)	SEC (credit)	VAC (credit)	Community Engagement& Services/ Field work /Internship	Total Minimum Credit
I	Paper-I(4) Paper-II(4)	Paper-I(4)		Choose one from MDC basket (3)	Odia (4)		Environmental Studiesand Disastermanagement (3)		22
II	Paper-III(4) Paper-IV(4)		Paper-I(4)	Choose one from MDC basket (3)	English (4)	SEC-I (3)			22
									44
III	Paper-V(4) Paper-VI(4) Paper-VII(4)	Paper-II(4)		Choose one from MDC basket (3)			Choose one from VAC basket (3)		22
IV	Paper-VIII(4) Paper-IX(4) Paper-X(4)		Paper-II(4)					CE/IP/FW (4)	20
									42
Total	10x4=40	2x4=8	2x4=8	3x3=9	2x4=8	1X3=3	2x3=6	1x2=4	86
Vocational Course of 4 credits for Diploma Certificate									

Table-III:Three Year Degree Course with Single Major and Two Minor

Semester	Core-I (credit)	Core-II (credit)	Core-III(credit)	MDC (credit)	AEC (credit)	SEC (credit)	VAC (credit)	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	Paper-I(4) Paper-II(4)	Paper-I(4)		Choose one from MDC basket (3)	Odia (4)		Environmental Studiesand Disastermanagement (3)		22
II	Paper-III(4) Paper-IV(4)		Paper-I(4)	Choose one from MDC basket (3)	English (4)	SEC-I (3)			22
									44
III	Paper-V(4) Paper-VI(4) Paper-VII(4)	Paper-II(4)		Choose one from MDC basket (3)			Choose one from VAC basket (3)		22
IV	Paper-VIII (4) Paper-IX (4) Paper-X(4)		Paper-II(4)					CE/IP/FW (4)	20
									42
V	Paper-XI (4) Paper-XII (4) Paper-XIII (4)	Paper-III (4)				SEC-II (3)	Choose one from VAC basket (3)		22
VI	Paper-XIV (4) Paper-XV (4)		Paper-III (4)			SEC III (3)	Choose one from VAC basket (3)		18
									40
Total	15X4=60	3X4=12	3X4=12	3X3=9	2X4=8	3x3=9	4x3=12	1x4=4	126

IncaseastudentoptsforNCCandclears‘C’certificateadditional16Creditshallbeawardedand total credit shallbe126+16 = 142Credit

Table-IV: Three Year Degree Course with Double Major

Semester	Core-I (credit)	Core-II (credit)	MDC (credit)	AEC (credit)	SEC (credit)	VAC (credit)	Community Engagement& Services/ Field work /Internship	Total Minimum Credit
I	Paper-I (4) Paper-II (4)	Paper-I (4) Paper-II (4)	Choose one from MDC basket (3)	Odia (4)		Environmental Studies andDisaster Management (3)		26
II	Paper-III (4) Paper-IV (4)	Paper-III (4) Paper-IV (4)	Choose one from MDC basket (3)	English (4)	SEC-I (3)			26
								52
III	Paper-V (4) Paper-VI (4) Paper-VII (4)	Paper-V(4) Paper-VII (4)	Choose one from MDC basket (3)			Choose one from VAC basket (3)		26
IV	Paper-VIII (4) Paper-IX (4) Paper-X (4)	Paper-VIII (4) Paper-X (4)					CE/IP/FW (4)	24
								50
V	Paper-XI (4) Paper-XII (4) Paper-XIII (4)	Paper-XI (4) Paper-XII (4)			SEC-II (3)	Choose one from VAC basket (3)		26
VI	Paper-XIV (4) Paper-XV (4)	Paper-XIV (4) Paper-XV(4)			SEC III (3)	Choose one from VAC basket (3)		22
								48
Total	15X4=60	12X4=48	3X3=9	2X4=8	3x3=9	4x3=12	1x4=4	150

Table-V: Three Year Degree Course with Three Core without Major

Semester	Core-I (credit)	Core-II (credit)	Core-III (credit)	MDC (credit)	AEC (credit)	SEC (credit)	VAC (credit)	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	Paper-I (4)	Paper-I (4)	Paper-I (4)	Choose one from MDC basket (3)	Odia (4)		Environmental Studies and Disaster Management (3)		22
II	Paper-II (4)	Paper-II (4)	Paper-II (4)	Choose one from MDC basket (3)	English (4)	SEC-I (3)			22
									44
III	Paper-III(4) Paper-IV(4)	Paper-III (4)	Paper-III(4)	Choose one from MDC basket (3)			Choose one from VAC basket (3)		22
IV	Paper-V(4)	Paper-IV(4) Paper-V(4)	Paper-IV(4)					CE/IP/FW (4)	20
									42
V	Paper-VI(4)	Paper-VI(4)	Paper-V(4) Paper-VI(4)			SEC-II (3)	Choose one from VAC basket (3)		22
VI	Paper-VII(4)	Paper-VII(4)	Paper-VII(4)			SEC-III (3)	Choose one from VAC basket (3)		18
									40
Total	7X4=28	7X4=28	7X4=28	3X3=9	2X4=8	3x3=9	4x3=12	1X4=4	126

IncaseastudentoptsforNCCandclears‘C’certificateadditional16Creditshallbeawardedand total credit shallbe126+16 = 142Credit

Table-VI: Fourth Year Hons. Without Research

Semester	Core-I (credit)	Core-II (credit)	Core-III (credit)	MDC (credit)	AEC (credit)	SEC (credit)	VAC (credit)	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	Paper-I(4) Paper-II(4)	Paper-I(4)		Choose one from MDC basket (3)	Odia (4)		Environmental Studiesand Disastermanagement (3)		22
II	Paper-III(4) Paper-IV(4)		Paper-I (4)	Choose one from MDC basket (3)	English (4)	SEC-I (3)			22
									44
III	Paper-V(4) Paper-VI(4) Paper-VII(4)	Paper-II(4)		Choose one from MDC basket (3)			Choose one from VAC basket (3)		22
IV	Paper-VIII (4) Paper-IX (4) Paper-X(4)		Paper-II(4)					CE/IP/FW (4)	20
									42
V	Paper-XI (4) Paper-XII (4) Paper-XIII (4)	Paper-III (4)				SEC II (3)	Choose one from VAC basket (3)		22
VI	Paper-XIV (4) Paper-XV (4)		Paper-III (4)			SEC III (3)	Choose one from VAC basket (3)		18
									40

VII	**Paper-XVI (4)** **Paper-XVII (4)** **Paper-XVIII (4)** **Paper-XIX (4)**	**Paper-IV (4)**							**20**
VIII	**Paper-XX (4)** **Paper-XXI (4)** **Paper-XXII (4)** **Paper-XXIII (4)**	**Paper-V (4)**							**20**
									40
Total	**23x4=92**	**5x4=20**	**3x4=12**	**3x3=9**	**2x4=8**	**3x3=9**	**4x3=12**	**1x4=4**	**166**

Table-VII: Fourth Year Hons. With Research

Semester	Core-I (credit)	Core-II (credit)	Core-III (credit)	MDC (credit)	AEC (credit)	SEC (credit)	VAC (credit)	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	Paper-I(4) Paper-II(4)	Paper-I (4)		Choose one from MDC basket (3)	Odia (4)		Environmental Studies and Disaster Management (3)		22
II	Paper-III(4) Paper-IV(4)		Paper-I (4)	Choose one from MDC basket (3)	English (4)	SEC-I (3)			22
III	Paper-V(4) Paper-VI(4) Paper-VII(4)	Paper-II(4)		Choose one from MDC basket (3)			Choose one from VAC basket (3)		22
IV	Paper-VIII (4) Paper-IX (4) Paper-X(4)		Paper-II (4)					CE/IP/FW (4)	20
V	Paper-XI (4) Paper-XII (4) Paper-XIII (4)	Paper-III(4)				SEC-II (3)	Choose one from VAC basket (3)		22
VI	Paper-XIV (4) Paper-XV (4)		Paper-III (4)			SEC-III (3)	Choose one from VAC basket (3)		18

VII	**Paper-XVI (4)** **Paper-XX (4)** **Paper-XXI (4)**	**Paper-IV(4)** **Paper-V(4)**							**20**
VIII	**Paper-XXII (4)** **Paper-XXIII (4)**							**Research 12**	**20**
									40
Total	**20x4=80**	**5x4=20**	**3x4=12**	**3x3=9**	**2x4=8**	**3x3=9**	**4x3=12**	**16**	**166**

Abbreviations

1. 'AEC' indicates 'Ability Enhancement Course'
2. 'MDC' indicates 'Multi Disciplinary Course
3. 'SEC' indicates 'Skill Enhancement Course'
4. 'VAC' indicates 'Value Addition Course'
5. 'CE/IP/FW' indicatesCommunityEngagement&Services/Fieldwork/Internship

ProcessofMultipleEntryandExit:

- A student after completion of 1st academic Session with completion of 42 Credits and anadditional 04 Credits in vocational stream can exit with a certificate issued by the HEI/Universityconcerned. Such student can re – enter to the UG programme into the 3rd semester within two yearsfromaward ofhis certificate.
- A student after completion of 2nd year with 84 and an additional **4 credit** in Vocational Streamcan exit with a diploma. Such students can re-enter to UG programme in 5th semester within twoyearsfrom award ofthisdiploma.
- Student who desires to undergo a 3-year degree programme will be allowed to exit aftercompletionof3rdyearwith minimum of 126/150creditswitha degree.

- However, the total duration for completing the UG program shall not exceed 7 years from theadmissioninto the 1st yearAcademicSession.
- StudentsmayacquireadditionalcreditunderValueadded/Multi-Disciplinary/Swayametc.The additional credit shall not be taken into account for Division/ Grade/ Rank etc. They shall notcountforadmission into higherprogram.

CHEMISTRY CORE PAPERS

PAPER-I: Atomic Structure, Periodicity of elements and Chemical Bonding

CourseTitle	Credits	Credit distribution	
		Lecture	Practical
AtomicStructure,Periodicityo felements andChemical Bonding	04	03	01

Course Objectives:

To provide the fundamental knowledge on the structure of atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. Various types of periodic properties and bondings have been reviewed to strengthen students for grasping this tricky topic and effectively tackle exam questions. The basics of acid-base titrimetric analysis has been incorporated in order to develop the analytical skills of the students.

Course Outcomes:

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1. Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom.
2. Learn the various atomic properties of atoms and their variations in the periodic table.
3. Gain the idea of different types of bondings and their associated properties.
4. Understand the theory and applications of various acid-base titrations.

SYLLABUS

(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

UNIT – I (12 Hours)

Atomic structure:

Rutherford's nuclear model of atom, Bohr's theory and the origin of hydrogen spectrum, Sommerfeld's extension of Bohr's theory, de-Broglie equation, Heisenberg's Uncertainty Principle and its significance. Postulates of wave mechanics, Derivation of Schrödinger's wave equation for hydrogen atom, significance of ψ and ψ^2. Radial and angular wave functions, Radial function plots, radial probability distribution plots, angular distribution curves. Shapes of s-, p-, d- and f-orbitals, Relative energies of orbitals. Slater's rule and its limitations, Quantum numbers and their significance. Pauli's Exclusion Principle, Hund's rule of maximum spin multiplicity and Aufbau principle.

UNIT – II (10 Hours)

Periodicity of elements:

Introduction to long form periodic table, Cause of periodicity, Division of elements into s-, p-, d- and f-blocks. Atomic radius, ionic radius, covalent radius and Van der Walls radius. Periodic trends in ionic and covalent radii. Ionization energy, electron affinity, electronegativity, and their variations in the periodic table. Applications of electronegativities. Pauling's/Mulliken's scale of electronegativity, Sanderson's electron density ratio.

UNIT – III (10 Hours)

Chemical bonding-I:

Ionic bond-General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Lattice energy, Born-Haber cycle and its application, Born-Lande equation, Madelung constant, importance of Kapustinskii equation for lattice energy. Solvation energy, Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

UNIT – IV (13 Hours)

Chemical bonding-II:

Covalent bond-Valence shell electron pair repulsion (VSEPR) theory, shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: CH_4, H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3^-, BrF_2^+, PCl_6^- , ICl_2^-, ICl_4^- , NH_4^+, $PO_4^{3-}$and SO_4^{2-}. Valence Bond theory (Heitler-London approach). Hybridization, equivalent and non-equivalent hybrid orbitals. Ionic character in covalent compounds: Dipole moment. Percentage ionic character from dipole moment and electronegativity difference, Mo l e c u l a r orbital diagrams of homo- & hetero-diatomic molecules (N_2, O_2, C_2, B_2, F_2, CO, NO) and their ions. Calculation of bond order. Concept of bent rule.

Metallic bond:

Concept of metallic bond, The free electron model, The valence bond model, The band model (molecular orbital approach), semiconductor and insulators.

Hydrogen bond:

Concept of hydrogen bond, nature of hydrogen bonding, consequences of hydrogen bonding and its importance.

Lab Work

Credit-01

(C L P = 1 0 1; Total Hours = 15 x 2 = 30)
(Laboratory periods: 30 Hours, 15 classes of 2 hours each)

List of experiments

1. Calibration and use of apparatus
2. Preparation of solutions of different Molarity/Normality.
3. Estimation of oxalic acid using standard NaOH solution
4. Estimation of sodium carbonate using standard HCl.
5. Estimation of carbonate and hydroxide present together in a mixture.
6. Estimation of carbonate and bicarbonate present together in a mixture.

Text Books:

1. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Co., 33rd Ed., 2017.
2. A. J. Elias, The Chemistry of the p-Block Elements-Syntheses, Reactions and Applications, University Press (India) Pvt Ltd., 2009.
3. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons, 1989.

Reference Books:

1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 2010.
2. B. E. Douglas, D. H. McDaniel, J. J. Alexander, Concepts and Models of InorganicChemistry, John Wiley & Sons, 1994.
3. P. W. Atkins, T. L. Overton, J. P. Rourke, M. T. Weller, F. A. Armstrong, Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press, 2010.
4. P. Chndra, C. Gupta, Chemical Dynamics and Coordination chemistry, 1st Ed., 2022.
5. A. K. Das, M. Das, Fundamental Concepts of Inorganic Chemistry, 1st Edition,Volume CBS Publishers & Distributors Pvt. Ltd., 2014.
6. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry-Principles of Structure and Reactivity, Pearson Education, 2009.
7. D. C. Harris, C. A. Lucy, Quantitative Chemical Analysis, 9th Ed, Freeman and Company,2016.

Paper-II
Fundamental Organic Chemistry

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Fundamental Organic Chemistry		04	03	01

Course Objectives:
To provide the fundamental knowledge on organic chemistry in order to comprehend other organic chemistry courses in coming semesters with greater depth. The purpose of this core paper is to review the basic concepts of electron displacement and the chemistry of aliphatic and aromatic hydrocarbons. Stereochemistry is also introduced to help to student to visualize the organic molecules and their spatial arrangement in three dimensional spaces and hands on experience on detection of organic molecules.

Course Outcomes:

1. Understanding the basic concepts of electronic displacement phenomena in organic molecules, various bond breaking processes and types of organic reactions.
2. Fundamental knowledge on symmetry and asymmetry aspect of organic molecules and their spatial arrangements in two-dimension and three-dimension with their stereochemistry.
3. Learning the synthesis, structure and stability of unsaturated hydrocarbons, understanding the concept of aromaticity and chemical reactions of unsaturated hydrocarbons and aromatic hydrocarbons.
4. Knowledge on selection of suitable solvent for purification and separation of organic compounds and detection of various elements present in it.

Syllabus
Lecture-Credit-03 (45 Hrs)

Unit–I:

Basics of Organic Chemistry (11 hrs)
Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications in dipole moment; organic acids and bases; their relative strength. Homolytic and heterolytic fission with suitable examples. Curly arrow rules; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stability of carbocations, carbanions, free radicals and carbenes.
Introduction to types of organic reactions with suitable examples: Addition, Elimination, Substitution, Rearrangement and Pericyclic reactions.
Carbon-carbon sigma bonds, chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Corey-House Reactions, Free radical substitutions: Halogenation –relative reactivity and selectivity.

Unit–II:

Stereochemistry (13 hrs)
Concept of Chirality/Asymmetry, Geometrical isomerism and Optical Isomerism: Optical Activity, Specific Rotation. Determination of Relative and absolute configuration in chiral molecules using D/L, R/S, cis/trans, Syn/Anti and E/Z descriptors using C.I.P rules. Representation by Fischer Projection, Newmann and Sawhorse Projection formulae in molecules containing one and two chiral-centres. Enantiomers, Distereoisomers, meso-structures, Racemic mixture and their resolution.
Stability and Conformational analysis: types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of alkanes (ethane and n-butane): Relative stability with energy diagrams. Energy diagrams of cyclohexane: Chair, Half chair, boat and twist boat forms.

Unit–III:

Chemistry of Unsaturated Hydrocarbons (13 hrs)

Carbon-Carbon Pi Bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.
Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/AntiMarkownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, syn and anti-hydroxylation (oxidation).1,2- and 1,4-addition reactions in conjugated dienes and Diels-Alder reaction; Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Unit–IV:

Chemistry of Aromatic Hydrocarbons (8 hrs)

Aromaticity: Hückel's rule, aromaticity in benzenoid and non-benzenoid compounds, cyclic carbocations/ carbanions and heterocyclic compounds with suitable examples.
Electrophilic aromatic substitution with mechanism: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the functional groups.

LAB WORK- Credit-01 (15 classes of 2 hours each)

List of Experiments

1. Detection of extra elements (N, Cl, Br, I and S) in organic compounds by Lassaigne's test.
2. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid groups in known organic compounds.
3. Separation and purification of any one component of following binary solid mixture (Benzoic acid/*p*-Toluidine; *p*-Nitrobenzoic acid/*p*-Aminobenzoic acid; *p*-Nitrotolune/*p*- Anisidine) based on the solubility in common laboratory reagents/solvents like water (cold, hot), ethanol (cold, hot), dil. HCl, dil. NaOH, dil.$NaHCO_3$ etc.
4. Determination of melting point and boiling point of different organic compounds

Text Books:

1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Ed., Pearson Education India, 2010.
2. A. Bahl, B. S. Bahl, Advanced Organic Chemistry, 5th Ed., S. Chand, 2012.
3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson Education India, 2003.

Reference Books:

1. T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, Solomons' Organic Chemistry, Global Ed., Wiley, 2024.
2. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., Oxford Publisher, 2012.
3. R. K. Bansal, Organic Reaction Mechanism, 3rd Ed., Tata McGraw-Hill Publications, 1998.
4. D. Nasipuri, Stereochemistry of Organic compounds, 4th Ed., New Age International Publisher, 2020.
5. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Ed., Pearson Education, 2003.
6. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part-A and Part-B, 5th Ed., Springer 2007.
7. N. K. Vishnoi, Advanced Practical Organic Chemistry, 3rd Ed., Vikas Publishing House, 2009.
8. O. P. Agarwal, Advanced Practical Organic Chemistry, Krishna Prakashan, 2014.
9. V. K. Ahluwalia, R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press, 2004.
10. H. T. Clarke, A Handbook of Organic Analysis: Qualitative and Quantitative, 4th Ed., CBS Publishers, 2021.

PAPER-III

States of matter, and Ionic equilibrium

Course Title	Code	Credit	Credit distribution	
			Lecture	Practical
States of matter, and Ionic equilibrium		04	03	01

Course Objectives:

The objective of this course is to develop basic and advance concepts regarding gases and liquids. It aims to study the similarity and differences between the two states of matter and reasons responsible for these. The objective of the practical is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-I course.

Course outcomes:

1. Derive mathematical expressions for different properties of gas and liquid and understand their physical significance.
2. Apply the concepts of gas equations and liquids while studying other chemistry courses and understand the importance of pH in every-day life.
3. Understand different lattice systems and apply working principles of XRD for understanding crystal structure by powder and single crystal method.
4. Handle stalagmometer and Ostwald viscometer properly and determine the density of aqueous solutions. Data reduction, interpretation using numerical and graphical methods.

SYLLABUS

Lecture-Credit 03 (45 hours)

Unit-I: Gaseous state (13 hour)

Kinetic molecular model of a gas, Collision frequency, Collision diameter, Collision cross section, Mean free path and viscosity of gases, including their temperature and pressure dependence, Relation between mean free path and coefficient of viscosity, Maxwell distribution of molecular velocities (no derivation); average, root mean square and most probable velocities and average kinetic energy, Law of equipartition of energy, Behaviour of real gases: Deviations from ideal gas behaviour, Causes of deviation from ideal behavior, Vander Wall equation and its application, Compressibility factor Z, and its variation with pressure for different gases, Critical Phenomenon and critical constant derivation.

Unit-II: Liquid state (10 hour)

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface

tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Capillary action in relation to cohesive and adhesive forces, Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Unit- III: Solid state (12 hour)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powderpattern method. Analyses of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals (stoichiometric and non- stoichiometric).

Unit-IV: Ionic equilibria (10 hour)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono- and diprotic acids. calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts and its application.

LAB WORK

Credit 01 (15 classes of 2 hours each)

List of experiments:

1. Determine the surface tension by (i) drop number (ii) drop weight method.
2. Study the variation of surface tension of detergent solutions with concentration and determination of CMC
3. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

4. Study the variation of viscosity of sucrose solution with the concentration of solute.
5. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
6. Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii)
7. Ammonium chloride-ammonium hydroxide
8. Determination of dissociation constant of a weak acid.
9. Determination of solubility product of PbI_2 by titrimetric method.

Text Books:

1. P. W. Atkins, J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. G. W. Castellan Physical Chemistry 4thEdn. Narosa 2004.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi 2011.

Reference books:

1. Puri, Sharma & Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
2. R. G., Mortimer Physical Chemistry, Elsevier (Academic Press), 3rd Ed, 2008.
3. T. Engel & P. Reid Physical Chemistry, 3rd Ed. Pearson 2013
4. Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017
5. Hrishikesh Chatterjee, Understanding PHYSICAL CHEMISTRY Through Theories and Problems, Nonlinear insights (opc) pvt. ltd. Publication division, 1st Ed., 2023.

PAPER-IV

Chemical thermodynamics, equilibrium, and Colligative property

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Chemical thermodynamics, equilibrium, and Colligative property		04	03	01

Course Objectives:

The learners should be able to apply principles and laws of thermodynamics to reversible and irreversible systems. In addition, they should be able to use spectroscopic data to calculate thermodynamic properties of ideal & real mixtures. In addition, understand the change in thermodynamic properties, equilibrium constants, partial molar quantities, chemical potential. Also able to identify factors affecting equilibrium constant using the principles and techniques of statistical thermodynamics.

Course outcomes:

By the end of the course, the students will be able to:

- Discuss the laws of thermodynamics and applications to natural phenomena.
- Acquire a strong foundation of partial molar properties, its variation with temp and pressure for different systems and able to apply on the thermodynamics of simple mixtures.
- Inculcate firm foundations in the fundamentals and application of chemical equilibrium, and ΔG derive the relationship between different equilibrium constants.
- Understand the basic concept of Solutions of non-volatile solutes, colligative properties. Calculate various thermodynamic properties ($\Delta H_{\text{neutralization}}$, $\Delta H_{\text{hydration}}$ & C_v) for chemical reactions using calorimeter.

SYLLABUS

Lecture-Credit 03 (45 hours)

Unit-I: Chemical thermodynamics (10 hours)

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

Unit-II (12 hours)

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

Unit-III : Systems of variable composition (13 hours)

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. **Chemical equilibrium**: 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 (vant Hoff's reaction). 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 principle (quantitative treatment) and its applications.

Unit-IV Solutions and Colligative Properties (10 hours)

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. 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.

LAB WORK- credit 01 (15 classes of 2 hours each)

List of experiments

1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.
4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

5. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of enthalpy of hydration of copper sulphate.
7. Determination of heat of solution (ΔH) of oxalic acid/benzoic acid from solubility measurement.

Text Books:

1. P. W. Atkins& J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. D. A. McQuarrie, & J. D Simon. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi 2004.
3. K. L. Kapoor, Text Book of Physical Chemistry, Mac Grow Hill, 3rdEdn. 2017
4. B. D. Khosla, V. C. Garg, & A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi 2011.

Reference Books:

1. T. Engel & P. Reid, Physical Chemistry 3rd Ed. Pearson 2013.
2. S.C. Kheterpal Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications 2011.
3. Puri, Sharma &Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.

PAPER-V

Acids and Bases, Metallurgy, Chemistry of main group elements

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Acids and Bases, Metallurgy, Chemistry of main group elements		04	03	01

Course Objectives:

To provide the basic knowledge on general principles of acids and bases, principle of metallurgy and chemistry of s- and p-block elements. Students can learn about chronological developments of the concepts of acids and bases. It will help students to get aware of the pH scale and classify a substance as acidic, basic, or neutral based on their pH or hydrogen ion concentration. Students can achieve the knowledge regarding volumetric analysis and preparation of metal complex.

Course Outcomes:

1. Know how the various theories of acid and base, and understand the occurrence and purification of metals
2. Learn the different properties of s- and p-block elements
3. Understand the preparation and properties of inorganic polymers.
4. Achieve knowledge on how to standardize, estimate and prepare inorganic compounds/metal ions.

SYLLABUS

(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

UNIT – I (10 Hours)
Acids and Bases

Different concepts of acids and bases: Arrhenius theory, Bronsted-Lowry theory, Lewis theory, The Lux-Flood definition, The Usanovich definition, acids and bases in proton solvents, Concept of conjugate acid and conjugate base, Concept of pH, Pearson's classification of Lewis acid and Lewis bases into Hard and Soft Acids and Bases (HSAB), HSAB principle, application of HSAB principle.

Principle of metallurgy

Chief modes of occurrence of metals, Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent, electrolytic reduction, hydrometallurgy. Methods of purification of metals: electrolytic process, parting process, Van Arkel-de Boer process, Mond's process and Zone refining.

UNIT – II (12 Hours)

Chemistry of *s*-Block Elements

General characteristics: melting point, flame colour, reducing nature, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water. Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, and sulphates. Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; Hydride and their classifications: ionic, covalent and interstitial, EDTA complexes of calcium and magnesium. Solutions of alkali metals in liquid ammonia and their properties.

UNIT – III (13 Hours)

Chemistry of *p*-Block Elements

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, catenation, allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behavior of first member of each group. interhalogen and pseudohalogen compounds, Structure, bonding and properties (acidic/basic nature, stability, ionic/covalent nature, oxidation/reduction, hydrolysis, action of heat) of the following:

- **Hydrides:** hydrides of Group 13 (only diborane), Group 14, Group 15, Group 16 and Group 17.
- **Oxides**: oxides of phosphorus, sulphur and chlorine
- **Oxoacids:** oxoacids of phosphorus and chlorine; peroxoacids of sulphur
- **Halides:** halides of silicon and phosphorus

UNIT – IV (10 Hours)

Noble gases

Occurrence and uses, rationalization of inertness of noble gases, clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6. Molecular shapes of noble gas compounds (VSEPR theory).

Inorganic polymer

Preparation, properties, structure and uses of the following compounds: Borazine, Silicates, silicones, phosphonitrilic halides $\{(PNCl_2)_n$ where n = 3 and 4$\}$, and concept of carbophosphazene.

Lab Work

(Credit-01)

(C L P = 1 0 1; Total Hours = 15 x 2 = 30)
(Laboratory periods: 30 Hours, 15 classes of 2 hours each)

List of experiments

1. Standardization of sodium thiosulphate solution by standard $K_2Cr_2O_7$ solution.
2. Estimation of copper using standard sodium thiosulphate solution (Iodometrically).
3. Estimation of available chlorine in bleaching powder iodometrically.
4. Preparation of Cuprous chloride (Cu_2Cl_2)
5. Preparation of Manganese (III) phosphate ($MnPO_4.H_2O$)
6. Preparation of Lead chromate ($PbCrO_4$)

Text Books:

1. A. J. Elias, The Chemistry of the p-Block Elements-Syntheses, Reactions and Applications, University Press (India) Pvt Ltd., 2009.
2. J. D. Lee, Concise Inorganic Chemistry Wiley India, 5th Edn., 2008.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.

Reference Books:

1. A. K. Das, Fundamentals of Inorganic Chemistry, Vol. I, CBS Publications, 2nd Ed., 2010.
2. S. Prakash, G. D. Tuli, S. K. Basu, R. D. Madan, Advanced Inorganic Chemistry, Vol. I, 7th Ed., S. Chand & Company Pvt. Ltd., 2021.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Publication Co., 33rd Ed., 2017.
4. D. E. Shriver, P.W.Atkins, Inorganic Chemistry, Oxford University Press, 5th Ed., 2010.
5. G. L. Miessler, P. J. Fischer, D. A. Tarr, Inorganic Chemistry, 5th Ed., Pearson, 2014.
6. J. Mendham, Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson, 2009.

V. K. Ahluwalia, S. Dhingra, A. Gulati, College Practical Chemistry, University Press, 2005.

(Paper-VI)
Chemistry of halogen, oxygen and sulphur containing organic compounds

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Chemistry of halogen, oxygen and sulphur containing organic compounds		04	03	01

Course Objectives:
To provide the knowledge on organic compounds containing halogen, alcohol, phenol, thiol, ether, thioether, aldehydes, ketones, carboxylic acids and its derivatives as functional groups. Further to know their preparation, properties and reactivity for developing the skills required for synthesizing a target molecule from a given molecule.

Course Outcomes:
1. Understanding on preparation, properties and reactions of haloalkanes, haloarenes, and organic compounds containing C, H, O and S functional groups.
2. Basic knowledge on various name reactions and their mechanisms involving substitution, addition, elimination and condensation.
3. Knowledge on functional group interconversion and synthetic applications of different organic compounds.
4. Knowledge on various functional group detection in organic compounds and preparation of derivatives of functional groups.

Syllabus
Lecture-Credit-03 (45 Hrs)

Unit-I:
Chemistry of Halogenated Hydrocarbons (10 hrs)
Alkyl halides: Methods of preparation, nucleophilic substitution reactions – SN_1, SN_2 and SN_i mechanisms with stereochemical aspects and effect of solvent and nucleophiles. substitution vs. elimination.
Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromatic substitution; SNAr, Benzyne mechanism.
Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Unit-II:
Alcohols, Phenols, Ethers and Epoxides (11 hrs)
Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, Ammonia derivatives and $LiAlH_4$.
Sulphur containing compounds: Preparation and reactions of thiols and thioethers

Unit-III:
Carbonyl Compounds (12 hrs)
Structure, reactivity and preparation. Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann rearrangements, α halo-form reaction and Baeyer-Villiger oxidation, - substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPVO.; Addition reactions of unsaturated carbonyl compounds: Michael addition.
Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethylaceto acetate.

Unit-IV:

Carboxylic Acids and Derivatives (12 hrs)

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

LAB WORK- Credit-01 (15 classes of 2 hours each)

List of Experiments

1. Functional group tests for amines (*p*-, *sec*- *tert*-), nitro, amide and imide groups in known organic compounds.
2. Benzolyation of one of the following amines (aniline, o-, m-, p- toluidines and o-, m-, p- anisidine) and one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.
3. Bromination of any one of the following:
   a) Acetanilide by conventional methods
   b) Acetanilide using green approach (Bromate-bromide method)
4. Nitration of any one of the following:
   a) Acetanilide/nitrobenzene by conventional method
   b) Salicylic acid by green approach (using ceric ammonium nitrate).
5. Identification of unknown organic compounds containing one functional group in CHO or CHN systems and their derivative preparation.

Text Books:

1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Ed., Pearson Education India, 2010.
2. A. Bahl, B. S. Bahl, Advanced Organic Chemistry, 5th Ed., S. Chand, 2012.
3. N. K. Vishnoi, Advanced Practical Organic Chemistry, 3rd Ed., Vikas Publishing House, 2009.

Reference Books:

1. T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, Solomons' Organic Chemistry, Global Ed., Wiley, 2024.
2. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., Oxford Publisher, 2012.
3. R. K. Bansal, Organic Reaction Mechanism, 3rd Ed., Tata McGraw-Hill Publications, 1998.
4. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, 6th Ed., Pearson Education, 2003.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part-A and Part-B, 5th Ed., Springer 2007.
6. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson Education India, 2003.
7. O. P. Agarwal, Advanced Practical Organic Chemistry, Krishna Prakashan, 2014.
8. V. K. Ahluwalia, R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press, 2004.
9. H. T. Clarke, A Handbook of Organic Analysis: Qualitative and Quantitative, 4th Ed., CBS Publishers, 2021.

PAPER-VII

Phase equilibrium, Chemical dynamics, catalysis and surface chemistry

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Phase equilibrium, Chemical dynamics, catalysis and surface chemistry		04	03	01

Course Objectives:

This course is offered by School of Chemistry as a core subject for the B.Sc. programme, with an emphasis on fundamental understanding phase equilibrium and chemical kinetics. The objective of this course is to develop basic and advance concepts regarding of Surface chemistry and catalysis. It aims to study the similarity and differences between adsorption isotherms and reasons responsible for these. The objective of the practical is to develop skills for working in physical chemistry laboratory pertaining to kinetics & adsorption isotherms. The student will perform experiments based on the concepts learnt in Physical chemistry-III course.

Course Outcomes:

By the end of the course, the students will be able to:

1. Establish the phase rule for one, two component systems, eutectics; and its thermodynamic derivation; fundamentals of physical transformation of pure materials.
2. Interpret chemical kinetics of chemical reactions and its impact on reaction mechanism.
3. Differentiate between homogenous and heterogenous catalysis & Acid Base Catalysis, differentiate between Physical adsorption, chemisorption and various adsorption isotherms.
4. Determine distribution coefficients of solution mixtures, Interpret and use data generated from kinetic studies by graphical and experimental methods.

SYLLABUS

Lecture-Credit 03 (45 hours)

UNIT-I: Phase Equilibria-I (10 hr)

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid- liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications (H_2O and sulphur system). Phase diagrams for systems of solid-liquid equilibria involving eutectic (Pb-Ag system, desilverisation of lead), congruent (ferric chloride-water) and incongruent (sodium sulphate- water) melting points.

UNIT-II: Phase Equilibria-II (13 hr)

Three component systems, water-chloroform-acetic acid system, triangular plots.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-III: Chemical Kinetics (12 hr)

Order and molecularity of a reaction, derivation of rate laws (Zero, first, and second order) and its differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of orders. Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions (HBr chain reaction).

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, qualitative treatment of the theory of absolute reaction rates.

UNIT-IV Catalysis (10 hr)

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. Surface chemistry: Physical adsorption, chemisorption, adsorption isotherms (Langmuir, Freundlich and Gibb's isotherms), nature of adsorbed state.

LAB WORK- credit 01 (15 classes of 2 hours each)

List of experiments

1. Determination of distribution coefficients of:

(a) Iodine between water and carbon tetrachloride.

(b) Acetic/ benzoic acid between water and cyclohexane.

2. Study the equilibrium of at least one of the following reactions by the distribution method:

- I_2 (aq) + $I^- \rightarrow I_3^-$(aq)
- Cu^{2+}(aq) + $nNH_3 \rightarrow Cu\ (NH_3)_n$

3. Study the kinetics of the following reactions.

(i) Integrated rate method:

a) Acid hydrolysis of methyl acetate with hydrochloric acid.

b) Saponification of ethyl acetate.

(ii) Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

4. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Text Books:

1. P. W. Atkins, J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. K. J. Laidler, Chemical kinetics, New York: Harper & Row 1916
3. J. Rajaram, J. C. Kuriacose Kinetics and Mechanisms of Chemical Transformations, Penguin Books Ltd, 2000.

Reference Books:

1. T. Engel, P. Reid, Physical Chemistry 3rd Ed. Pearson 2013.
2. D. A. McQuarrie, J. D. Simon, Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi 2004.
3. K. L. Kapoor, Text Book of Physical Chemistry, Mac Grow Hill, 3rdEdn. 2017

PAPER-VIII

Coordination Chemistry, Chemistry of d- and f-block elements, Inorganic Reaction Mechanism and electron transfer reactions

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Coordination Chemistry, Chemistry of d- and f-block elements, Inorganic Reaction Mechanism and electron transfer reactions		04	03	01

Course Objectives:

To provide the knowledge on the coordination compounds which find manifold applications in the diverse fields such as industrial catalysis, metallurgy, pharmaceutical industry, paints and pigments. Students will achieve the knowledge about the diverse kinetic aspects of the coordination compounds. They will also be familiarized with the chemistry of d- and f-block elements and get an idea about horizontal similarity in a periodin addition to vertical similarity in a group. Besides, the idea of inorganic reaction mechanism and the importance of electron transfer reactions have been reviewed. Synthesis and estimation of inorganic compoundshave been included to enhance the practical skill of students in this regard.

Course Outcomes:

1. Understand the chemistry of coordination compounds, and d- and f-Block elements.
2. Explain magnetic properties and colour of complexes on the basis of Crystal Field Theory.
3. Understanding the fundamental importance of inorganic reaction mechanism and electron transfer reaction
4. Achieved the knowledge of the preparation of inorganic complex, estimation by EDTA method and gravimetric method.

SYLLABUS

(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

UNIT – I (13 Hours)

Coordination Chemistry

Werner's Coordination theory, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds with coordination numbers 4 and 6. A brief idea about chelate effect, and labile and inert complexes. Valence bond theory and its application to complexes of coordination numbers 4 and 6. Examples of inner and outer orbital complexes. Crystal field theory and its application, measurement of Δ_o. Calculation of CFSE in weak and strong fields, concept of pairing energies, factors affecting the magnitude of Δ_o. Octahedral *vs.* tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field theory, and MO Theory (bonding and antibonding interactions, idea about σ, σ^*, π, π^*, n –MO).

UNIT – II (13 Hours)

Chemistry of d- and f-Block Elements

Chemistry of transition metals: General group trends with special reference to electronic configuration, colour, variable valency, magnetic properties (no temperature dependence), catalytic properties, and ability to form complexes. Distinction among the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy). Some importantcompounds of Cr, Mn, Fe and Co and their roles as laboratory reagents; Potassium dichromate, potassiumpermanganate, potassium ferrocyanide, potassium ferricyanide, sodium nitroprusside and sodium cobaltinitrite. Chemistry of Lanthanides and Actinides: electronic configuration, oxidation states, colour, spectral and magnetic properties. Lanthanide contraction (causes and effects), separation of lanthanides by ion exchange method. General features of actinides, separation of Np, Pm, Am from U.

UNIT – III (11 Hours)

Inorganic Reaction Mechanism

Thermodynamic and kinetic stability, Stepwise and overall formation constants and their relationship, factors affecting stability, Substitution reactions in square planar complexes, trans-effect, theories of trans- effect (electrostatic polarization and π-bonding theory), Substitution reactions in octahedral complexes, acid hydrolysis of octahedral Co(III) complexes with reference to effect of charge, chelation, steric crowding & effects of leaving group, base hydrolysis of octahedral Co(III) complexes: Conjugate base mechanism, test of conjugate base mechanism, anation reaction.

UNIT – IV (8 Hours)

Electron transfer reaction

Redox reactions: electron tunneling hypothesis, concept of Marcus-Hush theory, atom transfer reactions, one and two electron transfer, complementary and non-complementary reactions, inner sphere and outer sphere reactions, electron transfer through extended bridges, concept of hydrated electron.

Lab Work

Credit-01

(C L P = 1 0 1; Total Hours = 15 x 2 = 30)

(Laboratory periods: 30 Hours, 15 classes of 2 hours each)

List of experiments

1. Synthesis of hexamine nickel (II) complex, $[Ni (NH_3)_6] Cl_2$
2. Synthesis of tetraamminecopper (II) sulphate, $[Cu (NH_3)_4] SO4.H2O$
3. Estimation of Ca and Mg from cement by EDTA method
4. Estimation of nickel (II) using dimethylglyoxime (DMG)

Text Books:

1. J. D. Lee, Concise Inorganic Chemistry, Wiley India, 5th Edn., 2008.
2. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry– Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
3. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry Wiley-VCH., 1999.

Reference books

1. A. K. Das, Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
2. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons, 1989.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
4. D. E. Shriver, P. W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edn.
5. V. K. Ahluwalia, S. Dhingra, A. Gulati, College Practical Chemistry, University Press (2005).
6. S. Gulati, J. L. Sharma, S. Manocha, Practical Inorganic Chemistry, 1st Edn., CBS Publishers & Distributors Pvt Ltd., (2017).

Paper-IX
Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Polynuclear Hydrocarbons		04	03	01

Course Objectives:

Imparting information on natural products, nitrogen based organic compounds, heterocyclic compounds and polynuclear hydrocarbons with their chemical properties and structural elucidation. Imparting hands on training in estimation and analysis of organic compounds.

Course Outcomes:

1. Gaining knowledge on preparation, properties and synthetic application of nitrogen containing compounds including diazonium salts.
2. Understanding on isolation and structural elucidation of natural products and heterocyclic compounds and their chemical reactions.
3. Knowledge on structure and properties of fused aromatic compounds.
4. Learning on various procedures of estimation of organic compounds.

SYLLABUS
Lecture-Credit-03 (45 Hrs)

Unit-I:

Nitrogen Containing Functional Groups (13 hrs)

Amines: Effect of substituent and solvent on basicity; Preparation from nitro and nitriles and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.
Diazonium Salts: Preparation and their synthetic applications.

Unit-II:

Dyes and Polynuclear hydrocarbon derivatives (8 hrs)

Classification, colour and constitution; Mordant and Vat dyes; Chemistry of dyeing. Synthesis and applications of: *Azo dyes* – Methyl orange and Congo red (mechanism of Diazo coupling); *Triphenylmethane dyes*- Malachite Green, and crystal violet; *Phthalein dyes*– Phenolphthalein and Fluorescein. Edible dyes with example.

Preparation of Polynuclear Hydrocarbons: Reactions of naphthalene, anthracene, phenanthrene, acenaphthene, pyrene. Preparation and their structure elucidation (naphthalene) and important derivatives of naphthalene and anthracene.

Unit-III:

Heterocyclic Compounds (13 hrs)

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom, Reaction and mechanism of substitution reactions of: Furan, Pyrrole, Thiophene and Pyridine. Synthesis of Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis), Furan (Paal Knorr synthesis, Fiest-Benary Synthesis), Derivatives of Furan: Furfural and Furoic acid (preparation only) Pyridine (Hantzsch synthesis). Pyrimidine (synthesis from β-keto acid), Bicyclic Heterocyclic compound: Indole (Fischer indole synthesis and Madelung synthesis) Quinoline (Skraup synthesis, Friedlander Synthesis).

Unit-IV: Natural Products (11 hrs)

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

Terpenes

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, and *α*- terpineol.

LAB WORK

Credit-01 (15 classes of 2 hours each)

List of Experiments

1) Qualitative analysis of unknown organic compounds containing bifunctional groups
2) Estimation of Phenol/ Aniline
3) Estimation of Methyl Ketone
4) Determination of percentage purity of carbonyl compound.

Text Books:

1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Ed., Pearson Education India, 2010.
2. I. L. Finar, Organic Chemistry, Vol-2, 5th Ed., Pearson Publisher, 2002.
3. N. K. Vishnoi, Advanced Practical Organic Chemistry, 3rd Ed., Vikas Publishing House, 2009.

Reference Books:

1. T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, Solomons' Organic Chemistry, Global Ed., Wiley, 2024.
2. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., Oxford Publisher, 2012.
3. J. A. Joule, K. Mills, Heterocyclic Chemistry, 5th Ed., Wiley Blackwell, 2010.
4. R. K. Bansal, Heterocyclic Chemistry, 5th Ed., New Age International, 2017.
5. O. P. Agarwal, Organic Chemistry: Natural Products, Vol. I, Krishna Prakashan Media, 2015.
6. H. T. Clarke, A Handbook of Organic Analysis: Qualitative and Quantitative, 4th Ed., CBS Publishers, 2021.

PAPER-X

Conductance, electrochemistry, electrical properties of atoms and molecules

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Conductance, electrochemistry, electrical properties of atoms and molecules		04	03	01

Course Objectives:

This course offers in introductory knowledge of electrolytic conductance depth knowledge of electrochemical cells. Students are expected to have background knowledge in physical chemistry and mathematics up to the +2 level for this course. The objective of the practical is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-IV course.

Course Outcomes:

By the end of the course, the students will be able to:

1. The text provides an in-depth analysis of the conductance nature of electrolytic solutions, their thermodynamics, Debye-Huckel theory, ionic strength, mean ionic activity coefficient, and the Debye-Huckel limiting law.
2. Explain dynamic electrochemical processes and skill development to analyse it.
3. Understand the dynamic electrochemical processes and skill development to analyse it.
4. Develop skill to solve problems on Electrochemical Cells, electrode potentials, emf & solubility product measurements, potentiometric titrations, pK and pH measurements.

SYLLABUS

Lecture-Credit 03 (45 hours)

UNIT-I: Conductance-I (10 hr)

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

UNIT-II: Conductance-II (15 hr)

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT-III Electrochemistry-I (10 hr)

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes.

UNIT-IV Electrochemistry-II (10 hr)

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation). **Electrical properties of atoms and molecules**: Basic ideas of electrostatics, Electrostatics of dielectric media. Clausius-Mosotti equation and Lorenz-Laurentz equation (no derivation), Dipole moment and molecular polarizabilities and their measurements.

LAB WORK- credit 01 (15 classes of 2 hours each)
List of experiments

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:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Strong acid vs. weak base

I Perform the following potentiometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Dibasic acid vs. strong base

Text Books:

1. P. W Atkins. & J. de Paula, Elements of Physical Chemistry, Oxford University Press, 6th Ed., 2006.
2. J. O. Bockris & A. Reddy. Modern Electrochemistry, Kluwer Academic, 2002.
3. S. Glasstone, An Introduction to Electrochemistry: Affiliated East West Press Private, Limited. 1960

Reference Books:

1. T. Engel & P. Reid, Physical Chemistry 3rd Ed. Pearson 2013.
2. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi 2004.
3. Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications. 2002.

Paper-XI
Organic Spectroscopy

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Organic Spectroscopy		04	03	01

Course Objectives:

To provide knowledge on the principles of different advanced spectroscopic methods such as UV-Visible, FTIR, NMR and Mass-spectrometry and to develop analytical aptitude for interpretation of structure of the organic compounds by applying these spectroscopic methods. Imparting practical knowledge on UV-visible spectroscopy and colour of compounds.

Course Outcomes:

1. Gaining knowledge on principle of UV-visible and Infrared Spectroscopic techniques.
2. Gaining knowledge on principle of NMR Spectroscopic techniques.
3. Gaining knowledge on principle of Mass Spectrometry techniques.
4. Understanding and interpretation of different spectra of organic molecules.

SYLLABUS
Lecture-Credit-03 (45 Hrs)

Unit-I:

UV-Visible Spectroscopy (11 hrs)

Types of electronic transitions, λ_{max}, Lambert-Beer's law and its limitations, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Instrumentation (brief idea only), Application of Woodward rules for calculation of λ_{max} for the following systems: α, β- unsaturated carbonyl compounds, acids and esters; Conjugated dienes, distinction between cis and trans isomers.

Unit-II:

FTIR Spectroscopy (9 hrs)

Fundamental and non-fundamental molecular vibrations; IR absorption positions of O and N containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in simple functional group analysis.

Unit-III:

NMR Spectroscopy (15 hrs)

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Equivalent and non-equivalent protons, Spin-spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics; Interpretation of NMR spectra of simple organic compounds. ^{13}C NMR spectroscopy, chemical shift values and interpretation of NMR spectra. preliminary idea on NMR of ^{15}N, ^{19}F, ^{31}P nuclei.

Unit-IV:

Mass Spectrometry (10 hrs)

Introduction, Basic principle, Fragmentation pattern, instrumentation, Determination of molecular formulae, molecular ions, Parent peak, Base peak, isotopic peak and metastable ion peak. Use of molecular fragmentation, McLafferty rearrangement, Mass spectra of some classes of compounds (hydrocarbons, alcohols, phenols, ketones, aldehydes, acids and esters)

Problems involving identification of organic compounds using UV, IR, NMR and Mass spectroscopy.

LAB WORK

Credit-01 (15 classes of 2 hours each)

List of Experiments

1) Using an UV-visible spectrophotometer, obtain the uv-visible spectrum, determine the λ_{max} value and, after comparing the spectra of the following molecules, predict the effect of auxochrome and conjugation on absorption maxima.

   (a) Take and analyze the spectra of benzene, aniline, and 4-methoxyaniline using a suitable solvent. Then, compare the results after adding dil hydrochloric acid to it.

   (b) Take and analyze the spectra of salicylic acid, benzoic acid and *p*-amino benzoic acid, cinnamic acid in neutral and then compare the result after adding dil NaOH to it.

   (c) Take and analyze the spectra of o-nitrophenol, p-nitrophenols and nitrobenzene in neutral and then compare the result after adding dil NaOH to it.

2) Identification of labelled peaks in the ^{1}H NMR spectra of the known organic compounds and to explain their δ-values and splitting pattern on a supplied NMR spectra.

2) Identification of labelled peaks in the IR spectrum of a compound and to explain the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C≡C, C≡N) of a supplied spectrum.

Text Books:

1. W. Kemp, Organic Spectroscopy, 2nd Ed., Macmillan, 2019.
2. P. S. Kalsi, Spectroscopy of Organic Compounds, 9th Ed., New Age International Publishers, 2022.
3. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, Introduction to Spectroscopy, 5th Ed., Cengage India Private Limited, 2015.

Reference Books:

1. Y. R. Sharma, Elementary Organic Spectroscopy, 5th Ed., S. Chand, 2013.
2. Jag Mohan, Organic Spectroscopy: Principles and Applications, 2nd Ed., Narosa Publishers, 2009.
3. J. Singh, J Singh, Organic Spectroscopy: Principles, Problems and their Solutions, Pragati Prakashan, 2019.
4. R. M. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, Spectrometric Identification of Organic Compounds, 8th Ed., Wiley, 2022.

PAPER-XII

Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry		04	03	01

Course Objectives:

This course is offered by School of Chemistry as a core subject for the B.Sc. programme, with an emphasis on fundamental understanding of Quantum chemistry, molecular spectroscopy, and photochemistry. Students are expected to have background knowledge in mathematics up to the +2 level for this course. The objective of the practical is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-V course.

Course outcomes:

By the end of the course, the students will be able to:

1. Understand the postulates of quantum mechanics. Construct the Schrödinger wave equations for 1-D box, 3-D box, Rigid rotor, and SHO and able to interpret the solution of Schrödinger equation.
2. Understand LCAO-MO compare with VBT of H2 molecule. Apply the fundamentals of Quantum mechanics to interpret molecular spectroscopy.
3. Calculate quantum yield of photochemical reactions.
4. Interpret the data obtained from graphical methods of Lambert-Beer's law experiments and corelate with UV-Vis spectroscopy.

SYLLABUS

Lecture-Credit 03 (45 hours)

UNIT-I: Quantum Chemistry-I (10 hr)

Quantum mechanical operators, Postulates of quantum mechanics, Schrödinger equation and its application to particle in one-dimensional box (complete solution) - quantization of energy levels, zero-point energy, normalization of wave functions, probability distribution functions, nodal properties. Extension to three-dimensional boxes.

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

Rigid rotator model of rotation of diatomic molecule: Schrödinger equation, transformation to spherical polar coordinates. Derivation of rotational energy expression of diatomic molecule.

UNIT-II Chemical Bonding (15 hr)

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO- MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB

treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Localized and non-localized molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules.

UNIT-III: Molecular Spectroscopy-I (10 hr)

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

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

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

UNIT-IV: Molecular Spectroscopy-II (10 hr)

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. ***Electronic spectroscopy:*** Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Photochemistry 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, chemiluminescence.

LAB WORK
Credit 01 (15 classes of 2 hours each)

List of experiments

1. Study of absorption spectra (visible range) of $KMnO_4$ and determine the λ_{max} value. Calculate the energies of the transitions in kJ mol^{-1}, cm^{-1}, and eV.
2. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration.
3. Determine the dissociation constant of an indicator (phenolphthalein).
4. Determine the concentration of HCl against 0.1 N Na OH spectrophotometrically.
5. To find the strength of given ferric ammonium sulfate solution of (0.05 M) by using EDTA spectrophotometrically.
6. To find out the strength of $CuSO_4$ solution by titrating with EDTA spectrophotometrically.
7. To determine the concentration of Cu (II) and Fe (III) solution photometrically by titrating with EDTA.

Text Books:

1. D. A. McQuarrie, Quantum Chemistry, Viva Books, Indian Student Edition, Reprint, 2011
2. R.K. Prasad, Quantum Chemistry, New Age International, 2006
3. I. Levine, Quantum Chemistry, 7th Edition, Pearson, 2000

Reference Books:

1. T. Engel & P. Reid, Physical Chemistry 3rd Ed. Pearson 2013.
2. D. A. McQuarrie, & J. D. Simon, Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi 2004.
3. S.C. Kheterpal Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications. 2011.

PAPER-XIII
Chemistry of Organometallic Compounds

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Chemistry of Organometallic compounds		04	03	01

Course Objectives

To provide the basic knowledge and cutting-edge developments in the field of organometallic chemistry. This includes the classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species. Specific organometallic compounds are studied in detail to understand the basic concepts. It familiarizes the versatility of phosphine/NHC ligands as well as metathesis reactions. It provides much fundamentals about the qualitative inorganic analysis having multiple radical mixtures.

Course Outcomes:

1. Understand the basic concepts of organometallic compounds pertaining to their synthesis, structure and bonding
2. Understand the mechanistic phenomena of organometallic based catalytic reactions
3. Get knowledge on the versatility of phosphine/NHC ligands, and industrially important metathesis reactions.
4. Understand and explain the basic principles of qualitative inorganic analysis

SYLLABUS
(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

UNIT – I (12 Hours)

Organometallic Compounds-I

Definition of organometallic compound, classifications, nature of metal-carbon bond, nomenclature, the 18-electron rule, Concept of hapticity of organic ligands. Metal carbonyls: electron counting of metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear metal carbonyls of 3d series. 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, evidence of synergic effect and comparison of synergic effect with that in carbonyls.

UNIT – II (11 Hours)

Organometallic Compounds-II

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethyl aluminium in the polymerisation of ethene and propylene (Ziegler – Natta Catalyst). Ferrocene: preparation and reactions (acetylation, alkylation, metallation, Mannich condensation, nitration, halogenation, silylation, borylation,sulphonation), structure and aromaticity, comparison of aromaticity and reactivity with that of benzene. Fluxional molecules. Concept of coordinative unsaturation, oxidative addition, reductive elimination, insertion reaction, migratory insertion, intramolecular hydrogen transfer reaction, agostic interaction.

UNIT – III (12 Hours)

Organometallic Catalysis

General idea of catalysis, turnover number (TON), turnover frequency (TOF), hydrogenation of alkenes using Wilkinson's catalyst, Tolman catalytic loop, hydroformylation of alkenes (using cobalt catalyst), enantioselective hydrofomylation, wacker process, mosanto acetic acid synthesis, cativa process, hydrosilylation reactions, reduction of carbon monoxide by hydrogen (Fischer-Tropsch reaction). Concept of Pd-catalyzed cross-coupling reactions.

UNIT – IV (10 Hours)

Neutral Spectator Ligands and Metathesis Reactions

Steric and electronic structure of phosphine ligands, basicity of phosphine, monodentate and multidentate phosphines, cone angle, bite angle, N-heterocyclic carbenes (NHC), synthesis of NHC, alkene metathesis, mechanism of alkene metathesis, classification of metathesis reactions, significance of metathesis reactions.

Lab Work

(C L P = 1 0 1; Total Hours = 15 x 2 = 30)
(Laboratory periods: 30 Hours, 15 classes of 2 hours each)

Experiment

1. Qualitative analysis of mixtures containing 4 radicals (2 anions and 2 cations). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:

   CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, F^-, Cl^-, Br^-, I^-, NO_3^-, 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+}, Mg^{2+}.

   Mixtures may contain one insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) or combination of interfering anions e.g., CO_3^{2-} and SO_3^{2-}; NO_2^- and NO_3^-; Cl^-, Br^-, I^-; $Br^-$and I^-; NO_3^-, Br^-, I^-.

Text Books:

1. B. D. Gupta, A. J. Elias, Basic Organometallic Chemistry, 2nd Edn., University Press (2013).
2. R. C. Mehrotra, A. Singh, Organometallic Chemistry, New Age International Publishers, 2ndEdn, 2000.
3. Vogel's Qualitative Inorganic Analysis, 7th Ed, Revised by G. Svehela, 4th Ed., Person, 2007.

Reference Books:

1. A. K. Das, Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
2. D. E. Shriver, P. W. Atkins Inorganic Chemistry, Oxford University Press, 5th Edn.
3. J. E. Huheey, E. A. Keiter, R. L. Keiter, Inorganic Chemistry – Principles of structure and reactivity,Pearson Education, 4th Ed. 2002.
4. B. R. Puri, L. R. Sharma, K. C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Co., 33rdEd., 2017.
5. J. F. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, University ScienceBooks, 2010.

Paper-XIV

Analytical Methods of Chemistry

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Analytical Methods of Chemistry		04	04	00

Course Objectives:

This course is offered by School of Chemistry as a core subject for both 4-year B.Sc. with and without research Programs, with an emphasis on analytical methods of chemistry. This course aims to impart skills, promotes employability, and entrepreneurships in broad domains such as Thermal industry, pharma, dyes & paints, coating, metal & metallurgical PSUs, research, and academic institutes. Instrumentation proficiency: Students should gain hands-on experience with analytical instrumentation commonly used in chemical analysis, such as spectrophotometers, chromatographs, and mass spectrometers. The aims are to provide a sound physical understanding of the principles of analytical chemistry and to show how these principles are applied in chemistry and related disciplines— especially in life sciences and environmental science.

Course Outcomes:

1. Perform calibration and standardization procedures to ensure the accuracy and precision of analytical measurements, adhering to established protocols and standards.
2. Apply a variety of analytical techniques, such as spectroscopy, chromatography,

electrochemistry, and titrimetry, to quantitatively and qualitatively analyze chemical substances.

3. Collect, analyze, and interpret experimental data accurately using appropriate statistical methods and error analysis techniques.
4. Develop critical thinking and problem-solving skills and Implement quality control and assurance practices, including the use of control charts and validation of analytical methods, to ensure the reliability and reproducibility of analytical results.

SYLLABUS

Lecture-Credit 04 (60 hours)

Unit I – Tools and Data Handling (15 hr)

Calibration of tools, sampling. Errors and Statistics: significant figures, rounding off, accuracy and precision, determinate and indeterminate errors, standard deviation, propagation of errors, confidence limit, test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit II – Separation Techniques (15 hr)

Solvent Extraction: distribution Coefficient, distribution ratio, solvent extraction of metals, multiple batch extraction, counter-current distribution. - Chromatographic Techniques: classification, theory of chromatographic separation, distribution coefficient, retention, sorption, efficiency and resolution.
-Column, ion exchange, paper, TLC & amp; HPTLC: techniques and application. - Gas Chromatography: retention time or volume, capacity ratio, partition coefficient, theoretical plate and number, separation efficiency and resolution, instrumentation and application.

Unit III – Spectroscopic Techniques (15 hr)

Electromagnetic radiation, absorption, and emission of radiation – instrumentation: sources, monochromators, detectors. - Flame spectrometry: flame emission, AAS, ICP, instrumentation and application. - Absorption spectrometry: UV-VIS, IR, instrumentation, techniques and applications. **Unit IV – Thermal and Electroanalytical Techniques (15 hr)**

Thermogravimetry: instrumentation and techniques, TGA curves, DTA and DSC, applications. Electrogravimetry, coulometry, voltammetry, polarography, conductometry, instrumentation, techniques and application.

Textbooks:

1. D. C. Harris, Quantitative Chemical Analysis, 4th Edn., W. H. Freeman, 1995.

2. G. D. Christian & J. E. O'Reily, Instrumental Analysis, 2nd Edn., Allyn & Balon, 1986.

3. Skoog, Holler and Crouch, Principles of Instrumental Analysis, Cengage Learning, 6th Indian Reprint 2017.

Reference books

1. W. H. Hobert: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
2. O. Mikes, & R.A. Chalmes, Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London. 2001
3. Pavia, Lamman, Kriz and Vyvyan, Introduction to Spectroscopy, Cengage Learning, 3rd Indian Reprint 2017.

PAPER-XV

Solid and porous materials, and magnetochemistry and power cells

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Solid and porous materials, and magnetochemistry and power cells		04	03	01

Course Objectives:

To provide the basic understanding about the solid and porous materials with their diverse applications. Students will learn fundamentals of magnetochemistry and molecular magnetism which will be helpful for their competitive examinations. Course is designed to develop a comprehensive technological understanding in different power cells.

Course Outcomes:

1. Learn about the different materials, including theory and methods for the development of new materials with desired properties.
2. Know how pores can influence the properties of materials
3. Demonstrate an increased knowledge and understanding of magnetochemistry with critical thought and achieve the ability to analyze magnetochemical studies and data
4. Explain the principles that underlie the ability of various power cells and develop new idea of constructing power cells

SYLLABUS

(C L P = 4 4 0; Total Hours = 15 x 4 = 60)

UNIT – I (20 Hours)

Inorganic Solid Materials

Silicate industry:

Glass: Glassy state and its properties, classification (silicate and nonsilicate glasses), Manufacture and processing of glass, composite armoured properties of the following types of glasses: soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, colored glass, photosensitive glass.

Ceramics: Manufacture and types of ceramics, high technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes, carbon nanotubes and carbon fibers.

Cement: Classification of cement, ingredients and their role, manufacture of the cement, and their setting process and quick setting cements.

UNIT – II (15 Hours)

Crystal Engineering and Principle of Designing Porous Materials

Inorganic crystal engineering and design principle of metal-organic frameworks and organic-inorganic hybrids. Principles of ICE in the design of porous materials, their understanding and characterizations using X-ray diffraction and thermal methods. Surface characterization and surface behavior of such porous materials with special reference to the gas/solvent vapors sorption. Some special applications of such materials like gas storage, gas/solvent separation, etc. Understanding of the structure-property relationship for the design of functional molecular material or molecular devices- philosophy and the terminologies**.**

UNIT – III (15 Hours)

Magnetochemistry

Magnetic Substances: Terminology related with magnetic properties, Classification, Cooperative Magnetism, Ferromagnetic substances and related aspects, Application of hard and soft ferromagnetic substances. Para-, ferro- and antiferro-magnetism: Temperature dependence of magnetic susceptibility, Curie ‘s Law and Curie-Weiss Law, Pathways of ferro- and antiferromagnetism, magnetic properties of an electron, paramagnetism and thermal energy, Spin-orbit Coupling, Magnetic properties of compounds of d- and f-block elements: concentrated and dilute systems, Magnetically frustrated systems, single molecule magnet (SMM), single ion magnet (SIM), single chain magnet (SCM).

UNIT – IV (10 Hours)

Power cells

Primary and secondary batteries, Battery components and their role, characteristics of battery, working principles of following batteries: Pb-battery, Li-battery, solid state electrolyte battery, fuel cell, solar cell, polymer cell.

Text Books:

1. F. Gomez-Granados, J. C. Moreno-Pirajan, L. Giraldo-Gutierrez, Porous Materials: Theory and Its Application for Environmental Remediation (Engineering Materials), Springer Nature Switzerland AG; 1st Ed. 2021.
2. R. L. Dutta, A. Syamal, Elements of magnetochemistry, 2nd Ed, Affiliated East-West Press Pvt. Ltd, 2010.
3. J. N. Lalena, D. A. Cleary, O. B. M. H. Duparc, Principles of Inorganic Materials Design, 3rd Ed, Wiley, 2020.

Reference Books:

1. C. N. R. Rao, K. Biswas, Essentials of Inorganic Materials Synthesis, John Wiley & Sons, Inc., 2015.
2. C. Julien, A. Mauger, A. Vijh, K. Zaghib, Lithium Batteries: Science and Technology, Springer, 2015.
3. C. S. Solanki, Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, Prentice Hall India Learning Pvt. Ltd., 2013.
4. D. Pavlov, Lead-Acid Batteries: Science and Technology, Elsevier Science, 2015.
5. S. P. Jiang, Q. Li, Introduction to Fuel Cells: Electrochemistry and Materials, Springer, 2022.
6. A. Ramanan, G. R. Desiraju, J. J. Vittal, Crystal Engineering: A Textbook, World Scientific Publishing Co. Pte. Ltd., 2011.
7. A. Earnshaw, Introduction to Magnetochemistry, Academic Press, 2013.

PAPER-XVI

Chemistry of Biomolecules

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Chemistry of Biomolecules		04	03	01

Course Objectives:

The objective of this course is to familiarize the student with biomolecules such as carbohydrates, amino acids, proteins, peptides, lipids and enzymes. The student will comprehend the structure, nomenclature, and properties of various biomolecules and their functions in biological systems. It will also help the learners to build the concept of metabolism by studying the chemistry and energetics of biomolecules in biochemical reactions.

Course Outcomes

1. Imparting knowledge on various biomolecules with their detailed classification, structure, nomenclature and functions.
2. Understanding the chemistry and energetics of food to energy conversion in biological systems.
3. Gaining knowledge on type of enzymes and their roles in metabolism of biomolecules in various biochemical reactions.
4. Practically determine saponification value and iodine number of fat and oil and determine the reducing andnon-reducing sugars by Benedict's reagent.

Syllabus

Lecture-Credit-03 (45 Hrs)

Unit-I:

Carbohydrate (13 hrs)

Occurrence, classification (mono-, di- and poly- saccharides), chemical structure, constitution and absolute configuration of glucose and fructose, epimers and anomers relationships, mutarotation, determination of ring size of glucose and fructose, Haworth projections and Fischer projection conformational structures, interconversions of aldoses and ketoses. Chemical properties of monosaccharides and Killiani-Fischer synthesis and Ruff degradation; Synthesis of Disaccharides – (Sucrose, Lactose and maltose) by condensation reactions.

Unit-II:

Amino Acids, Peptides, Proteins and Nucleic acids (11 hrs)

Amino acids: Classification, Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis.

Peptides: Classification, 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.

Proteins: Structure of proteins, protein denaturation and renaturation.

Nucleic Acids: Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

Unit-III:
Lipids (12 hrs)
Introduction to oils and fats, common fatty acids present in oils and fats, role of lipids in our body, structure and classification, importance of omega-3 and omega-6 fatty acids and their sources. Physical and chemical properties of oils and fats, acid value, saponification value, iodine value, smoke point, flash point, fire point, and specific gravity. Chemical reactions of oil and fat, rancidity, conversion of oil to fat through hydrogenation, Baudouin test, Halphens test, Hexabromide test.

Unit-IV:
Enzymes (9 hrs)
Introduction to enzyme nomenclature, classification and characteristics. Salient features of active site of enzymes. Enzyme-substrate formation theory. Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action, enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive including allosteric inhibition).

LAB WORK
Credit-01 (15 classes of 2 hours each)

List of Experiments

(1) Determination of Saponification value of supplied oil.
(2) Determination of Iodine value of supplied oil.
(3) Qualitative analysis of carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
(4) Quantitative estimation of sugars:
    a) Estimation glucose by titration with Fehling's solution.
    b) Estimation glucose and sucrose in a given mixture.
(5) Estimation of glycine by Sorenson's formalin method.
(6) Study of the titration curve of glycine
(7) Separation and identification of amino acids by paper chromatography
(8) Separation of blue and orange dyes from methyl orange by paper chromatography
(9) Separation and identification of food dyes by paper chromatography
(10) Separation of two immiscible liquids by paper chromatography
(11) Separation of blue and yellow dyes using isopropanol by paper chromatography

Textbooks
1. D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry, 7th Ed., W. H. Freeman Co., 2017.
2. J. L. Jain, S. Jain, N. Jain, Fundamentals of Biochemistry, S. Chand, 2016.
3. E. J. Wood, Wilson and Walker Principle and Techniques of Practical Biochemistry, Cambridge University Press, 2009.

Reference Books:
2. D. Das, Biochemistry, 14th Ed., Academic Publishers, 2015.

3. A. V. S. S. Rao, A Textbook of Biochemistry, 9th Ed., UBS, 2002.
4. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th Ed., Pearson Education India,2010.
5. G. P. Talwar, L. M. Srivastava, Textbook of Biochemistry and Human Biology,3rd Ed., Prentice HallIndia, 2002.
6. J. M. Berg, J. L. Tymoczko, L. Stryer, Biochemistry, 6th Ed., W. H. Freeman, 2006.
7. P. J. Kennelly, K. M. Botham, O. Mcguinness, V. W. Rodwell, P. A. Weil, Harper's IllustratedBiochemistry, 32nd Ed., Lange-McGraw-Hill, 2022.
8. T. W. Graham Solomons, C. G. Fryhle, S. A. Snyder, Solomons' Organic Chemistry, Global Ed., Wiley,2024.

PAPER-XVII

Polymer Chemistry

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Polymer chemistry		04	03	01

Course Objectives:

This course is offered by School of Chemistry as a core subject for the 4-year B.Sc. Programme, with an emphasis on fundamental understanding of the type of bond in a polymer and rationally design the monomers for a given polymer. To describe various methods used for synthesizing polymers. To use analytical methods to characterize a polymer. To study the properties of polymers.

Course outcomes:

5. The learners will be able to classify the polymers based on nature, occurance, mode of synthesis, thermal properties etc.
6. To differentiate between methods and mechanism of polymerization process.
7. Calculate molecular weights of polymers and study the applications & properties.
8. The learners will be able to design the monomers for the preparation of polymers of interest, characterize and understand the properties polymers.

SYLLABUS

Lecture-Credit 03 (45 hours)

UNIT-I (10 hr)

Introduction and history of polymeric materials:
Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.
Functionality and its importance: Criteria for synthetic polymer formation, classification of

polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi- functional systems, Poly-functional systems.

UNIT-II (13 hr)

Mechanism & Kinetics of Polymerization:

Polymerization reactions – addition and condensation, mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques. **Crystallization and crystallinity:** Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

UNIT-III (10 hr)

Molecular weight of polymers and their determination (M_n, Mw, M_v, M_z) by end group analysis, viscometry and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Glass transition temperature (T_g) and its determination: WLFequation, outlines of factors affecting glass transition temperature (T_g).

UNIT-IV (12 hr)

Properties of polymers

(physical, thermal and mechanical properties). Preparation, structure, properties and applications of the following polymers: polyolefins (polyethylene, polypropylene), polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon), polyamides (nylon-6 and nylon 6,6). Thermosetting polymers - phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, conducting polymers (polyacetylene, polyaniline). Brief outline of biodegradable polymers.

LAB WORK

Credit-01 (15 classes of 2 hours each)

List of experiments

1. Preparation of nylon-6,6 / Polyaniline
2. Preparations of phenol-formaldehyde resin-novalac / phenol-formaldehyde resin resold.
3. Preparation of urea-formaldehyde resin
4. Redox polymerization of acrylamide
5. Precipitation polymerization of acrylonitrile
6. Determination of molecular weight by viscometry:
   a. Polyacrylamide / Polystyrene
   b. (Polyvinyl pyrolidine (PVP)
7. Determination of acid value/saponification value of a resin.
8. Determination of hydroxyl number of a polymer using colorimetric method.
9. Estimation of the amount of HCHO in the given solution by sodium sulphite method
10. Analysis of some IR spectra of polymers – Identification of labelled peaks in IR spectra of known polymer.

Text Books:

1. V. R. Gowarikar, Jayadev Sreedhar, N. V. Viswanathan, Polymer Science 1st Edition, New Age International Publishers, 1986.
2. Premamoy Ghosh, Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rdEdition, McGraw Hill Education, 2010.
3. P. Bahadur & N.V.Sastry, Principles of polymer science, Narosa Publishing house, New Delhi2002.

Reference books

1. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
2. Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)
3. Seymour/Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).
4. Nayak P.L., Polymer Chemistry, Kalyani Publisher (2017).
5. Hundiwale G.D., Athawale V.D., Kapadi U.R. and Gite V. V., Experiments in Polymer Science, New Age Publications (2009).

PAPER-XVIII
Green Chemistry

Course Title	Code	Credit	Credit distribution	
			Lecture	Practical
Green Chemistry		04	03	01

Course Objectives:

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuit of the goals of Green Chemistry, Principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles.

Course outcomes:

1. Discuss about the role of principles of green chemistry.
2. Explain the importance of green synthesis.
3. Interpret the knowledge of prevention of hazardous chemicals in reactions.
4. Evaluate the efficiency of green catalysts & interpret the use of biocatalysts.

SYLLABUS

Lecture-Credit 03 (45 hours)

UNIT-I (13 hr)

Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Principles of Green Chemistry and Designing a Chemical synthesis-I

Twelve principles of Green Chemistry. Explanations of principle with special emphasis on - Designing green synthesis processes: Prevention of Waste/ by-products; maximize the incorporation of the materials used in the process into the final products (Atom Economy) with reference to rearrangement, addition, substitution and elimination reactions; Prevention/ minimization of hazardous/ toxic products; Designing safer chemicals; Use of safer solvents and auxiliaries (e.g. separating agent) - green solvents (supercritical CO_2, water, ionic liquids), solventless processes, immobilized solvents.

UNIT-II (10 hr)

Principles of Green Chemistry and Designing a Chemical synthesis-II

Explanation of green chemistry principles with special emphasis on: Energy efficient processes for synthesis - use of microwaves and ultrasonic energy. Selection of starting materials (use of renewable feedstock); avoidance of unnecessary derivatization (e.g. blocking group, protection groups, deprotection); Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products use of chemically safer substances for prevention of chemical accidents, inherent safer design greener - alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol); real-time, in-process monitoring and control to prevent the formation of hazardous substances; development of green analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

UNIT-III (10 hr)

Examples of Green Synthesis/ Reactions and some real-world cases-I

Green Synthesis of the following compounds: adipic acid, catechol, methyl methacrylate, urethane, disodium iminodiacetate (alternative to Strecker synthesis), paracetamol, furfural.

Microwave assisted reactions: Applications to reactions (i) in water: Hofmann Elimination, hydrolysis (of benzyl chloride, methyl benzoate to benzoic acid), Oxidation (of toluene, alcohols); (ii) reactions in organic solvents: Diels-Alder reaction and Decarboxylation reaction.

Ultrasound assisted reactions: Applications to esterification, saponification, Simmons-Smith Reaction (Ultrasonic alternative to Iodine).

UNIT-IV (12 hr)

Examples of Green Synthesis/ Reactions and some real-world cases-II

Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments; Designing of Environmentally safe marine antifoulant; Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments; Synthesis of a compostable and widely applicable plastic (poly lactic acid) from

corn; Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

Future Trends in Green Chemistry

Oxidizing and reducing reagents and catalysts; multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Green chemistry in sustainable development. (Bio-diesel, bio-ethanol and biogas).

LAB WORK
Credit 01 (15 classes of 2 hours each)

List of experiments

1. Acetylation of primary amine (Aniline to N-phenylacetamide) using Zn dust.
2. Nitration of salicylic acid by green method (Using calcium nitrate and acetic acid).
3. Bromination of acetanilide using ceric ammonium nitrate/KBr.
4. Microwave assisted nitration of Phenols using $Cu(NO_3)_2$.
5. Detection of elements in organic compounds by green method (Sodium carbonate fusion)
6. Base catalyzed Aldol condensation (Synthesis of dibenzalpropanone)
7. Vitamin C clock reaction using vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch. Effect of concentration on clock reaction.
8. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
9. Diels Alder reaction in water: Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.
10. Preparation and characterization of nanoparticles (Cu,Ag) using plant extract.

Text Books:

1. P.T. Anastas & J.K. Warner, Green Chemistry- Theory and Practical, Oxford University Press 2000.
2. V.K. Ahluwalia & M. Kidwai.: New Trends in Green Chemistry, Anamalaya Publishers, New Delhi 2004.
3. V. Kumar An Introduction to Green Chemistry, Vishal Publishing Co., 2015.

Reference Books:

1. A.S. Matlack. Introduction to Green Chemistry, Marcel Dekker 2001.
2. A K. Das and M. Das, Environment Chemistry with Green Chemistry, Books and Allied (P) Ltd. 2010.
3. R.K. Sharma, I.T. Sidhwani &, M.K Chaudhari. I.K. *Green Chemistry Experiment:A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN978-93-81141-55-7, 2013.

E-Contents: The supporting materials can be found on the **website of the Berkeley Center for Green Chemistry** (**http://bcgc.berkeley.edu/)**.

Case Study: https://shorturl.at/cjuHI

Paper-XIX
Oxidation, Reduction, Reagents, Rearrangements and Name Reactions

Course Title	Code	Credit	Credit Distribution	
			Lecture	Practical
Oxidation, Reduction, Reagents, Rearrangements and Name Reactions		04	04	-

Unit-I:
Oxidation Reactions (17 hrs)
Oxidation of (a) alcohols to carbonyls by chromium, manganese, aluminium, silver, ruthenium, DMSO, hypervalent iodine and TEMPO based reagents, (b) alkenes to epoxides by peroxides/per acids, Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation (c) alkenes to carbonyls with bond cleavage by Manganese, Osmium, Ruthenium and lead based oxidants and ozonolysis (d) alkenes to alcohols/carbonyls without bond cleavage, Wacker oxidation, selenium, chromium based allylic oxidation process.

Unit-I:
Reduction Reactions (17 hrs)
Reduction reactions (a) in heterogeneous medium by Palladium/Platinum/Rhodium/Nickel (Resenmund reduction) and in homogeneous medium (Wilkinson reaction). Noyori asymmetric hydrogenation. (b) Metal based reductions using Li/Na in liquid ammonia (Birch reduction), Sodium, Magnesium, Zinc, Titanium and Samarium. (c) Reduction by hydride transfer reagents: Aluminium alkoxide, Sodium borohydride ($NaBH_4$), di-isobutylaluminium hydride (DIBAL-H), Sodium cyanoborodydride, Lithium trialkylborohydride, reduction with hydrazine (Wolff-Kischner reduction), reduction with trialkyltinhydride.

Unit-III:
Reagents in Organic Synthesis (13 hrs)
Functionalized Grignard reagents, organozinc, organo-lithium, organocopper, organopalladium, lithium diisopropylamide (LDA), Dicyclohexylcarbodiimide (DCC), organosilicon, organoborane, organotin, crown ethers, Dichlorodicyano benzoquinone (DDQ), Osmium tetroxide, 1,3-Dithiane, Trimethyl silyl iodide, Tri-n-butyl tin hydride.

Unit-IV:
Rearrangement and Name Reactions (13 hrs)
Nature of migration and migratory aptitude of groups in rearrangements reaction, Wagner-Meerwein, Favorskii, Fries, Benzil-Benzilic acid, Arndt-Eistert synthesis, Neber, Beckmann, Hofmann, Schmidt, Lossen, Shapiro reaction, Von-Richter, Sommelet-Hauser rearrangement, Wolff, Stevens reaction.

Recommended Textbooks

1. S. N. Sanyal, Reactions, Rearrangements and Reagents, 4th Ed., Bharati Bhawan Publishers & Distributors, 2019.
2. R. K. Bansal, Organic Reaction Mechanism, 3rd Ed., Tata McGraw-Hill Publications, 1998.
3. R. K. Bansal, Synthetic Approaches in Organic Chemistry, Narosa Publishing House, India, 1996.

Reference Books:

1. W. Carruthares, I. Coldham, Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, 2015.
2. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part-A and Part-B, 5th Ed., Springer 2007.
3. J. March, M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Ed., Wiley, 2013.
4. I. L. Finar, Organic Chemistry, Vol-2, 5th Ed., Pearson Publisher, 2002.
5. R. O. C. Norman, J. M. Coxon, Principle of Organic Synthesis, 3rd Ed., CRC Press, 2017.

PAPER-XX

Quantum chemistry & Statistical Thermodynamics

Course Title	Code	Credit	Credit distribution of the course	
			Lecture	Practical
Quantum chemistry & Statistical Thermodynamics		04	04	00

Course Objectives:

This course is offered by School of Chemistry as a core subject for the B.Sc. programme, with an emphasis on fundamental understanding of Quantum chemistry, molecular spectroscopy, and photochemistry. Students are expected to have background knowledge in mathematics up to the +2 level for this course. The objective of the practical is to develop skills for working in physical chemistry laboratory. The student will perform experiments based on the concepts learnt in Physical chemistry-V course.

Course Outcomes:

By the end of the course, the students will be able to:

1. Understand the approximation method encompassing Linear variation principle, perturbation theory.
2. Apply HMO to different conjugated systems.
3. Acquire a firm knowledge of statistical methods, Ensambles, and apply the concept of molecular partition functions to macroscopic systems.
4. Compare the thermodynamic properties of different statistics.

SYLLABUS

Lecture-Credit 04 (60 hours)

UNIT-I: (15 hours)

Approximation Methods: The variation theorem, linear variation principle, Perturbation theory (first order and non-degenerate). Applications of variation method and perturbation theory to the Helium atom.

UNIT-II: (15 hours)

Huckel theory of conjugated systems, Calculation of π-bond energy, delocalization energy, electronic & charge density calculation, and bond order. Applications to ethylene, butadiene, cyclopropenyl radical, and cyclobutadiene.

UNIT-III: (15 hours)

Fundamentals of Statistical methods, Starling's approximation, Statistical Thermodynamics: mathematical & thermodynamic probability. Maxwell Boltzman distribution between partition function. Types of Partition functions: translational, rotational, vibrational and electronic partition functions.

UNIT-IV: (15 hours)

Types of Statistics- Bose-Einstein statistics, Maxwell-Boltzman, Fermi-Dirac statistics. Calculation of results of three types of statistics.

Text Books:

1. D. A. McQuarrie, Quantum Chemistry, Viva Books, Reprint, 2011, Indian Student Edition
2. Statistical Thermodynamics: M. C. Gupta, New Age Pvt Publication
3. Statistical Mechanics and Thermodynamics, C. Garrod, Oxford Univ. Press, New York.

Reference Book:

1. Atkin's Physical Chemistry: P. W. Atkins, J. D. Paula, Oxford University Press
2. Statistical Mechanics, D. A. McQuarrie, University Science Books, California.
3. Statistical Mechanics - A Concise Introduction for Chemists B. Widom, Cambridge University Press

PAPER-XXI
Chemical group theory, electronic spectra of metal complexes, and nuclear chemistry

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Chemical group theory, electronic spectra of metal complexes, and nuclear chemistry		04	03	01

Course Objectives:

To provide basic knowledge on symmetry of molecules applied through mathematical group theory. Gives idea about the electronic transitions between d-orbitals, L-S coupling, qualitative Orgel diagrams for different d^n systems, selection rules for electronic spectral transitions, charge transfer phenomena, Nuclear chemistry has been introduced to inculcate students about the chemistry of inner core of atoms. Lab work has been designed for preparing key inorganic compounds and estimating important ingredients of day-to-day use in a product in order to make students competent in this regard.

Course Outcomes:

1. Learn a significant knowledge on formal group theory for understanding molecular spectroscopy.
2. Explore the fundamentals of electronic spectra of coordination complexes.
3. Understand the stability of nucleus and its reactions, and the applications of radioisotopes in different fields.
4. Achieve the knowledge on quantitative estimation of important ingredients in various commonly used products, and also get the synthetic skills of preparing key inorganic compounds

SYLLABUS

(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

UNIT – I (12 Hours)
Fundamentals of group theory

Symmetry operation, symmetry element, classification of symmetry elements, definition of group, subgroup, cyclic groups, molecular point groups, group multiplication table, group generators, symmetry of platonic solids, conjugacy relation and classes, matrix representation of symmetry elements.

UNIT – II (11 Hours)

Character table and normal modes

Character of a representation, reducible and irreducible representation, Great orthogonality theorem (qualitative description only), properties of irreducible representation. Character table (explanation and significance), construction of character tables for C_{2v} and C_{3v} point groups, direct product, standard reduction formula, Normal modes for C_{2v} and C_{3v} molecules.

UNIT – III (11 Hours)

Electronic spectra of metal complexes

Electronic transitions between d-orbitals, L-S coupling, Orgel diagrams for $3d^1$ to $3d^9$ ions. Selection rules for electronic spectral transitions, relaxation in selection rules. spectrochemical series of ligands, nephelauxetic series, Evaluation of Dq, B and beta (β) parameters for the complex, charge transfer spectra (elementary idea). Significance of Tanabe-Sugano diagram.

UNIT – IV (11 Hours)

Nuclear Chemistry

Nuclear stability, magic numbers, radioactivity, general characteristics of radioactive decay particles, decay kinetics, nuclear reaction, Bethe's notation, types of nuclear reaction, nuclear cross section, compound nuclear theory, nuclear fission, liquid drop model, shell model, hard core preformation theory, fission fragments and their mass distribution, charge distribution, ionic charge of fission fragments, working principle of nuclear reactor, concept of boron-neutron capture therapy, concept of nuclear fusion.

Lab work

(C L P = 1 0 1; Total Hours = 15 x 2 = 30)

(Laboratory periods: 30 Hours, 15 classes of 2 hours each)

List of experiments:

1. Estimation of iodine in iodized common salt iodometrically
2. Estimation of phosphoric acid in cola drinks by molybdenum blue method
3. Preparation of potash alum from scrap aluminum
4. Preparation of potassium of trioxalatoferrate (III) trihydrate, $K_3[Fe(C_2O_4)_3].3H_2O$
5. Determination of alkali content in antacid tablet using HCl
6. Determination of acetic acid in commercial vinegar

Text Books:

1. K. V. Ready, Symmetry and Spectroscopy of Molecules, New Age Int. Publishers, 2nd Ed, 2009.
2. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age International Pvt. Ltd., 4th Ed. 2011.
3. A. Sakthivel , D. T. Masram, M. Sathiyendiran, S. Kaur-Ghumaan, Electronic and Magnetic Properties of Transition and Inner Transition Elements and Their Complexes, Publish with Nova Science Publishers, 2017.

Reference Books:

1. F. A. Cotton, Chemical Applications of Group Theory, Wiley India (P) Ltd., 3rd Ed, 2009.
2. G. L. Miessler, P. J. Fischer, D. A. Tarr, Inorganic chemistry, 5th Ed., 2014.
3. D. E. Shriver, P. W. Atkins, Inorganic Chemistry, Oxford University Press, 5th Edn.
4. D. Gabel, R. Moss, Boron Neutron Capture Therapy: Toward Clinical Trials of Glioma Treatment, Springer-Verlag New York Inc., 1st Ed, 2012.
5. A. J. Elias, General Chemistry Experiments, University Press, 2007.
6. Y. R. Sharma, Modern Approach to Practical Chemistry, Kalyani Publishers, 2008.
7. Vogel's Qualitative Inorganic Analysis, 7th Ed, Revised by G. Svehela, 4th Ed., Person, 2007.

Paper-XXII
Pericyclic reactions, Photochemistry and Retrosynthesis

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Pericyclic reactions, Photochemistry and Retrosynthesis		04	03	01

Syllabus
Lecture-Credit-03 (45 Hrs)

Course Objective

Imparting knowledge in the theory and applications of various aspects of pericyclic reactions and photochemistry and synthetic aptitutde of organic molecules. It will also help to understand the synthesis and mechanisms of various reactions.

Course Outcome

1. Understand the concepts related to organic synthesis, mechanisms.
2. Apply their understanding about the photochemical reactions of industrial significance.
3. Evaluate the photochemical reactions based on the influence of the substituents on substrate
4. molecules.
5. Design new photochemical reactions in order to achieve the required product(s).

Unit-I:

Pericyclic Reaction-I: **(8 hrs)**

Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann rules, Correlation diagrams, FMO and PMO approaches. Electrocyclic reactions - Conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems.

Unit-II:

Pericyclic Reaction-II: **(12 hrs)**

Cycloaddition reactions - suprafacial and antarafacial additions, 4n and 4n+2 systems, Correlation diagrams and FMO method, Allowed and forbidden reactions. Diels-Alder reactions: retro Diels-Alder reaction- FMO mechanism for endo- and exo-selectivity, stereochemistry, inter- and intramolecular reactions.

Sigmatropic rearrangements: [i,j] H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations, Sommelet-Hauser, Claisen, thio-Claisen, Cope, Oxa and aza-Cope rearrangements, Ene reaction.

Unit-III:

Photochemistry: **(12 hrs)**

First order Photochemical processes Light absorption, Fluorescence and Phosphorescence. Photochemistry of Alkene: Isomerization, Intramolecular reactions of the olefinic bond,di-π-methane, oxa di-π- and aza di-π-methane rearrangements, Photochemistry of vision. Photochemistry of Carbonyl compounds: Norrish type I and II reaction, Paterno-Buchi reaction, Photoreduction. Photochemistry of Arenes: Photochemical aromatic substitution, addition and isomerisation reaction. Photo-Fries reactions of anilides, Barton reaction, the mechanisms of reactions involving free radicals- Sandmayer, Gomberg- Bachmann, Pschorr, Ulmann and Hunsdiecker reactions. Singlet molecular oxygen reactions.

Unit-IV:

Retrosynthesis: (13hrs)

An introduction to synthons and synthetic equivalents, disconnection approach, functional group interconversions, the importance of the order of events in organic synthesis. one group C-X and two group C-X disconnections, chemo selectivity, reversal of polarity, cyclisation reactions. One Group C-C disconnection: Alcohols and carbonyl compounds, regioselectivity, Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. Two group C-C Disconnections:

Diels-Alder reaction, 1,3-difunctionalised compounds, α, β- unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds. Michael addition and Robinson annulation. Protecting Groups, Principle of protection of alcohol, amine, carbonyl and carboxyl groups.

LAB WORK

Credit-01 (15 classes of 2 hours each)

List of Experiments

(1) Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

(2) Diels Alder reaction in water: Reaction between furan and maleic acid in water at room temperature rather than in benzene under reflux condition.

(3) Preparations of the following compounds: Aspirin/Paracetamol/Barbituric acid/
(4) Synthesis of methyl orange.
(5) Synthesis of amide derivative from carboxylic acid and amine or from esters
(6) Synthesis of esters by refluxing glacial acetic acid and ethanol in presence of sulphuric acid.

(7) Retrosynthetic analysis of biomolecules.

Textbooks

1. S. Warren, P. Wyatt, Organic synthesis, the disconnection approach, 2nd Ed., Wiley, 2012.
2. J. Singh, J Singh, Photochemistry and Pericyclic Reactions, New Age Science, 2009.
3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson Education India, 2003.

Reference Books:

1. S. Kumar, V. Kumar, S. P. Singh, Pericyclic Reactions: A Mechanistic and Problem-SolvingApproach, Academic Press, 2015.
2. W. Carruthares, I. Coldham, Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press, 2015.
3. J. March, M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Ed., Wiley, 2013.
4. R. K. Bansal, Organic Reaction Mechanism, 3rd Ed., Tata McGraw-Hill Publications, 1998.
5. R. K. Bansal, Synthetic Approaches in Organic Chemistry, Narosa Publishing House, India, 1996.
6. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., Oxford Publisher, 2012.
7. T. L. Gilchrist, R. C. Storr, Organic Reactions and Orbital Symmetry, 2nd Ed., Cambridge University Press, 1979.
8. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part-A and Part-B, 5th Ed., Springer 2007.
9. I. L. Finar, Organic Chemistry Vol. I & Vol. II, Longman, Cambridge, 2011.

PAPER-XXIII

Research Methodology for Chemistry

Course Title	Code	Credit	Credit distribution	
			Lecture	Practical
Research Methodology for Chemistry		04	04	00

Course Objectives:

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

Course Outcomes:

By the end of the course, the students will be able to:

1. Follow ethical practices in chemistry
2. Do Data analysis
3. Literature survey in different modes
4. Use e-resources.
5. Avoid plagiarism, understand the consequences and how to avoid

SYLLABUS

Lecture-Credit 04 (60 hours)

UNIT-I: (15 hours)

Scope of Research, Research Databases and Metrics

Define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, importance and future scope. **Print Database (traditional)**: Sources of information: Primary, secondary, tertiary sources; **Digital: Databases (modern source):** Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; **EBSCO:** e-Resources Gateway for Universities of Odisha (odisha university | OSHEC | e-Resources for Universities and Colleges of Odisha); **Research metrics**: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index; **Author identifiers/ profiles:** ORCID, Publons, Google Scholar, ResearchGate, VIDWAN.

UNIT-II: (10 hours)

Statistical tools and validation for chemists

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

UNIT-III: (15 hours)

Research and Publication ethics:

Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Drillbit/Urkund etc), redundant publications; **Publication Ethics:** Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, **publication misconduct:** problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals; **IPR** - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS)

UNIT-IV: (20 hours)

Science Communications:

Types of scientific documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis; Thesis writing – Windows and/or linux operating system, programming fundamentals, basics of high level programming language-C: editing, compilation and running a programme, storing data, elementary numerical methods, different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes; Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

Text Books:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment. Fourth Ed., Chapman Hall, London.

Reference Book:

1. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
2. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
3. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992. OSU safety manual 1.01

E-Contents:

1. Google Scholar
2. Scopus preview - Scopus - Welcome to Scopus
3. Web of Science
4. CAS Insights | CAS
5. Reveal online attention to research - Altmetric
6. odisha university | OSHEC | e-Resources for Universities and Colleges of Odisha

MDC BASKET

MDC-I: Biochemistry

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Biochemistry		03	03	0

Course Objectives:

The objective of this course is to familiarize the student with various biomolecules interacting with metal ions, biomolecular catalysis, and to get knowledge about the metabolism of various biomolecules.

Course Outcomes

1. Imparting knowledge on various metal ions involved in biological processes.
2. Understanding the principle of catalysis and energetics in complex biochemical reactions.
3. Understanding of various enzymes and their functions in biology.
4. Gaining knowledge on metabolism of dietary and endogenous bio-macromolecules.

Unit-I:
Metal ions in biology (15 hrs)
General introduction to important metal ions (Na, K, Mg, Ca, Cu, Fe, Zn, Co and Mo) and their functions, passive and active transport processes, Na+ /K+ pump, calcium pump, ionophores. Storage and transport of iron, copper and zinc. Siderophores, ferritin and transferrin in regard to iron-storage and transportation. Chemistry of porphyrin, iron porphyrins (heme proteins): hemoglobin (Hb), myoglobin (Mb) and their behavior as oxygen carrier, O2 affinity, cooperativity and Bohr's effect, heme protein as electron carrier with particular reference to cytochrome-c and cytochrome-450, and cytochrome oxidase. Non-heme iron-sulphur protein as electron carrier (rubredoxins and ferredoxin). Non-heme oxygen uptake protein (hemerythrin and hemocyanin). Chemistry of chlorophyll: Photosynthesis, the light and dark reaction.

Unit-II:
Biomolecular Catalysis (8 hrs)
Metal-activated enzyme and metalloenzyme. Biological significance and mechanistic aspects of carboxypeptidase, carbonic anhydrase, blue-oxidases, non-blue oxidases, superoxide dismutase, Catalases, peroxidases, structure and biological functions of molybdenum nitrogenase.

Unit-III:
Basic Bioorganic chemistry (11 hrs)
Basic considerations, proximity effects in organic chemistry, molecular adaptation- Bio-isosterism, molecular recognition at the supra molecular level. Examples of some typical enzyme mechanism: chymotrypsin, ribonuclease, lysozyme. Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, Thiamine pyrophosphate, pyridoxal phosphate, NAD^+, $NADP^+$, FMN, FAD,

lipoic acid, Vitamin B_{12}.
Mechanism of reactions catalyzed by cofactors. A Nucleophilic displacement on a phosphorous atom, multiple displacement reaction and coupling of ATP cleavage to endergonic processes, transfer of sulphate, addition and elimination reactions, enolic intermediates in the isomerization reactions, β cleavage and condensation, isomerization, rearrangement, carboxylation, decarboxylation.

Unit-IV:
Metabolism of biomolecules (11 hrs)
Nutritive roles of carbohydrates, lipids, amino acids and proteins and their sources in various foods. Digestion, absorption, transportation and metabolism of carbohydrates (glycolysis, citric acid cycle, glycogenesis, glycogenolysis, gluconeogenesis, hexose monophosphate pathway, Blood sugar level and equilibrium), lipids (oxidation of fatty acids, fatty acid synthesis), proteins (transamination and deamination of protein, urea cycle, nitrogen balance, biosynthesis of proteins) Importance of cholesterol, phospholipids and lipoproteins in human health. Energy metabolism energy requirement, respiratory quotient, calorific value of food, standard calorific content of food types.

Textbooks

1. A. Das, A. K. Das, Mahua Das, Bioinorganic Chemistry, Books and Allied Pvt. Ltd., 2017.
2. P. S. Kalsi and J. P. Kalsi, Bioorganic, Bioinorganic and Supramolecular Chemistry, New Age Publications 3rdEdition 2017
3. Bio-organic Chemistry, Harish Kumar and Parmjit S. Panesar, published by Narosa Publishing House Pvt. Ltd., New Delhi, 2012.

Reference Books:

1. John E. McMurry and Tadhg P. Begley, The Organic Chemistry of Biological Pathways, 2nd Editions
2. Kurt Faber, Bio-transformations in Organic Chemistry, 7th Edition, Springer
3. An Introduction to Medicinal Chemistry- Vth Edition Graham L Patrick (Qxford 2013).
4. Burger's Medicinal Chemistry & Drug discovery, Vol 1-3, 15th Ed, 2014.
5. Bioorganic Chemistry, A chemical Approach to Enzyme action, Hermann Dugas and C. Penny Springer Verlag

MDC-II: Environmental Chemistry

Course Title	Code	Credit	Credit Distribution of the course	
			Lecture	Practical
Environmental Chemistry		03	03	0

Course Objectives:

The objectives of a course in environmental chemistry typically aim to provide students with a deep understanding of the chemical processes occurring in the environment and their impacts on ecosystems, human health, and the planet as a wholewith a comprehensive understanding of the components and processes of environmental systems, including the atmosphere, hydrosphere, lithosphere, and biosphere, and their interactions. Investigation of the chemical composition of environmental compartments, including the atmosphere (air pollutants), hydrosphere (water pollutants), and lithosphere (soil pollutants), and the sources, fate, and transport of pollutants in these compartments. To examine the chemical properties and toxicological effects of environmental pollutants on ecosystems and human health, including acute and chronic toxicity, bioaccumulation, biomagnification, and risk assessment.

Course outcomes:

1. gain a comprehensive understanding of the chemical processes occurring in the environment, including the sources, fate, and transport of pollutants
2. develop analytical skills in environmental chemistry, and apply a range of analytical techniques for the detection, and characterization of environmental pollutants.
3. aware of global environmental issues and challenges such as climate change, pollution, biodiversity loss, and resource depletion.
4. apply the principles of environmental chemistry for mitigating environmental pollution, promoting environmental conservation, and contributing to the development of environmentally friendly technologies and policies.

UNIT I (15 hr)

Environment Introduction, Composition of atmosphere, vertical temperature, heat budget of the earth atmospheric system, vertical stability atmosphere, Biogeochemical Cycles of C, N, P, S and O. Biodistribution of elements.Hydrosphere Chemical composition of water bodies-takes, streams, rivers and wet lands etc. Hydrological cycle. Aquatic pollution-inorganic, organic, pesticide agricultural, industrial and sewage, detergents, oil spills and oil pollutants. Water quality parameters- dissolved oxygen, biochemical oxygen demand, solids, metalsm, content of chloride, sulphate, phosphate, nitrate and mocro-organisms. Water quality standards, Analytical methods for measuring BOD, DO, COD, F, oils,metals (As, Cd, Cr, Hg, Pb, Se etc)residual chloride and chlorine demand. Purification and treatment of water.

UNIT II (15 hr)

Soils composition, micro and macro nutrients, pollution-fertilizers, pesticides, plastics and metals, waste treatment Atmosphere Chemical composition of atmosphere-particles, ions and radicals and their formation. Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals, chlorofluorohydrocarbons. Greenhouse effect, acid rain, air pollution controls and their chemistry. Analytical methods for measuring air pollutants. Continuous monitoring instruments.

UNIT III (8 hr)

Industrial Pollution Cement, Sugar, distillery, drug, paper and pulp, thermal power plants, nuclear power plants, metallurgy. Polymers, drugs etc. Radionuclide analysis. Disposal of wastes and their management.

UNIT IV (7 hr)

Environmental Toxicology, Chemical solutions to environmental problems, biodegradability, principles of decomposition.

Text Books

1. Environmental Chemistry, A. K. De, Wiley Eastern
2. Environmental Chemistry, S.E. Manahan, Lewis Publishers
3. Environmental Chemistry with Green Chemistry, A. K. Das, Books & Allied (P) Ltd., Kolkata, 1st Edn, 2010

References Books

1. Environmental Chemistry, S.E. Manahan, Lewis Publishers
2. Environmental Chemistry with Green Chemistry, A. K. Das, Books & Allied (P) Ltd., Kolkata, 1st Edn, 2010
3. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication
4. Erach Bharucha. Textbook of Environmental Studies, Universities Press, 2005

MDC-III: Biophysical chemistry

Course Title	Code	Credit	Credit Distribution	
			Lecture	Practical
Biophysical chemistry		03	3	0

Course Objectives:

To provide students with anUnderstanding Molecular Interactions,To learn quantitative techniques and methods for studying biomolecular systems,Thermodynamics and Kinetics of Biological Processes, Structural Biology,Membrane Biophysics, To explore the applications of biophysical chemistry in various fields such as drug discovery, protein engineering, biotechnology, and medical diagnostics.

Course outcomes:

1. The students will acquire knowledge of structure and biological functions of proteins and enzyme.
2. Students will acquire knowledge The structure of nucleic acids and their interaction with proteins.
3. Acquire the firm knowledge of the antibody generation and drug discovery approach.
4. The will also provide students an opportunity to know about the principles and applications of latest methods used to analyse amino acid and proteins.

Syllabus

Unit I: Fundamentals of Biological Macromolecules (10 hr)

Structure and physical properties of amino acids, classification, structure, function, and folding of proteins, internal rotational angle, conformations of proteins: Ramachandran plot, secondary, tertiary and quaternary structure. Structures of nucleic acids, Properties of nucleosides and nucleotides; composition of nucleic acids, Stabilizing interactions in biomolecules.

Unit II: Molecular Interaction, thermodynamics, and kinetics of biological systems (13 hr)

Intermolecular interactions, Review of biomolecular structure and function. Recombinant DNA technology and protein purification, Molecular recognition, Techniques to probe binding interactions, Allostery and cooperativity, Protein-protein interactions, Modular interactions in cell signalling, Kinases: activation and regulation, thermodynamics and kinetics as they apply to biological systems, study of equilibrium constants, reaction rates, and the energetics of biochemical reactions.

Unit III: Antibodies and Cell signalling (12 hr)

Drug discovery approach, Antibodies and generation of synthetic antibodies, NMR spectroscopy: structure and dynamics, Magnetic resonance imaging, Protein folding and techniques to probe folding, intrinsically disordered proteins, Folding in cells: chaperones, Biophysics of cell membranes and membrane proteins, Cell signalling through GPCRs, Molecular transport; application to single molecule FRET.

Unit IV: Biophysical techniques for the Structural and Conformational Analysis (10 hr)

General principle and qualitative treatment of the techniques to understand the structure and characteristics of enzymes, protein and nucleic acid: X-ray crystallography – protein crystals, myoglobin, nitrogenase, pepsinogen; NMR spectroscopy-NMR spectra of amino acids, UV-vis absorption spectroscopy, Fluorescence spectroscopy and Vibrational spectroscopy. Determination of protein structures by spectroscopic methods (FTIR, NMR), thermodynamics of protein folding by spectroscopic methods, protein conformational study by NMR and fluorescence spectroscopy. Methods for the separation of biomolecules: General principles, including Chromatography; Sedimentation, Moving Boundary Sedimentation, Electrophoresis, Isoelectric focusing.

Text Books:

1. Lesk, A.M., Introduction to Protein Science: Architecture, Function, and Genomics, 2nd edition, 2010, Oxford University Press.

2. Cantor, C.R. and Schimmel, P.R., Biophysical Chemistry, 1980, Freeman.

3. Van Holde, K.E., Johnson, W.C. and Ho, P.S., Principles of Physical Biochemistry, 2nded, 2006, Pearson Education.

Reference Books:

1. Harding, S.E. and Chowdhry, B. Z. Protein-Ligand Interactions, Oxford University Press.
2. Principles of Biochemistry, Lehninger, 8th edition, W H Freeman & Co
3. Biochemistry by Stryer, 9th edition, W H Freeman & Co
4. Molecular Cell Biology, Harvey Lodish, 9th edition, W H Freeman & Co 5. Fundamentals of Biochemistry Voet and Voet, 6th Edition Wiley

SEC BASKETS

SEC-I: Computational Chemistry and Molecular Modelling

Course Title	Code	Credit	Credit Distribution	
			Lecture	Practical
Computational Chemistry and Molecular Modelling		03	3	0

Course Objectives:

The objectives of a course in environmental chemistry typically aim to make students learn the theoretical background of computational techniques in molecular modelling. To give the different flavours of computational chemistry by the end of this course. To provide hands-on experience in molecular modelling on various software.

Course outcomes:

1. Explain the theoretical background of computational techniques and selective application to various molecular systems.
2. Compare computational and experimental results and explain deviations.
3. Perform Optimization of geometry parameters of a molecule (such as shape, bond length and bond angle) through the use of software like Chem Sketch and Argus Lab in interesting hands-on exercises.
4. Perform analysis of molecular properties using various software.

UNIT I (10 hr)

Molecular mechanics – Vibrational motion, normal modes of vibration, the quantum mechanical treatment, the taylor expansion, the morse potential, more advanced empirical potential, molecular mechanics, professional molecular mechanics force fields, a sample MM calculation, General features of potential energy surfaces.

UNIT II (12 hr)

The LCAO procedure, the electronic energy, the koopmans theorem, open-shell system, unrestricted Hartree-Fock theory, the J and K operator, Bond lengths and the Huckel model, molecular mechanics and pi-electron systems, alternant hydrocarbons, treatment of heteroatoms, Extended Huckel theory.

UNIT III (13 hr)

Basic sets – Introduction, the energy calculation from the STO function, the energy calculation of multielectron systems, Gaussian type orbitals, Difference between STOs & GTOs, classifications of basis sets, A comparison of energy calculation of the Hydrogen atoms based on STO-2G, STO-3G & STO-^G basis sets, contracted Gaussian type orbitals, Double and Zeta basis sets and split Valence basis sets, polarized basis sets.

UNIT IV (10 hr)

Semiempirical methods – Introduction, NDO, CNDO, MNDO, AM1 & PM3 methods, Ab Intio Method – Introduction, level of theory, geometry input, An Ab-intio HF-LCAO calculation, computation of the correlation energy, Density Functional Theory – Introduction, electron density, pair density, development of DFT, the kohn and Sham method, density functionals, the Lee, Yang and Parr correlation energy functional and the potentials, DFT methods, application of DFT method.

Text Books

1. Alan Hinchliffe, Modelling Molecular structures, John Wiley & sons, ltd
2. Lewars, E. (2003), **Computational Chemistry**, Kluwer academic Publisher.
3. Cramer, C.J. (2004), **Essentials of Computational Chemistry**, John Wiley & Sons.

References Books

1. Electron Density theory of atoms and molecules-N. H. March, Academic press, London
2. Hinchcliffe, A. (1996), **Modelling Molecular Structures**, John Wiley & Sons.
3. Leach, A.R. (2001), **Molecular Modelling**, Prentice-Hall.
4. House, J.E. (2004), **Fundamentals of Quantum Chemistry**, 2nd Edition, Elsevier.
5. McQuarrie, D.A. (2016), **Quantum Chemistry**, Viva Books.
6. Levine, I. N.; **Physical Chemistry**, 5th Edition, McGraw –Hill.

E-content and tools available:

1. https://www.afs.enea.it/software/orca/orca_manual_4_2_1.pdf
2. https://dasher.wustl.edu/chem430/software/avogadro/learning-avogadro.pdf
3. http://www.arguslab.com/arguslab.com/ArgusLab.html
4. https://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf
5. https://gaussian.com/techsupport/
6. https://gaussian.com/man/
7. https://gaussian.com/wp-content/uploads/dl/gv6.pdf
8. https://dasher.wustl.edu/chem478/software/spartan-manual.pdf
9. http://www.mdtutorials.com/gmx/
10. https://vina.scripps.edu/manual/

SEC-II: Cosmetic and pharmacological chemistry

Course Title	Code	Credit	Credit Distribution	
			Lecture	Practical
Cosmetic and pharmacological chemistry		03	3	0

Course Objectives:

The objectives of a course aim at introducing the fundamental principles in pharmaceuticsand cosmetics alongside analytical techniques and basics in biological systems, cell biology, microbiology and physiology. This course will focus on design, formulation, manufacture and evaluation of pharmaceutical and cosmetic products. The final year willdelve deeper into more advanced and niche topics including drug design, personalised medicines, responsible innovation and sustainability.

Course outcomes:

Students after successful completion of the course will be able to:

1. Explain the principles of formulation and application of Cosmetics & perfumes.
2. Acquire a critical knowledge on synthetic techniques of drugs.
3. Demonstrate the skills in various aspects of the fermentation technology and apply for production.
4. Comprehend the applications offer mentation.

Syllabus: (45 hours)

Unit-I (10 hrs)

Chemistry of Cosmetics

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours.

Unit- II (12 hrs)

Chemistry of Perfumes

Essential oils and their importance in cosmetic industries with reference to Eugenol, Geranial, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmine, Civet one, Mascon.

Unit–III (10hrs)

Drugs & Pharmaceuticals – I

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, ibuprofen)

Unit–IV (13hrs)

Drugs & Pharmaceuticals - II

Synthesis of the representative drugs of the following classes: Antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glycerol triturate), antilaprosy (Daps one), HIV-AIDS related drugs (AZT-Zidovudine).

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B_2, Vitamin B_{12} and Vitamin C.

Text Books

1. A handbook of lndustrial Organic Chemistry by Samuel P Sadtler, JB Lippincott company.
2. Handbook Industrial Chemistry by Mohammad Farhat Ali Khan, First edition
3. Industrial Chemistry, E. Stocchi: Vol -I, Ellis Horwood Ltd. UK.

Reference Books:

1. Engineering Chemistry P.C. Jain, M. Jain:Dhanpat Rai & Sons, Delhi.
2. Industrial Chemistry, Sharma, B.K. & Gaur, Goel Publishing House, Meerut (1996)
3. Introduction to Medicinal Chemistry, G.L. Patrick: Oxford University Press, UK.
4. Medicinal and Pharmaceutical Chemistry, Hakishan, V.K. Kapoor: Vallabh Prakashan, Pitampura, New Delhi.
5. Principles of Medicinal Chemistry, William O. Foye, Thomas L., Lemke, David A. William: B.I. Waverly Pvt. Ltd. New Delhi.
6. Industrial Microbiology, 3rd Edition, JR Casida L.E. (2015New Age International (P) Limited Publishers, New Delhi, India.
7. Industrial Microbiology: An Introduction. 1st Edition, Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001) Blackwell Science, London, UK.
8. Microbiology. 5th Edition, Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) Tata McGraw-Hill Publishing Company Limited, New Delhi

SEC-III: Corrosion and prevention

Course Title	Code	Credit	Credit Distribution	
			Lecture	Practical
Cosmetic and pharmacological chemistry		03	3	0

Course Objectives:

Most of the industries such as chemical, mining and petroleum industries are facing the corrosion problems. In a recent survey made in India it was estimated that the annual loss due to corrosion is approximately 3 – 4% loss of the GDP. The course is offered to impart: Knowledge about the problem faced by industries, Develop understanding about the mechanism and process of corrosion, Knowledge about various methods for protection against corrosion. The scientific principles and methods that underlie the cause, detection, measurement, and prevention of many metal corrosion problems in engineering practice.

Course outcomes:

1. To obtain detailed understanding of corrosion science and technology, basic theory and correlation with materials degradations
2. Students should able to solve the problems related to corrosion analysis and to design a suitable material for causes
3. To examine corrosion reliability issue in industry using corrosion instrument and standards
4. Corrosion data interpretation, analysis, and integration and Understand the criteria for determining corrective action for high-level corrosion problems within various industrial systems

Syllabus

UNIT-I: (**10 hours**):

Definition of corrosion, Corrosion Damage, Classification of corrosion, Electrochemical Aspects, Electrochemical Reactions, Mixed Potential Theory

UNIT-II: (**15 hours**):

Polarization, Passivity, Environmental Effects, Effect of Oxygen and Oxidizers, Effect of Temperature, Effects of Corrosive Concentration, Effect of Galvanic Coupling Using Mixed Potential Theory

UNIT-III: (10 hours):

Corrosion Testing: Standard Expressions for Corrosion Rate, Galvanic corrosion, Erosion Corrosion, Crevice Corrosion, Intergranular Corrosion, Pitting, Stress Corrosion. Tafel and Linear Polarization, AC Impedance, Small-Amplitude Cyclic Voltammetry. Paint Tests, Sea Water Tests. Interpretation of Results

UNIT-IV (10 hours):

Materials Selection, Alteration of Environment, Design, Cathodic and Anodic Protection, Coatings, High-Temperature Corrosion and Mechanisms and Kinetics, High-Temperature Materials, Corrosion problems in selected industry

Text Books:

1. Mars G. Fontana, Corrosion Engineering, 3rd edition, McGraw-Hill Book Company, 1986
2. David Talbot and James Talbot, Corrosion Science and Technology, CRC Press, New York, 1998
3. H. H. Uhlig and R. W. Revie, Corrosion and Corrosion Control, Wiley (NY) (1985)

Reference Books:

1. K.E. Perumal and V.S. Raja, Corrosion Failures: Theory, Case Studies, and Solutions" 1st edition, John Wiley & Sons, USA
2. ASM Handbook Vol-13 (A, B & C)
3. ASTM and NACE standards for corrosion testing
4. R. G. Kelly, John R. Scully, D. W. Shoesmith, and R. G. Buchheit "Electrochemical Techniques in Corrosion Science and Engineering" 1st edition, CRC Press
5. Neil Birks, Gerald H. Meier, Frederick S. Pettit "High Temperature Oxidation and Corrosion of Metals" Cambridge University Press.

VAC BASKET

VAC-I: BASIC NUTRITION & FOOD CHEMISTRY

Course Title	Code	Credit	Credit Distribution	
			Lecture	Practical
Basic nutrition & food chemistry		03	3	0

Course Objectives:

The objective of this course is to enrich the subject knowledge of students in terms of relationship between nutrition and human well being as well as to understand the functions, importance of all nutrients for different age groups and special groups. This course is freshly designed which includes major and minor components of foods along with composition and properties of food.

Course Outcomes:

1. Understand the basic chemistry and classification of nutrition and vitamins
2. Gain knowledge on relationship between nutrition and health.
3. Brief discussion of Carbohydrates, Lipids, Proteins, Amino acids, Vitamins and Enzymes.

SYLLABUS

(CL P= 3 3 0; Total Hours = 15 x 3 = 45)

Unit-I: Nutrition I (12 hrs)

Introduction to nutrition –functions of foods, definition of nutrition, nutrients, adequate optimum and good nutrition, malnutrition. Food as a source of nutrients. Inter relationship between nutrition and health, visible symptoms of good health. Food guide-basic five food groups and usage of food guide. Use of food in body-digestion, absorption, transport, utilization of nutrients in the body.

Unit-II: Nutrition II (10hrs)

Water as a nutrient, function, sources, requirement, structure, water balance – effect of deficiency. Introduction to chemistry of water and ice. Moisture in food: Hydrogen bonding, Bound water, Free water, Water activity and Food stability. Energy – Unit of energy, food as a source of energy, energy value of food, the body's need for energy, B.M.R. activities. Utilization of food for energy requirements. Acid – base balance.

Unit-III: Food Chemistry I (13 hrs)

Carbohydrates- composition, classification, sources, functions, structure, physical & chemical properties. Other sweetening agents, functions of sugar in food (Browning reaction), changes during cooking and processing. Lipids – composition, nomenclature, saturated, unsaturated fatty acids, classification, food sources, functions of fats. Physical and chemical properties, emulsions, chemistry & technology of fat and oil processing. Role of food lipids in flavor Proteins – composition, classification sources, functions, denaturation, and protein deficiency, determination of protein quality. Amino acids – classification, Physio-chemical properties, modification of food protein through processing and storage. Enzymes. Nomenclature, specificity, catalytic regulations, kinetics factors influencing enzyme activity, controlling enzyme action. Enzyme added to food during processing, modification of food by endogenous enzyme. Enzyme inhibitors in food.

Unit-IV: Food Chemistry II (10 hrs)

Mineral functions, sources, Bio-availability, and deficiency of following minerals – calcium, Iron, Iodine, Fluorine, sodium, potassium. Vitamins – Classification, units of measurement, sources, functions and deficiency diseases caused by following vitamins: Fats soluble vitamins – Vitamin A, D, E and K. Water soluble vitamins – Vitamin C and B-complex Vitamins and minerals structure general causes of loss in food. Fortifications, Enrichment and Restoration. Pigments indigenous to food, structure, chemical and physical properties. Effect of processing and storage. Flavours – Vegetables, fruit and spice flavours, fermented food, Meat and sea food.

Text Books

1-Dr. D. V. Ahirrao and Dr. N. H. Desale A text Book of Food and Nutrition , Publisher : Harshwardhan Publication Pvt. Ltd. Limbaganesh, Dist. Beed (Maharashtra) Pin-431126.

1. Swaminathan, M. (2012). Advanced Text book on food and Nutrition, Vol. II. The Bangalore Printing And.

References Books

1. Damodran, S., Parkin, K.L and Fennema, D.R. (2007). Fennema's Food Chemistry. 4th edition. CRC Press.
2. Guthrie, H.A. (1983). Introductory nutrition. 5th Edition. Mosby, St. Louis.
3. Meyer, L.H. (2004). Food Chemistry. Textbook Publishers. ISBN: 0758149204.
4. Mudambi, S.R., Rao, S.M. and Rajagopal, M.V.(2006). Food science. 2nd Edition. New Age International publishers.
5. Mudambi, S.R and Rajgopal, M.V. (2001). Fundamentals of Foods and Nutrition. 4th Edition.new Age International Publishers.
6. Shakuntla, M.N and Shadaksharaswamy, M. (2013). Food Facts and Principles. New Age International.
7. Srilakshmi, B. Food science. 3rd Edition. NewAge International.
8. Willson, D. (1999). Evan Principles of Nutrition. 4th Edition. John Willey & Sons: New York.

VAC-II: Nanoscience and Nanotechnology

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Nanoscience and Nanotechnology		03	03	00

Course Objectives:

This course is based on the emerging area of nanotechnology that has the ability to transform techniques by which materials and products will be produced in the future with novel and superior properties to meet the global challenges. The goal of the course is to prepare and train students in this evolving technology which lies at the interfaces of chemistry, physics and biology. The course starts with fundamental concepts and then proceed to nanoscale phenomena and properties. Further, this is followed by discussions on the synthesis and methods for their characterization. Emerging and potential applications of nanomaterials are considered in the final segment of the course.

Course Outcomes:

1. Understand the basic principles of nanomaterials and nanotechnology.
2. Learn the synthesis and state-of-the-art characterization techniques for nanomaterials.
3. Achieve the knowledge on the stabilities of nanoparticles due to various factors and the idea on recent applications of nanomaterials.
4. Gain interest for opting research in the field of nanoscience in order to develop new functional nanomaterials and meet the current challenges of the society.

SYLLABUS
(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

Unit-I: Basics of nanomaterials (10 hr)

Dimension of nanoregime, concepts of nanoparticle, nanomaterial, quantum dot, nanoscience and nanotechnology, Types of nanomaterials: 0D-, 1D-, 2D- and 3D-nanomaterials, Nanocomposites, Concepts of magnetic- and superparamagnetic nanoparticles, Properties of nanomaterials due to the effect of size and surface energy.

Unit-II: Synthesis and characterization of nanomaterials (15 hr)

Concepts of top-down approach and bottom-up approach, Solution phase *vs.* vapour phase synthesis, Solution based chemical methods of synthesis of metal-nanoparticles (Au, Pd, Pt, Ag) and metal oxide nanoparticles (Fe_3O_4, ZnO), Use of reverse micelle in the synthesis of nanoparticle, Sol-gel process. Surface plasmon resonance, Use of some important techniques to characterize nanomaterials: FT-IR spectroscopy, UV-Visible spectroscopy, Zeta potential analysis, Dynamic light scattering (DLS) measurement, Scanning electron microscopy (SEM) analysis, Transmission electron microscopy (TEM) analysis and powder X-ray diffraction.

Unit-III: Stabilization of nanoparticles (10 hr)

Electrostatic stabilization: Origin of surface charge at the solid-liquid interface, zero-point charge and isoelectric point, electric double layer at the solid-liquid interface, Helmholtz model, Gouy model, Stern model, interaction between two nanoparticles involving electric double layer, interaction between two nanoparticles having surface charges. Caping agents and their role in the steric stabilization of nanoparticles.

Unit-IV: Applications of nanomaterials (10 hr)

Medical fields: Biosensing, drug delivery, dendrimer-based nanomedicine, MRI contrast agent, nanoscale device in medical treatment; Applications of nanomaterials in energy storage and energy conversion devices, Waste water treatment by using nanoparticles, Nanoparticle catalyzed oxidation of CO to CO_2.

Text Books:

1. A. K. Das, M. Das, An Introduction to Nanomaterials and Nanoscience, 1st Ed., CBS Publishers & Distributors Pvt. Ltd., 2017.
2. F. J. Owens, C. P. Poole Jr, The Physics and Chemistry of Nanosolids, Wiley-Interscience, 2008.
3. N. Kumar, S. Kumbhat, Concise Concepts of Nanoscience and Nanomaterials Scientific Publishers, 2023.

Reference Books:

1. Nanomaterials-Synthesis, Properties and Applications, Edited by A. S. Edelstein and R. C. Cammarata, Institute of Physics Publishing, London, 1998.
2. G. A. Ozin, A. C. Arsenault, L. Cademartiri, C. A. Mirkin, Nanochemistry: A Chemical Approach to Nanomaterials, RSC Publishing, 2005
3. E. L. Wolf, Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Wiley-VCH, 2nd Reprint, 2005.
4. D. C. Agrawal, Introduction to Nanoscience and Nanomaterials, World Scientific, 2020.
5. B. S. Murthy, P. Shankar, B. Raj, B. B. Rath, J. Murday, Textbook of Nanoscience and Nanotechnology, 1st Ed., Orient Blackswan Pvt. Ltd., 2012.

VAC-III: Surfactants and Detergents

Course Title	Code	Credit	Credit Distribution	
			Lecture	Practical
Surfactant and detergents		03	3	0

Course Objectives:

The objective of this course is to enrich the subject knowledge of students in terms of surfactants and detergents. This course is freshly designed which includes classification, synthesis mechanism, surface properties and industrial applications of the prepared oleo-derivatives.

Course Outcomes:

1. Understand the basic chemistry and classification of surfactants and detergents.
2. Gain knowledge on characterisation of surfactant assemblies.
3. Describe synthesis methodologies and surface properties of anionic, cationic, non-ionic and amphoteric surfactants and detergents.
4. Learn analytical skills/ methods in characterizing surfactants, detergents and builders.

SYLLABUS
(C L P = 3 3 0; Total Hours = 15 x 3 = 45)

Unit-I: Structural aspects of surfactants (12 hrs)

Surfactants, Classification (Anionic surfactants, Cationic head surfactant, Zwitterionic surfactants, Nonionic surfactant, Biosurfactants, Gemini surfactant, double tailed surfactant, Bolaform), Synthesis of Surfactant, Behaviour of Surfactants in aqueous and nonaqueous solution, Different types of interactions, Surface activity, Surface tension, Factors for organization of surfactants and types of organized assemblies, Hydrophobic interactions, electrostatic interactions, Critical micellar concentration (CMC), Factors affecting CMC, Methods of CMC determination. Aggregation number, Shape and Size of micelle.

Unit-II: Characterization and application of surfactant assemblies (10 hrs)

Spectroscopic investigation and analytical methods, determination of polarity of micelle, structures of micelle, Determination of aggregation number, Industrial Applications of surfactants, Beneficiation of minerals, micellar catalysis, Drug delivery, Wetting, Dispersion and foaming.

Unit-III: Characterization and application of detergents (13 hrs)

Detergents, Principal groups of synthetic detergents, Anionic detergents, Cationic detergents, Non-ionic detergents, Amphoteric detergents, Industrial methods of preparation of Detergents, Concept of hard and soft water, Removal of hardness of water, General idea of builders, additives, Manufacture of Shampoos. theories of glyceride structure, Hydrolysis of glycerides, Oils and fats, Use of oil in the manufacturing of soap, Principle of soap cleaning, Analysis of soaps as per BIS standards, The use of enzymes in detergents. Catalytic hydrogenation of oil, Recovery of Nickel from hydrogenated oil product.

Unit-IV: Analytical techniques and impact (10 hrs)

Analytical techniques for synthetic detergents, surfactants and builders: Active matter, SO_3 content, molecular weight, amine value, moisture content, P_2O_5 content, silicate analysis, Na_2CO_3/ NaOH content, DOS in CMC etc. Biological effects and toxicity of surfactants, mechanism of biodegradability and eutrophication, estimation of biodegradability.

Text Books

1. B. K. Sharma, Industrial Chemistry, Part-1 and Part-2, Krishna Prakashan, 2023.
2. P. K. Chattopadhyay, Modern Technology of Soaps and Detergents, 2003.
3. M. Drew, Surfactant science and technology, John Wiley & Sons, 2005.

References Books

1. R. J. Farn, ed. Chemistry and technology of surfactants, John Wiley and Sons, 2008.
2. U. Zoller, ed. Handbook of detergents, part E: applications, Vol. 141, CRC Press, 2008.
3. M. Showell, ed. Handbook of detergents, part D: formulation. Vol. 128, CRC Press, 2016.
4. The complete Technology Book on Detergents, 2nd Ed., Niir Board, 2013.
5. Soaps and Detergent Edited by K. S. Parasuram.
6. Surfactants and Interfacial Phenomenon by M. J. Rosen.
7. Catalysis in Micellar and Macromolecular Systems by E. J. Fendler and J. H. Fendler.
8. The Manufacture of Soaps other Detergents and Glycerin Edited by Edgar Woollatt.

Summer Vocational Course	
1	Industrial pollution, management, industrial visit
2	Instrumental handling and training
3	Water and soil analysis, and pollution analysis
4	Chemistry of plastics and visit to CIPET
5	Chemistry of refractories and ceramics

STATE MODEL SYLLABUS FOR UNDER GRADUATE COURSE IN CHEMISTRY

(Bachelor of Science Examination)

UNDER

CHOICE BASED CREDIT SYSTE

Course structure of UG Chemistry Honours				
Semester	**Course**	**Course Name**	**Credits**	**Total marks**
Semester -I	AECC-I	AECC-I	04	100
	C-I	Inorganic Chemistry-I	04	75
	C-I Practical	Inorganic Chemistry-I Lab	02	25
	C-II	Physical Chemistry-I	04	75
	C-II Practical	Physical Chemistry-I Lab	02	25
	GE-I	GE-I	04	75
	GE-I Practical	GE-I Lab	02	25
			22	**400**
Semester -II	AECC-II	AECC-II	04	100
	C-III	Organic Chemistry-I	04	75
	C-III Practical	Organic Chemistry-I Lab	02	25
	C-IV	Physical Chemistry-II	04	75
	C-IV Practical	Physical Chemistry-II	02	25
	GE-II	GE-II	04	75
	GE-II Practical	GE-II Lab	02	25
			22	**400**
Semester -III	C-V	Inorganic Chemistry-II	04	75
	C-V Practical	Inorganic Chemistry-II Lab	02	25
	C-VI	Organic Chemistry-II	04	75
	C-VI Practical	Organic Chemistry-II Lab	02	25
	C-VII	Physical Chemistry-III	04	75
	C-VII Practical	Physical Chemistry-III Lab	02	25
	GE-III	GE-III	04	75
	GE-III Practical	GE-III Lab	02	25
	SEC-I	SEC-I	04	100
			28	**500**
Semester - IV	C-VIII	Inorganic Chemistry-III	04	75
	C-VIII Practical	Inorganic Chemistry-III Lab	02	25
	C-IX	Organic Chemistry-III	04	75
	C-IX Practical	Organic Chemistry-III Lab	02	25
	C-X	Physical Chemistry-IV	04	75
	C-X Practical	Physical Chemistry-IV Lab	02	25
	GE-IV	GE-IV (Theory)	04	75
	GE-IV Practical	GE-IV (Practical)	02	25
	SEC-II	SEC-II	04	100
			28	**500**

Semester	Course	Course Name	Credits	Total marks
Semester -V	C-XI	Organic Chemistry-IV	04	75
	C-XI Practical	Organic Chemistry-IV	02	25
	C-XII	Physical Chemistry-V	04	75
	C-XII Practical	Physical Chemistry-V	02	25
	DSE-I	DSE-I	04	75
	DSE-I Practical	DSE-I Lab	02	25
	DSE-II	DSE-II	04	75
	DSE-II Practical	DSE-II Lab	02	25
			24	**400**
Semester - VI	C-XIII	Inorganic Chemistry- IV	04	75
	C-XIII Practical	Inorganic Chemistry-IV	02	25
	C-XIV	Organic Chemistry-V	04	75
	C-XIV Practical	Organic Chemistry-V	02	25
	DSE-III	DSE-III	04	75
	DSE-III Practical	DSE-III Lab	02	25
	DSE-IV	DSE-IV	04	75
	DSE-IV Practical	DSE-IV Lab	02	25
	OR			
	DSE-IV	Dissertation	06	100*
			24	**400**
		TOTAL	**148**	**2600**

Discipline Specific Elective Papers: (Credit: 06 each)

(4 papers to be selected by students of Chemistry Honours): DSE (1-IV)

1. Polymer Chemistry
2. Green Chemistry
3. Industrial Chemicals & Environment
4. Inorganic Materials of Industrial Importance
5. *Dissertation (can be opted as alternative of DSE-IV only and of 6 credits. **Dissertation content: 60, Seminar cumViva: 20)**
6. Analytical Methods in Chemistry (Alternative)

CHEMISTRY

HONOURS PAPERS:

Core course – 14 papers
Discipline Specific Elective – 4 papers (out of the 6 papers suggested)

Generic Elective for non Chemistry students – 4 papers. Incase the University offers 2 subjects as GE, then papers 1 and 2 will be the GE paper.

Marks per paper - Midterm : 15 marks, End term : 60 marks, Practical- 25 marks Total – 100 marks Credit per paper – 6

Teaching hours per paper – 40 hours Theory classes + 20 hours Practical classes

CORE PAPER I: INORGANIC CHEMISTRY-I

Unit-I: Atomic structure

Bohr's theory, its limitations and atomic spectrum of hydrogen atom, Sommerfeld's modification. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle (time independent) and its significance, Derivation of Schrödinger's wave equation (for hydrogen atom) in Cartesian coordinate, significance of ψ and ψ^2. Normalized and orthogonal wave functions. Sign of wave functions; Setting of Schrödinger's equation in polar coordinates (derivation not required), radial and angular wave functions for hydrogen atom. Radial and angular distribution curves; Shapes of s, p, d and f orbitals; Quantum numbers and their significance. Pauli's Exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations**.**

Unit-II: Periodicity of elements

Periodicity of Elements: 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-blocks. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling's/ Mulliken's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization. Sanderson's electron density ratio.

Unit-III: Chemical bonding-I

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) Covalent bond: Valence Bond theory (Heitler-London approach). Hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements, equivalent and non-equivalent hybrid orbitals, Resonance and resonance energy.

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 (CO^+, NO^+, NO^-).

Unit-IV Chemical bonding-II

VSEPR theory, shapes of simple molecules and ions containing lone and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. 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. (ii) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process**.**

Oxidation-reduction: Redox equations, standard electrode potential and its applications to inorganic reactions. Principles involved in some volumetric analyses (iron and copper).

Recommended Text Books:

1. Lee J. D., Concise Inorganic Chemistry Wiley India, 5th Edn., 2008.
2. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017
4. Selected Topic in Inorganic Chemistry, S. Chand, New Delhi, 17th Ed., 2010.

Reference books

5. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. I, CBS Publications, 2nd Ed. 2010.
6. Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.

CORE PAPER I LAB

Students are required to learn the followings:

i. Calibration and use of apparatus
ii. Preparation of solutions of different Molarity/Normality of titrants.

List of experiments

(A) Acid-Base Titrations

i. Estimation of carbonate and hydroxide present together in mixture.
ii. Estimation of carbonate and bicarbonate present together in a mixture.
iii. Estimation of free alkali present in different soaps/detergents

(B) Oxidation-Reduction Titrimetry

i. Standardization of $KMnO_4$ with standard sodium oxalate and estimation of Fe(II) using standardized $KMnO_4$ solution.
ii. Estimation of percentage of oxalic acid and sodium oxalate in a given mixture.
iii. Estimation of Fe(II) and Fe(III) in a mixture by standard $K_2Cr_2O_7$ solution.

Reference text:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Gulati Shikha , Sharma Gulati JL and ManochaShagun, Practical Inorganic Chemistry, 1stEdn., CBS Publishers & Distributors Pvt Ltd., (2017).

CORE PAPER II

PHYSICAL CHEMISTRY- I

Unit-I: Gaseous state-I

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waal's equation of state, its derivation and application in explaining real gas behaviour. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit-II Liquid state

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Ionic equilibria- I

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

Unit- III: Solid state

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analyses of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals (stoichiometric and non- stoichiometric). Glasses and liquid crystals.

Unit-IV: Ionic equilibria - II

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

Recommended Text Books:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Puri, Sharma &Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
3. Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017
4. Castellan G. W. Physical Chemistry 4thEdn. Narosa (2004).

Reference Books:

1. Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications
2. Mortimer R. G., Physical Chemistry, Elsevier (Academic Press), 3rd Ed (2008).
3. Ball D. W. Physical Chemistry Thomson Press, India (2007).
4. Engel T. & Reid P., Physical Chemistry, 3rd Ed. Pearson (2013)

CORE PAPER II LAB

Surface tension measurements.

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

Viscosity measurement using Ostwald's viscometer.

a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
b. Study the variation of viscosity of sucrose solution with the concentration of solute.

pH-metry

a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b. Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide
c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d. Determination of dissociation constant of a weak acid.

Ionic equilibria

a. Determination of solubility product of PbI_2 by titrimetric method.

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed.; McGraw-Hill, New York (2003).
3. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry, Viva Books (2009).
4. Halpern, A. M. &McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co., New York (2003).

CORE PAPER – III

ORGANIC CHEMISTRY I

Unit –I: Basics of organic chemistry

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and heterolytic fission with suitable examples. Curly arrow rules; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stability of carbocations, carbanions, free radicals and carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Carbon-carbon sigma bonds

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Unit – II: Stereochemistry

Fischer Projection, Newmann and Sawhorse Projection formulae; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.

Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with one and two chiral-centres, Distereoisomers, meso-structures, Racemic mixture and resolution, inversion. Relative and absolute configuration: D/L and R/S designations.

Unit – III: Chemistry of aliphatic hydrocarbons Carbon-Carbon pi bonds:

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2- and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Cycloalkanes and Conformational Analysis

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of alkanes (ethane and n-butane): Relative stability with energy diagrams. Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

Unit – IV: Aromatic hydrocarbons

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

Recommended Text Books:

1. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Bhal and Bhal, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.
3. Kalsi, P. S., Stereochemistry Conformation and Mechanism; 8thEdn, New Age International, 2015.

Reference Books:

1. Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013)
2. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.
3. Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

CORE PAPER III LAB

Students are required to learn the followings:

- Checking the calibration of the thermometer
- Determination of melting point, effect of impurities on the melting point – mixed melting point of two unknown organic compounds
- Determination of boiling point of liquid compounds [boiling point lower than and more than 100°C (up to 160°C) by distillation and capillary method, respectively](**e**.g., ethanol, cyclohexane, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide etc.).

List of experiments

1. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid groups and identification of unknown organic compounds of CHO system (without element detection).
2. Separation and purification of any one component of following binary solid mixture based on the solubility in common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, etc. and determination of melting point.
   Benzoic acid/p-Toluidine; p-Nitrobenzoic acid/p-Aminobenzoic acid; p-Nitrotolune/p-Anisidine etc.
3. Chromatography

- Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
- Separation of a mixture of two sugars by ascending paper chromatography OR
- Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Reference Books

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

CORE PAPER IV PHYSICAL CHEMISTRY II

Unit-I: Chemical thermodynamics

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

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

Unit-II

Carnot cycle, efficiency of heat engine, Carnot theorem

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.

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

Unit-III

Systems of variable composition

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

Chemical equilibrium

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 (vant Hoff's reaction). 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 principle (quantitative treatment) and its applications.

Unit-IV Solutions and Colligative Properties

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

Recommended Text Books:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Principles of Physical Chemistry, Puri, Sharma &Pathania, Vishal Publishing Co, 47th Edn., 2017.
3. Text Book of Physical Chemistry, K. L. Kapoor, Mac Grow Hill, 3rdEdn. 2017
4. Castellan G. W. Physical Chemistry 4th Ed. Narosa (2004).

Reference Books:

1. Engel T. & Reid P., Physical Chemistry 3rd Ed. Pearson (2013).
2. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
3. Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.

CORE PAPER IV LAB THERMOCHEMISTRY

a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

c) Calculation of the enthalpy of ionization of ethanoic acid.

d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.

e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.

f) Determination of enthalpy of hydration of copper sulphate.

g) Determination of heat of solution (ΔH) of oxalic acid/benzoic acid from solubility measurement.

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, New Age International: New Delhi (2001).
3. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry, Viva Books (2009)

CORE PAPER V: INORGANIC CHEMISTRY-II

UNIT-I : General Principles of Metallurgy

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 process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

Acids and Bases

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.

UNIT-II: Chemistry of *s* and *p* Block Elements - I

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.

UNIT-III: Chemistry of *s* and *p* Block Elements - II

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.

Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes. Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

UNIT-IV: Noble Gases

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).

Inorganic Polymers:

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

Recommended Text Books:

1. Lee J. D., Concise Inorganic Chemistry Wiley India, 5thEdn., 2008.
2. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
4. Shriver D. E.,Atkins P. W., InorganicChemistry, Oxford UniversityPres ,5thEdn.(2010).

Reference books

1. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. I, CBS Publications, 2nd Ed. 2010.
2. Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.

CORE PAPER V LAB

Iodometric / Iodimetric titrations

(i) Standardization of sodium thiosulphate solution by standard of $K_2Cr_2O_7$ solution.

(ii) Estimation of Cu(II) using standard sodium thiosulphate solution (Iodimetrically).

(iii) Estimation of available chlorine in bleaching powder iodometrically.

Inorganic preparations

(i) Cuprous oxide (Cu_2O)

(ii) Cuprous chloride, Cu_2Cl_2

(iii) Manganese(III) phosphate, $MnPO_4.H_2O$

(iv) Aluminium potassium sulphate $K_2SO_4.Al_2(SO_4)_2.24H_2O$ (Potash alum).

(v) Lead chromate ($PbCrO_4$)

Reference Books:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson, 2009.
2. Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).
3. Gulati Shikha , Sharma Gulati JL and ManochaShagun, Practical Inorganic Chemistry, 1stEdn., CBS Publishers & Distributors Pvt. Ltd., (2017).

CORE PAPER VI ORGANIC CHEMISTRY-II

UNIT-I: Chemistry of Halogenated Hydrocarbons

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts, nucleophilic aromaticsubstitution; SNAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

UNIT-II: Alcohols, Phenols, Ethers and Epoxides

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-BlancReduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitutionreactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

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

UNIT-III: Carbonyl Compounds

Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Perkin, Cannizzaro and Wittig reaction, Beckmann rearrangements,α haloform reaction and Baeyer Villiger oxidation, - substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV.; Addition reactions of unsaturated carbonyl compounds: Michael addition.

Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

UNIT-IV: Carboxylic Acids and their Derivatives

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic, lactic, malic, tartaric, citric, maleic and fumaric acids;

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

Sulphur containing compounds: Preparation and reactions of thiols and thioethers**.**

Recommended Text Books:

1. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Bhal and Bhal, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.
3. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009..

Reference Books:

1. Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013)
2. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.
3. Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

CORE PAPER VI LAB

Organic preparations:

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

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

iii. Bromination of any one of the following:
   a. Acetanilide by conventional methods
   b. Acetanilide using green approach (Bromate-bromide method)

iv. Nitration of any one of the following:
   a. Acetanilide/nitrobenzene by conventional method
   b. Salicylic acid by green approach (using ceric ammonium nitrate).

The above derivatives should be prepared using 0.5-1g of the organic compound. Calculate percentage yield, based upon isolated yield (crude) and theoretical yield.

Purification of the crude product by recrystallisation from water/alcohol, or sublimation, whichever is applicable and determination of melting point.

Reference Books

1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, Pearson (2011)
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
4. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
5. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

CORE PAPER VII PHYSICAL CHEMISTRY-III

UNIT-I: Phase Equilibria-I

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications (H_2O and sulphur system).

Phase diagrams for systems of solid-liquid equilibria involving eutectic (Pb-Ag system, desilverisation of lead), congruent (ferric chloride-water) and incongruent (sodium sulphate-water) melting points, completely miscible solid solutions (intermediate, medium, maximum freezing points).

UNIT-II: Phase Equilibria-II

Three component systems, water-chloroform-acetic acid system, triangular plots.

Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications tofractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, partial miscibility of liquids, CST, miscible pairs, steam distillation.

Nernst distribution law: its derivation and applications.

UNIT-III : Chemical Kinetics

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of orders.

Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, qualitative treatment of the theory of absolute reaction rates.

UNIT-IV Catalysis

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

Surface chemistry:

Physical adsorption, chemisorption, adsorption isotherms (Langmuir, Freundlich and Gibb's isotherms), nature of adsorbed state.

Recommended Text Books:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Puri, Sharma &Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
3. Kapoor K. L., Text Book of Physical Chemistry, McGraw Hill, 3rd Edn. 2017
4. Castellan G. W. Physical Chemistry 4thEdn. Narosa (2004).

Reference Books:

1. Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications
2. Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill (2011).
3. Ball D. W. Physical Chemistry Thomson Press, India (2007).
4. Engel T. & Reid P., Physical Chemistry 3rd Ed. Pearson (2013)

CORE PAPER VII LAB

1. Determination of distribution coefficients of:
   (a) Iodine between water and carbon tetrachloride.
   (b) Acetic/ benzoic acid between water and cyclohexane.
2. Study the equilibrium of at least one of the following reactions by the distribution method:

- $I_2\ (aq) + I^- \rightarrow I_3^-(aq)$
- $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

3. Study the kinetics of the following reactions.

(i) Integrated rate method:

a) Acid hydrolysis of methyl acetate with hydrochloric acid.

b) Saponification of ethyl acetate.

(ii) Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

4. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed.*; McGraw-Hill: New York (2003).
3. Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

CORE PAPER VIII INORGANIC CHEMISTRY-III

UNIT-I: Coordination Chemistry

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding.

IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, Labile and inert complexes.

Crystal field theory, measurement of CFSE weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq in octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of ligand field and MO Theory.

UNIT-II: Transition Elements-I

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer &Bsworth diagrams). Difference between the first, second and third transition series.

UNIT-III: Transition Elements-II

Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

Lanthanoids and Actinoids

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

General features of actinoids, separation of Np, Pm, Am from U.

UNIT-IV: Bioinorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. 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.

Iron and its application in bio-systems, Haemoglobin and myoglobin.

Recommended Text Books:

1. Lee J. D., Concise Inorganic Chemistry, Wiley India, 5th Edn., 2008.
2. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
3. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
4. ShriverD. E.,Atkins P. W., InorganicChemistry, Oxford UniversityPres ,5thEdn..

Reference books

1. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
2. Bioinorganic Chemistry, Asim Kumar Das, Books & Allied (P) Ltd. 1st ed. 2015.
3. Selected Topic in Inorganic Chemistry, Mallick, Madan and Tuli, S. Chand Publisher. 17th Ed. 2010.
4. Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.

CORE PAPER VIII LAB

Inorganic preparations

Preparation of complexes:

Hexamine nickel(II), $[Ni(NH_3)_6]Cl_2$

i. Potassium trioxalatoferrate(III) trihydrate

ii. Tetraamminecopper(II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$

iii. Tetraamminecarbonatocobalt(III) nitrate

Complexometric titration

i. Estimation of Ca by EDTA

ii. Estimation of Mg by EDTA

Gravimetric Analysis:

i. Estimation of nickel(II) using dimethylglyoxime (DMG).
ii. Estimation of copper as CuSCN
iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
iv. Estimation of Al(III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminiumoxinate).

Chromatography of metal ions

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

i. Ni(II) and Co(II)
ii. Fe (III) and Al(III)

Reference Books:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS (1978).
2. Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).
3. Gulati Shikha , Sharma Gulati JL and ManochaShagun, Practical Inorganic Chemistry, 1st Edn., CBS Publishers & Distributors Pvt Ltd., (2017).

CORE PAPER IX ORGANIC CHEMISTRY-III

UNIT-I: Nitrogen Containing Functional Groups

Preparation and important reactions of nitro and compounds, nitriles.

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

UNIT-II : Diazonium Salts

Preparation and their synthetic applications.

Polynuclear Hydrocarbons

Reactions of naphthalene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene. Polynuclear hydrocarbons.

UNIT-III : Heterocyclic Compounds

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine. Fischer indole synthesis and Madelung synthesis,

Derivatives of furan: Furfural and furoic acid (preparation only).

UNIT-IV

Alkaloids

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

Terpenes

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

Recommended Text Books:

1. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Advanced Organic Chemistry, 2nd Edition, Arun Bahl & B S Bahl, S. Chand Publisher, 2012.

Reference Books:

1. Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013)
2. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.
3. Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

CORE PAPER IX LAB

Qualitative organic analysis of organic compounds

1. Detection of extra elements (N, X, S) in organic compounds by Lassaigne's test.
2. Qualitative analysis of unknown organic compounds containing simple functional groups under CHN system (amine, nitro, amide and imide), determination of melting/boiling point, and preparation of their derivative.

Reference Books

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical OrganicChemistry, 5th Ed., Pearson (2012)
3. Ahluwalia, V.K. & Dhingra, S. Comprehensive Practical Organic Chemistry:Qualitative Analysis, University Press (2000).
4. Ghoshal, A., Mahapatra, B., Nad, A. K. An Advanced Course in Practical Chemistry, New Central Book Agency (2007).

CORE PAPER X PHYSICAL CHEMISTRY-IV

UNIT-I : Conductance-I

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

UNIT-II : Conductance-II

Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

UNIT-III Electrochemistry-I

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass electrodes.

UNIT-IV Electrochemistry-II

Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Electrical properties of atoms and molecules

Basic ideas of electrostatics, Electrostatics of dielectric media. Clausius-Mosotti equation and Lorenz-Laurentz equation (no derivation), Dipole moment and molecular polarizabilities and their measurements.

Recommended Text Books:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Puri, Sharma &Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
3. Kapoor, K. L., Text Book of Physical Chemistry, Mac Grow Hill, 3rdEdn., 2017
4. Castellan G. W. Physical Chemistry 4th Ed. Narosa (2004).

Reference Books:

1. Engel T. & Reid P., Physical Chemistry 3rd Ed. Pearson (2013).
2. Levine, I. N. Physical Chemistry 6thEd., Tata McGraw-Hill (2011).
3. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
4. Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications

CORE PAPER X LAB

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:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Strong acid vs. weak base

Potentiometry

I Perform the following potentiometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Dibasic acid vs. strong base

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P., Experiments in Physical Chemistry8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. &McBane, G. C., Experimental Physical Chemistry 3rdEd.; W.H. Freeman & Co., New York (2003).
4. Viswanathan, B., Raghavan, P.S., Practical Physical Chemistry, Viva Books (2009).

CORE PAPER XI ORGANIC CHEMISTRY-IV

UNIT-I Organic Spectroscopy-I

UV Spectroscopy: Types of electronic transitions, λ_{max}, Lambert-Beer's law and its limitations, Chromophores and Auxochromes,Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward rules for calculation of λ_{max} for the following systems: α,β the unsaturated aldehydes: ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

UNIT-II Organic Spectroscopy-II

IR Spectroscopy: Fundamental and non-fundamental molecular vibrations; IR absorptionpositions of O and N containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in simple functional group analysis.

UNIT-III Organic Spectroscopy-III

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift andfactors influencing it; Spin-spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics; Interpretation of NMR spectra of simple compounds.

Mass Spectroscopy- Basic principle, Fragmentation pattern, instrumentation, determination of m/e ratio. Application of mass spectroscopy on CH_4, C_2H_6, *n*-butane and *neo*-pentane.

Applications of IR, UV & NMR for identification of simple organic molecules.

UNIT-IV Carbohydrates

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; Polysaccharides – Elementary treatment of starch, cellulose.

Recommended Text Books:

1. Kemp William, Organic Spectroscopy, 3rd Edition, Palgrave Publisher, 1991.
2. Davis, B. G., Fairbanks, A. J., Carbohydrate Chemistry, Oxford Chemistry Primer, Oxford University Press.
3. J Kalsi P. S., Spectroscopy of Organic Compounds, 5th Edition, , New Age International Publishers, 2016.
4. Advanced Organic Chemistry, 2nd Edition, Arun Bahl & B S Bahl, S. Chand Publisher, 2012.

Reference Books:

1. Y R Sharma, Elementary Organic Spectroscopy, 5th Edition, S. Chand & Company, 2013.
2. Jag Mohan, Organic Spectroscopy and Applications, NarosaPublishrs, 2012.
3. Graham Solomons T. W., Fryhle, Craig B., Snyder Scott A, Organic Chemistry, Wiley Student Ed, 11th Edition (2013).
4. Jonathan Clayden, Nick Greeves, Stuart Warren, Organic Chemistry, 2nd Edition, Oxford Publisher, 2014.
5. Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

CORE PAPER XI LAB

1. Qualitative analysis of carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
2. Qualitative analysis of unknown organic compounds containing simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.
3. Quantitative estimation of sugars:

(c) Estimation glucose by titration with Fehling's solution.

(d) Estimation of sucrose by titration with Fehling's solution.

(e) Estimation glucose and sucrose in a given mixture.

4. Identification of labelled peaks in the ^{1}H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.
5. Identification of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (CORE PAPERH, O-H, N-H, CORE PAPERO, CORE PAPERN, CORE PAPERX, C=C, C=O, N=O, C≡C, C≡N stretching frequencies; characteristic bending vibrations are included).

Reference Books:

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

CORE PAPER XII PHYSICAL CHEMISTRY V

UNIT-I: Quantum Chemistry-I

Quantum mechanical operators, Postulates of quantum mechanics, Schrödinger equation and its application to particle in one-dimensional box (complete solution) - quantization of energy levels, zero-point energy, normalization of wave functions, probability distribution functions, nodal properties. Extension to 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 wave functions. 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 (Preliminary treatment).

UNIT-II Chemical Bonding

Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Localized and non-localized molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

UNIT-III : Molecular Spectroscopy-I

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation.
Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.
Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

UNIT-IV: Molecular Spectroscopy-II

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.
Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Photochemistry

Characteristics of electromagnetic radiation, 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, chemiluminescence.

Recommended Text Books:

1. McQuarie D., Quantum Chemistry, University Science Publishers, 2007
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. Banwell, C. N. &McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2010).
4. Prasad R K., Quantum Chemistry, New Age International Publishers, 4thEdn, 2010.
5. Rohatagi Mukherjee K K., Fundamentals of Photochemistry, Wiley Eastern Ltd., 1992.

Reference Books:

1. Puri, Sharma &Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 47th Edn., 2017.
2. Kapoor, K. L., Text Book of Physical Chemistry, McGraw Hill, Vol. II, IV
3. Levine, I. N. Quantum Chemistry, PHI

CORE PAPER XII LAB

Spectroscopy/Colorimetry

1. Study of absorption spectra (visible range) of $KMnO_4$ and determine the λ_{max} value. Calculate the energies of the transitions in kJ mol^{-1}, cm^{-1}, and eV.
2. Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration.
3. Determine the dissociation constant of an indicator (phenolphthalein).

Spectrophotometric titration

1. Determine the concentration of HCl against 0.1 N Na OH spectrophotometrically.
2. To find the strength of given ferric ammonium sulfate solution of (0.05 M) by using EDTA spectrophotometrically.
3. To find out the strength of $CuSO_4$ solution by titrating with EDTA spectrophotometrically.
4. To determine the concentration of Cu(II) and Fe(III) solution photometrically by titrating with EDTA.

Reference Books

1. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in PhysicalChemistry 8th Ed.;* McGraw-Hill: New York (2003).
3. Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry 3rdEd.;* W.H. Freeman & Co.: New York (2003).
4. J. N. Gurtu, R. Kapoor, Experimental Physical Chemistry.

CORE PAPER XIII INORGANIC CHEMISTRY-IV

UNIT-I: Organometallic Compounds-I

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. 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.

UNIT-II: Organometallic Compounds-II

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (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.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation), structure and aromaticity, comparison of aromaticity and reactivity with that of benzene.

UNIT-III: Catalysis by Organometallic Compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinson's Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)

Theoretical Principles in Qualitative Analysis (H_2S Scheme)

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 and phosphate) and need to remove them after Group II.

UNIT-IV

Thermodynamic & kinetic aspects and reaction mechanism of metal complexes

Thermodynamic and kinetic stability, Stepwise and overall formation constants and their relationship, factors affecting stability. Introduction to inorganic reaction mechanisms-types of reaction and classification od substitution reaction. Substitution reaction of square planar complexes, Trans effect and its applications, theories of trans-effect (electrostatic polarization and Static π-Bonding Theory). Kinetics of octahedral substitution (classification of metal ions based on water exchange rate), General mechanism of ligand substitution reactions in octahedral complexes (D, I, I_d, I_a).

Recommended Text Books:

1. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
2. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
3. ShriverD. E.,Atkins P. W., InorganicChemistry, Oxford UniversityPres ,5thEdn..
4. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996-0307.

Reference books

1. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
2. Selected Topic in Inorganic Chemistry, Mallick, Madan and Tuli, S. Chand Publisher. 17th Ed. 2010.
3. Mehrotra R.C. and Singh, A. *Organometallic Chemistry,* New Age International Publishers, 2ndEdn, 2000.
4. Gupta B. D. and Elias A. J., Basic organometallic Chemistry, 2ndEdn., University Press (2013).
5.

CORE PAPER XIII LAB

- Qualitative analysis of mixtures containing 4 radicals (2 anions and 2 cations). Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
  CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-}, F^-, Cl^-, Br^-, I^-, NO_3^-, 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+}, Mg^{2+}.
- Mixtures may contain one insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of interfering anions e.g. CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^- , NO_3^- and I^-.
- Spot tests should be done whenever possible.

Reference Books

1. Vogel's Qualitative Inorganic Analysis, 7th Ed, Revised by G. Svehela, 4th Ed., Person (2007).
2. Gulati Shikha , Sharma Gulati JL and ManochaShagun, Practical Inorganic Chemistry, 1stEdn., CBS Publishers & Distributors Pvt Ltd., (2017).

CORE PAPER XIV ORGANIC CHEMISTRY-V

UNIT-I: Amino Acids, Peptides and Proteins

Amino acids: Classification; α-Amino acids - Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and electrophoresis.
Peptides: Classification, determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, CORE PAPERprotecting and CORE PAPERactivating groups -Solid-phase synthesis.
Proteins: Structure of proteins, protein denaturation and renaturation

UNIT-II: Enzymes

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereo specificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Nucleic Acids

Components of nucleic acids, Nucleosides and nucleotides;

Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine;

Structure of polynucleotides.

UNIT-III: Lipids

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenntion of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

Concept of Energy in Biosystems

Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism and anabolism).
Overview of catabolic pathways of fat and protein.

Interrelationship in the metabolic pathways of protein, fat and carbohydrate. Caloric value of food, standard caloric content of food types.

UNIT-IV: Pharmaceutical Compounds: Structure and Importance

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Dyes

Classification, colour and constitution; Mordant and Vat dyes; Chemistry of dyeing. Synthesis and applications of: *Azo dyes* – Methyl orange and Congo red (mechanism of Diazo Coupling); *Triphenylmethane dyes* - Malachite Green, and crystal violet; *Phthalein dyes* – Phenolphthalein and Fluorescein.

Recommended Text books

1. Nelson, D.L., Cox, M.M. and Lehninger, A.L. Principles of Biochemistry. 6thEdn. W.H. Freeman and Co. (2013).
2. Kar Ashutosh, Medicinal chemistry, New Age International (P) Ltd., (2007)
3. Debojyoti Das, Biochemistry, (part-I) Academic Publishers (1979)

Reference Books:

1. Talwar, G.P. & Srivastava, M. Textbook of Biochemistry and Human Biology, 3rd Ed. PHI Learning.
2. Berg, J.M., Tymoczko, J.L. &Stryer, L. Biochemistry, W.H. Freeman, 2002.
4. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange Medical Books/ McGraw-Hill.
5. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry, 6th Edition. W.H. Freeman and Co. (2002).
6. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).
7. The Tools of Biochemistry (1977; Reprint 2011) Cooper, T.G., Wiley India Pvt. Ltd. (New Delhi), ISBN: 978-81-265-3016-8.

CORE PAPER XIV LAB

1. Preparations of the following compounds

i. Aspirin

ii. Methyl orange

2. Estimation of phenol and aniline by bromination method.
3. Saponification value of an oil/fat/ester.
4. Estimation of glycine by Sorenson's formalin method.
5. Estimation formaldehyde (formalin).
6. Estimation of ascorbic acid in fruit juices/Vitamin C tablet (Iodometric method)
7. Determination of Iodine number of an oil/ fat.

Reference Books:

1. Arthur, I. Vogel, Elementary Practical Organic Chemistry, Part-1 Small scale preparations, Indian Edition, Pearson (2011).
2. Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
3. Arthur, I. Vogel, *Quantitative Organic Analysis,* Pearson.
4. Wilson, K. & Walker, J. Practical Biochemistry. Cambridge University Press (2009).

Discipline Specific Elective Paper-1

POLYMER CHEMISTRY

UNIT-I

Introduction and history of polymeric materials:
Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

Functionality and its importance:
Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.

UNIT-II
Mechanism & Kinetics of Polymerization:
Polymerization reactions – addition and condensation, mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Crystallization and crystallinity:
Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

UNIT-III
Molecular weight of polymers and their determination (M_n,M_w, M_v, M_z) by end group analysis,viscometry and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Glass transition temperature (T_g) and it determination: WLFequation, Outlines of factors affecting glass transition temperature (T_g).

UNIT-IV: Properties of polymers (physical, thermal and mechanical properties).

Preparation, structure, properties and applications of the following polymers: polyolefins (polyethylene, polypropylene), polystyrene, polyvinyl chloride, polyvinyl acetate, polyacrylamide, fluoro polymers (Teflon), polyamides (nylon-6 and nylon 6,6). Thermosetting polymers - phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, conducting polymers (polyacetylene, polyaniline). Brief outline of biodegradable polymers.

Recommended Text Books:

1. V. R. Gowarikar, Jayadev Sreedhar, N. V. Viswanathan, Polymer Science 1st Edition, New Age International Publishers, 1986.
2. Premamoy Ghosh, Polymer Science and Technology: Plastics, Rubber, Blends and Composites, 3rdEdition, McGraw Hill Education, 2010.
3. P. Bahadur &N.V.Sastry, Principles of polymer science, Narosa Publishing house, New Delhi 2002.
4. Fred W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)

Reference books

1. L.H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
2. Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)
3. Seymour/Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).
4. Nayak P.L., Polymer Chemistry, Kalyani Publisher (2017).

Discipline Specific Elective Paper I LAB Polymer synthesis (At least three experiment)

1. Preparation of nylon-6,6 / Polyaniline
2. Preparations of phenol-formaldehyde resin-novalac / phenol-formaldehyde resin resold.
3. Preparation of urea-formaldehyde resin
4. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
   a. Purification of monomer
   b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutylonitrile (AIBN)
5. Redox polymerization of acrylamide
6. Precipitation polymerization of acrylonitrile

Polymer characterization/analysis (At least two different experiment)

1. Determination of molecular weight by viscometry:
   a. Polyacrylamide / Polystyrene
   b. (Polyvinyl pyrolidine (PVP)
2. Determination of acid value/saponification value of a resin.
3. Determination of hydroxyl number of a polymer using colorimetric method.
4. Estimation of the amount of HCHO in the given solution by sodium sulphite method
5. Analysis of some IR spectra of polymers – Identification of labelled peaks in IR spectra of known polymer.

Reference Books:

1. Hundiwale G.D., Athawale V.D., Kapadi U.R. and Gite V. V., Experiments in Polymer Science, New Age Publications (2009)
2. Malcohm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
3. Joel R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
4. Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
5. Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd ed. Oxford University Press (2005)

Discipline Specific Elective Paper-1I GREEN CHEMISTRY

UNIT-I

Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Principles of Green Chemistry and Designing a Chemical synthesis-I

Twelve principles of Green Chemistry. Explanations of principle with special emphasis on - Designing green synthesis processes: Prevention of Waste/ by-products; maximize the incorporation of the materials used in the process into the final products (Atom Economy) with reference to rearrangement, addition, substitution and elimination reactions; Prevention/ minimization of hazardous/ toxic products; Designing safer chemicals; Use of safer solvents and auxiliaries (e.g. separating agent) - green solvents (supercritical CO_2, water, ionic liquids), solventless processes, immobilized solvents.

UNIT-II: Principles of Green Chemistry and Designing a Chemical synthesis-II

Explanation of green chemistry principles with special emphasis on:

Energy efficient processes for synthesis - use of microwaves and ultrasonic energy. Selection of starting materials (use of renewable feedstock); avoidance of unnecessary derivatization (e.g. blocking group, protection groups, deprotection); Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products use of chemically safer substances for prevention of chemical accidents, inherent safer design greener - alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol); real-time, in-process monitoring and control to prevent the formation of hazardous substances; development of green analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes;

UNIT-III: Examples of Green Synthesis/ Reactions and some real world cases-I

Green Synthesis of the following compounds: adipic acid, catechol, methyl methacrylate, urethane, disodium iminodiacetate (alternative to Strecker synthesis), paracetamol, furfural.

Microwave assisted reactions: Applications to reactions (i) in water: Hofmann Elimination, hydrolysis (of benzyl chloride, methyl benzoate to benzoic acid), Oxidation (of toluene, alcohols); (ii) reactions in organic solvents: Diels-Alder reaction and Decarboxylation reaction.

Ultrasound assisted reactions: Applications to esterification, saponification, Simmons-Smith Reaction (Ultrasonic alternative to Iodine).

UNIT-IV: Examples of Green Synthesis/ Reactions and some real world cases-II

Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments; Designing of Environmentally safe marine antifoulant; Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments; Synthesis of a compostable and widely applicable plastic (poly lactic acid) from corn; Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

Future Trends in Green Chemistry

Oxidizing and reducing reagents and catalysts; multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; Green chemistry in sustainable development. (Bio-diesel, bio-ethanol and biogas)

Recommended Text Books:

1. Anastas P.T. & Warner J.K.: Green Chemistry- Theory and Practical, Oxford University Press (2000).
2. Ahluwalia V.K. & Kidwai M.: New Trends in Green Chemistry, Anamalaya Publishers, New Delhi (2004).
3. Kumar V., An Introduction to Green Chemistry, Vishal Publishing Co., (2015).

Reference Books:

1. Matlack A.S. Introduction to Green Chemistry, Marcel Dekker (2001).
2. Das Asim K. amd Das Mahua , Environment Chemistry with Green Chemistry, Books and Allied (P) Ltd. (2010)

Discipline Specific Elective Paper II LAB At least five experiments should be done:

1. Acetylation of primary amine (Aniline to N-phenylacetamide) using Zn dust.
2. Nitration of salicylic acid by green method (Using calcium nitrate and acetic acid).
3. Bromination of acetanilide using ceric ammonium nitrate/KBr.
4. Microwave assisted nitration of Phenols using $Cu(NO_3)_2$.
5. Detection of elements in organic compounds by green method (Sodium carbonate fusion)
6. Base catalyzed Aldol condensation (Synthesis of dibenzalpropanone)
7. Vitamin C clock reaction using vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch. Effect of concentration on clock reaction.
8. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.
9. Diels Alder reaction in water: Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.
10. Preparation and characterization of nanoparticles (Cu, Ag) using plant extract.
11. Preparation of propene by following two methods or any other reactions like addition, elimination, substitution showing atomic economy can be studied

(I) Triethylamine ion + OH^- → propene + trimethylpropene + water

(II) 1-propanol $\xrightarrow{H_2SO_4/\Delta}$ propene + water

Reference Books:

1. Monograph on Green Chemistry Laboratory Experiments, edited and published by Green Chemistry Task Force Committee, DST Govt. of India, p. 1-79.
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistryexperiment*. American Chemical Society, Washington DC (2002).
3. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment:A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN978-93-81141-55-7 (2013).

Discipline Specific Elective Paper-III

INDUSTRIAL CHEMICALS AND ENVIRONMENT

UNIT-I: Industrial Gases and Inorganic Chemicals

Industrial Gases: Large scale production, uses, storage and hazards in handling of thefollowing gases: oxygen, nitrogen, argon, hydrogen, acetylene, carbon monoxide, chlorine, sulphur dioxide.
Inorganic Chemicals: Manufacture, application and hazards in handling thefollowing chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, potassium dichromate and potassium permanganate.

Industrial Metallurgy

Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

UNIT-II: Environment and its segments

Ecosystems. Biogeochemical cycles of carbon, nitrogen and sulphur.

Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone. Major sources of air pollution.
Pollution by SO_2, CO_2, CO, NO_x, and H_2S and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal.

UNIT-III

Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources andnature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.
Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, fertilizer. Sludge disposal.
Industrial waste management: incineration of waste. Water treatment and purification (reverse osmosis, ion exchange). Water quality parameters for wastewater, industrial water and domestic water.

UNIT-IV: Energy and Environment

Sources of energy: Coal, petrol and natural gas. Nuclear fusion/fission, solar energy, hydrogen, geothermal, tidal and hydel.
Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis

Introduction to biocatalysis: Importance in green chemistry and chemical industry.

Recommended Text Books:

1. De, A. K. *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi, 2010.

2. Stocchi E., *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

Reference Books:

4. Felder R.M. and Rousseau R.W., *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
5. Dara S. S., *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
6. Miller G.T., Environmental Science, 11th edition. Brooks/ Cole (2006).
7. Mishra, Environmental Studies, Selective and Scientific Books, New Delhi (2005).

Discipline Specific Elective Paper III LAB

1. Determination of Dissolved Oxygen (DO) in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
6. Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
7. Measurement of dissolved CO_2.
8. Study of some of the common bio-indicators of pollution.
9. Estimation of SPM in air samples.
10. Preparation of borax/ boric acid.

Reference Books:

1. Dara S. S., A Textbook on Experiments and Calculations in Engineering Chemistry S Chand & Company; 9th Revised edition (2015).
2. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
3. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
4. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
5. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.

Discipline Specific Elective Paper-1V

INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE

Unit 1: Silicate Industries

Glass: Glassy state and its properties, classification (silicate and nonsilicate glasses).Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Unit II

Fertilizers: 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.

Batteries: 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 III: Surface Coatings:

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint,

Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.

Unit IV

Alloys: Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon, decarbonization, demanganization, desulphurization, dephosphorisation) and surface treatment (argon treatment, heat treatment nitriding, carburizing). Composition and properties of different types of steels.

Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

Recommended Text Books:

1. Stocchi E., *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
3. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.

Reference Books:

1. Felder R.M. and Rousseau R.W., *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
2. Dara S. S., *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
3. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.

Discipline Specific Elective Paper-IV LAB

List of Practical

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Determination of composition of dolomite (by complexometric titration).
5. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
6. Analysis of Cement.
7. Estimation of Iron from Cement Volumetrically
8. Preparation of pigment (zinc oxide).

Reference Books

1. Dara S. S., A Textbook on Experiments and Calculations in Engineering ChemistryS Chand & Company; 9th Revised edition (2015).
2. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
3. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
4. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
5. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
6. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
7. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.

Alternative to DSC CORE PAPER IV

Discipline Specific Elective Paper-V

DISSERTATION

A project work is to be carried out by the student in consultation with the teachers of the department. The report of work (dissertation) in a standard format is to be submitted and presented for evaluation.

Distribution of marks

(a) Project Report/Dissertation (Proper documentation of literature, data, discussion etc. and logical flow of work undertaken): 50 Marks
(b) Seminar/Presentation: 30 marks
(c) Viva voce: 20 marks

A brief Guidelines to Project Work:

1. Students shall undertake the project work (experimental/theoretical) related to any branch ofchemistry/Chemical science under the guidance of teacher(s) from the department or jointly with teachers/research personnel of other institutes.
2. The following activities have been outlined as guidelines (not exhaustive):

- Physiochemical studies (pH, conductivity, turbidity, etc.) of different wetlands (ponds, lakes, river etc.)
- Analysis of iron in pond / tube well / river water.
- Analysis of Hardness of water samples.
- Adulteration detection activities in food stuff and other edible items.
- Extraction and preliminary characterization of useful chemicals (as far as possible) from plants.
- Solubility, surface tension, and viscosity measurements of some solution of practical relevance, (cough syrup, soap solution, pesticides, fertilizers.. etc.)
- Pollution related activities (Industrial/Agricultural/Municipal etc.)
- Nutrition related activities, (essential metal detection in food, cereals, pulses, fruits etc.).
- Small synthetical work (inorganic/Organic/Polymeric compounds)

3. The UG level project work is a group activity, maximum number of students being limited to three. HOD to notify the name of teacher(s) for supervising the project work of each group. A teacher can guide more than one group, if necessary.
4. No two groups in the same institution are permitted to do project work on the same problem.
5. Each student shall prepare and submit the project report separately for evaluation. Two copies of project report are required to be submitted in bound form (spiral/paperback).
6. The project report shall be divided as:

Chapter I: Introduction (Introduction on the topic, review of literature, objective and scope of the work)

Chapter II: Materials and methods

Chapter III: Results and discussion

Chapter IV: Conclusions and Scope of future studies

Chapter V: References

Reference Books:

1. M. A. Malati, An Investigative, Integrated Approach to Practical Project Work; Mid-Kent College of Higher/Further Education, UK (October 1999); Imprint: Woodhead Publishing; ISBN: 978-1-898563-47-1.
2. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed., Prentice-Hall, Harlow.

Alternative for Discipline Specific Elective (DSE) Papers

Discipline Specific Elective Paper-VI

ANALYTICAL METHODS IN CHEMISTRY

Unit I: UV-Visible and IR Spectrometry

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, 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 composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

Unit II : Qualitative and quantitative aspects of analysis

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

Flame Atomic Absorption Spectrometry

Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Unit III: Thermal and electro-analytical methods of analysis

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

Classification of electro-analytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.

Unit IV: Separation techniques

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

Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: TLC and HPLC.

Recommended text books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Skoog, Holler and Crouch, Principles of Instrumental Analysis, Cengage Learning, 6th Indian Reprint (2017).
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.

Reference books

1. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Mikes, O. &Chalmes, R.A. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
4. Pavia, Lamman, Kriz and Vyvyan, Introduction to Spectroscopy, Cengage Learning, 3rd Indian Reprint (2017).
5. Dash U N , Analytical Chemistry

Discipline Specific Elective Paper -V LAB

1. Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
2. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.
3. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.
4. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC
5. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
6. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
7. Analysis of soil: determination of pH of soil, total soluble salt, estimation of calcium, magnesium, phosphate, nitrate
8. Separation of metal ions from their binary mixture.
9. Separation of amino acids from organic acids by ion exchange chromatography.
10. Determination of dissolved oxygen in water.
11. Determination of chemical oxygen demand (COD).

Reference Books:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G. H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

GENERIC ELECTIVE (GE)

Generic Elective Paper I (Theory)

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

SECTION A: INORGANIC CHEMISTRY-1

Unit-I: Atomic Structure

Review of Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra.

Quantum mechanics: Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Quantum numbers and their significance, shapes of s, p and d atomic orbitals, nodal planes.

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit-II: Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics, energy considerations.Lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules and its applications.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules (N_2, O_2) and heteronuclear diatomic molecules (CO, NO). Comparison of VB and MO approaches

Section B: Organic Chemistry-1

Unit- III: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive effect, Electromeric effect, Resonance and hyperconjugation. Cleavage of bonds: Homolysis and heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Hückel's rule.

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (up to two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). D and L; cis-trans nomenclature; CIP Rules: R/ S (for one chiral carbon atoms) and E / Z Nomenclature (for up to two C=C systems).

Unit-IV : Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Up to 5 Carbons).*Preparation:*Catalytic hydrogenation, Wurtz reaction,Kolbe's synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Alkenes: (Up to 5 Carbons)*Preparation:*Elimination reactions: Dehydration of alkenesand dehydrohalogenation of alkyl halides (Saytzeff's rule); cis-alkenes (Partial catalytic hydrogenation) and trans-alkenes (Birch reduction). *Reactions:* cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis,

Alkynes: (Up to 5 Carbons)*Preparation:*Acetylene from $CaC_2$and conversion intohigher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysis.

Recommended Text Books:

1. Lee J. D., Concise Inorganic Chemistry, Wiley India, 5thEdn., 2008.
2. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
3. ShriverD. E.,Atkins P. W., InorganicChemistry, Oxford UniversityPres ,5thEdn..
4. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
5. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. BhalArun & BhalB S , Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.
7. Kalsi, P. S. Stereochemistry Conformation and Mechanism; 8thEdn, New Age International, 2015.

Reference books

1. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
2. Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.
3. Mallick, Madan and Tuli, S. Chand Selected Topic in Inorganic Chemistry, , 17thEdn. 2010.
4. Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

Generic Elective Paper I LAB Section A: Inorganic Chemistry

Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.

Section B:Organic Chemistry

1. Detection of extra elements (N, S, Cl) in organic compounds (containing up to two extra elements)
2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)

(f) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.

(g) Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).

Generic Elective Paper II (Theory)

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Section A: Physical Chemistry-I

Unit-I: Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics.

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

Chemical Equilibrium

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o, Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases

Unit- II: Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Section B: Organic Chemistry-II

Unit- III

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

Alkyl and Aryl Halides

Alkyl Halides (Up to 5 Carbons) Types of Nucleophilic Substitution (SN_1, SN_2 and SNi) reactions.
Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile &isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.
Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer &

Gattermann reactions.

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

Unit- IV

Alcohols, Phenols and Ethers (Up to 5 Carbons)

Alcohols: Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes and ketones, carboxylic acid and esters.
Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. ReimerTiemann Reaction, Gattermann-Koch Reaction,

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): Formaldehyde, 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, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction.

Recommended Text Books:

1. Atkins P. W. & Paula, J. de, Elements of Physical Chemistry, Oxford University Press, 6th Ed., (2006).
2. Principles of Physical Chemistry, Puri, Sharma &Pathania, Vishal Publishing Co, 47th Edn., 2017.
3. K. L. Kapoor, Text Book of Physical Chemistry, Mac Grow Hill, 3rdEdn. 2017.
4. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Arun Bahl & B S Bahl, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.

Reference Books:

1. Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.
2. Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

Generic Elective Paper II LAB Section A: Physical Chemistry

Thermochemistry (any three)

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH.

Ionic equilibria

pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

b) Preparation of buffer solutions:

- Sodium acetate-acetic acid
- Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water) and determination of melting.
2. Preparations, recrystallisation, determination of melting point and calculation of quantitative yields of the followings:

(a) Bromination of Phenol/Aniline

(b) Benzoylation of amines/phenols

(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
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., New Delhi (2011).
4. Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).

Generic Elective Paper- III (Theory)
CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OFMATTER &

CHEMICAL KINETICS

UNIT-I: General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.
Hydrometallurgy, Methods of purification of metals (Al, Pb, Fe, Cu, Ni): electrolytic, oxidative refining, Parting process, van Arkel-de Boer process and Mond's process.

s- **and *p*-Block Elements**

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling &Mulliken scales). Allotropy in C, S, and P. Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert pair effect, diagonal relationship and anomalous behaviour of first member of each group.

UNIT-II: Compounds of *s*- and *p*-Block Elements

Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements.
Concept of multicentre bonding (diborane).

Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Hydrides of nitrogen (NH_3, N_2H_4, N_3H, NH_2OH); Oxoacids of P, S and Cl; Halides and oxohalides: PCl_3, PCl_5, $SOCl_2$.

Section B: Physical Chemistry-3

UNIT-III: Kinetic Theory of Gases
Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation.
Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.
Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Liquids
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).

UNIT-IV

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, and CsCl (qualitative treatment only). Defects in crystals.

Chemical Kinetics

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). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Recommended Text Books:

1. Lee J. D., Concise Inorganic Chemistry, Wiley India, 5thEdn., 2008.
2. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
3. ShriverD. E.,Atkins P. W., InorganicChemistry, Oxford UniversityPres ,5thEdn..
4. Principles of Physical Chemistry, Puri, Sharma &Pathania, Vishal Publishing Co, 47th Edn., 2017.
5. K. L. Kapoor, Text Book of Physical Chemistry, Mac Grow Hill, 3rdEdn. 2017.

Reference Books:

1. Kheterpal S.C., Pradeep's Physical Chemistry, Vol. I & II, Pradeep Publications.
2. Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.

Generic Elective Paper -III LAB

Section A: Inorganic Chemistry

Qualitative analysis of inorganic slat mixture using H_2S: not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations : NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+

Anions: CO_3^{2-}, S^{2-}, SO_3^{2-}, NO_3^-, Cl^-, Br^-, I^-, NO_2^-, SO_4^{2-}, PO_4^{3-}, F^-

(Spot tests should be carried out wherever feasible)

Section B: Physical Chemistry

Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Reference Books:

1. Svehla, G, Vogel's Qualitative Inorganic Analysis, 7th Ed, 4th Ed., Pearson Education (2007).
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
3. Gulati Shikha , Sharma Gulati JL and ManochaShagun, Practical Inorganic Chemistry, 1stEdn., CBS Publishers & Distributors Pvt Ltd., (2017).

Generic Elective Paper- IV (Theory)

ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

Section A: Inorganic Chemistry-4

UNIT-I

Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co.

A study of the following compounds (including preparation and important properties);

Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$.

Organometallic Compounds

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. π-acceptor behaviour of carbon monoxide. Synergic effects (VB approach).

UNIT-II: Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, and structural role (bones).

Section B: Organic Chemistry-4

UNIT-III

Polynuclear and heteronuclear aromatic compounds

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine.

Active methylene compounds

Preparation: Claisen ester condensation. Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules havingup to 6 carbon).

UNIT-IV: Application of Spectroscopy (UV-Visible, IR) to Simple Organic Molecules

Electromagnetic radiations, electronic transitions, λ_{max}&ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating $\lambda_{max}$of conjugated dienes and α, β – unsaturated compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Recommended Text Books:

1. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
2. ShriverD. E.,Atkins P. W., InorganicChemistry, Oxford UniversityPres ,5thEdn..
3. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, , Pearson Education, 4th Ed. 2002.
4. Morrison, R. N. & Boyd, R. N., Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Arun Bahl & B S Bahl, Advanced Organic Chemistry, 2nd Edition, S. Chand Publisher, 2012.

Reference books

1. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed. 2010.
2. Das Asim K., Bioinorganic Chemistry, Books & Allied (P) Ltd. 1st ed. 2015.
3. Pradeep's Inorganic Chemistry, Vol. I & II, Universal Book seller, 14th Ed. 2017.
4. Dhawan, S.N., Pradeep's Organic Chemistry, (Vol. I and II), Pradeep Publications

Generic Elective Paper IV LAB

Section A: Inorganic Chemistry

1. Preparation of following compounds (Any two)

a. Cuprous oxide (Cu_2O)

b. Cuprous chloride, Cu_2Cl_2

c. Manganese(III) phosphate, $MnPO_4.H_2O$

d. Lead chromate ($PbCrO_4$

2. Separation of mixtures by chromatography: Measure the R_f value in each case.

(Combination of two ions to be given)

- Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or
- Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}

Section B: Organic Chemistry

Systematic qualitative organic analysis of organic compounds possessing mono-functional groups (-COOH, phenolic, aldehyde, ketone, amide, nitro, amines) and preparation of one derivative.

Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6thEdn, Pearson, 2009.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
3. Ahluwalia, V.K., Dhingra, S. and Gulati A, College Practical Chemistry, University Press (2005).
4. Gulati Shikha , Sharma Gulati JL and ManochaShagun, Practical Inorganic Chemistry, 1stEdn., CBS Publishers & Distributors Pvt. Ltd., (2017).

SKILL ENHANCEMENT COMPULSORY COURSES (SECC)

Optional for SECC II paper

Skill Enhancement Compulsory Courses (SECC Option-I) PESTICIDE CHEMISTRY

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship.

Synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor). Ecofriendly pesticides.

Safety measures: Environmental aspects and degradability

Reference Books:

1. R. J. W. Cremlyn: *Pesticides:* John Wiley and Sons Ltd (1978)
2. D.S. Reddy, M. Pushpa Latha, Pesticides, New Vishal Publications (2015).
3. Roy N. K., Chemistry of Pesticides. CBS Publisher & Distributors P Ltd; 1st Ed. (2010)

Skill Enhancement Courses (SECC Option II) FUEL CHEMISTRY

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value

Coal:Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization ofcoal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications.

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals:

Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting)Solid and semisolid lubricants, synthetic lubricants.

Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

Reference Books:

1. E. Stocchi: *Industrial Chemistry*, Vol -I, Ellis Horwood Ltd. UK.
2. P.C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
3. B.K. Sharma: *Industrial Chemistry,* Goel Publishing House, Meerut.

List of topics included in CBCS syllabus requiring training of College Teachers for 21 days

Theory (15 days)

1. Quantum Chemistry
2. Organometallics
3. Coordination Chemistry
4. Polymer Chemistry
5. Green Chemistry
6. Organic Chemistry

Practical (6days)

1. Green chemistry and other new practical's introduced in the new CBCS syllabus

List of minimum instrument required for undertaking practical classes of UG-CBCS in Chemistry (Core and DSC Practicals)

Sl.	Name of the instrument	Numbers
1.	Ostwald's viscometer	02
2.	Tensiometer (Surface tension measurements)	01
3.	Digital pH-meter with accessories	02
4.	Digital Conductivity meter with accessories	02
5.	Potentiometer with accessories	01
6.	Colorimeter	01
7.	Calorimeter with accessories (precision thermometer)	01
8.	Visible spectrophotometer (single beam)	01
9.	Magnetic stirrer (with/without hot plate)	02
10.	Heating mantle	01
11.	Melting point apparatus	02
12.	Vacuum pump for filtration	01
13.	Single distillation units (All glass) 2lit/hr capacity	02
14.	Single pan digital balance with precision 0.01 gm and 0.001 gm	02
15.	Water bath (Electrical)	01
16.	Fume hood	01
17.	Kipp'sapparature (PP)	02
18.	Fire extinguishers	02
19.	Aspirator for chromatographic developer	01
20.	Air oven (up to ^{300oC})	01
21.	Microwave oven (kitchen quality)	01
22.	Small lab accessories like glassware, plastic wares, laboratory wires and other small accessories as per requirement.	