Three/Four Yr. Degree Course
(Single Major & Double Minor with Research)
based on NEP-2020

CHEMISTRY

(Effective from Session 2026-27)
(Batch: 2026-2029)

SAMBALPUR UNIVERSITY
JYOTI-VIHAR, BURLA, SAMBALPUR, ODISHA-768019

The model curriculum and credit frame work for under graduate programmes as multiple entry and exit option with research and without research of National Education Policy-2020.

I. ***Certificate Course:*** *One Academic Year (Frist & Second Semester and Summer Vocational Course and Community Work)* ***44 Credits***

II. ***Diploma Course:*** *Two Academic year (Frist, Second, Third & Fourth Semester and Summer Vocational Course and Community Work)* ***86 Credits***

III. ***3yr. Degree Course:*** *Three Academic Year (Frist, Second, Third, Fourth, Fifth & Sixth Semester and Community Work)* ***126 Credits***

IV. ***4yr. Degree Course (Honours):*** *Four Academic Year (Frist, Second, Third, Fourth, Fifth, Sixth, Seven & Eight Semester and Community Work)* ***166 Credits***

V. ***4yr. Degree Course (Honours with Research):*** *Four Academic Year (Frist, Second, Third, Fourth, Fifth, Sixth, Seven & Eight Semester and Community Work)* ***166 Credits***

Type of Course:

I. ***Major (Core-I):*** *is the subject of main focus and the degree will be awarded in that discipline.*

II. ***Minor Stream (Core-II):*** *helps a student to gain a brooder understanding knowledge beyond the major discipline. A student may gather 28 credits from a single subject*

III. ***Multidisciplinary U.G. Progrmme (09 Credits):*** *Three introductory-level Multidisciplinary Course baskets are offered for students to choose any one from each semester outside of the subject/discipline/faculty: A group of related subject i.e., faculty (Arts/Commerce/Science). The student can opt three different subject/course for each semester examination.*

IV. ***Ability Enhancement Course (AEC 08 Credits):*** *Student are required to achieve competency in a Modern Indian Language (MIL)and in the English language with special emphasis on language and communication skills (not literally skill). Literature and Linguistic courses shall be offered in major core and minor stream. In lieu of Odia, a student may opt for only Sanskrit, Hindi or Urdu.*

V. ***Skill Enhancement Course (SEC 09 Credits):*** *A student has to opt the Skill Enhancement courses from the basket as per the subject available in the institution. The students can opt for any one course for each semester examination and these courses are aimed at imparting practical skills, hands-on training, soft skills, etc., to enhance the employability of students.*

VI. ***Value Added Course (VAC 12 Credits):*** *The VAC course basket are prearranged for the students to choose for each semester's examination.*

VII. ***Summer Internship/Apprenticeship/Summer Project (04 Credits with 120 Hours):*** *Community Engagement and Services/ Field work/ Internship programme is mandatory for all students of 4th Semester undergraduate Programmes of NEP-*

2020 carrying 4 credits which shall be completed in 120h (Students admitted in the session 2024-25 onwards) under affiliated colleges of Sambalpur University.

A. ***Internship:*** *A course requiring students to participate in a professional activity or work experience or cooperative education activity with an entity external to the education institution, normally under the supervision of an expert of the given external entity. A key aspect of the internship is induction into actual work situations.*

• Internships may be undertaken anywhere in India, subject to institutional approval and compliance with credit requirements.

• Internships involve working with local industry, government or private organizations, business organizations, artists, crafts persons, NGOS, Private Sector organizations, Government / Public Sector institutions, Industries, MSMEs (Online or Offline) and similar entities to provide opportunities for students to actively engage in on-site experiential learning.

• ***Online / Digital Internship Opportunities:*** *Internship may also be undertaken in online or hybrid mode through recognized Government of India platforms, subject to institutional approval and fulfilment of credit requirements.*

• Students may undertake internships or field work through their own arrangement, subject to prior approval of the concerned HEI.

B. ***Community Engagement and Services/ Field work:*** *Community Engagement activities shall be conducted through NSS. Students not enrolled under NSS may undertake community engagement projects / field work for 120h duration under the supervision of faculty members.*

- *After completion of Internship students will collect an internship completion certificate from the organization /competent authority.*
- ***Submission of Report and Evaluation:*** *Students opted for Internship/ Community engagement projects/ Field work are required to submit a report to the Institution for evaluation. Supporting documents like feedback from the host Organisation, geotagged photos and other relevant documents should be submitted with the report.*

Table-I: Course Table Structure for Certificate Course: Exit after first Academic Year

One Academic Year: (1st & 2nd Semester and a Summer Vocational Course and Community Work)

Semester	Core-I	Core-II	Core-III	Multidisciplinary	AEC	SEC	VAC	Community Engagement & Field Work	Credit
I	2x4=8	1x4=4		1x3=3	1x4=4		1x3=3		22
II	2x4=8		1x4=4	1x3=3	1x4=4	1x3=3			22
Total	**4x8=16**	**1x4=4**	**1x4=4**	**2x3=6**	**2x4=8**	**1x3=3**	**1x3=3**		**44**

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

Two Academic Year: (1st, 2nd, 3rd & 4th Semester and a Summer Vocational Course and Community Work)

Semester	Core-I	Core-II	Core-III	Multidisciplinary	AEC	SEC	VAC	Community Engagement & Field Work	Credit
I	2x4=8	1x4=4		1x3=3	1x4=4		1x3=3		22
II	2x4=8		1x4=4	1x3=3	1x4=4	1x3=3			22
									44
III	3x4=12	1x4=4		1x3=3			1x3=3		22
IV	3x4=12		1x4=4						20
									42
Total	**10x4=40**	**2x4=8**	**2x4=8**	**3x3=9**	**2x4=8**	**1x3=3**	**2x3=6**		**86**

Table-III: Course Table Structure for Three Years Degree Course with Single Major and Two Minor

Semester	Core-I	Core-II	Core-III	Multidisciplinary	AEC	SEC	VAC	Community Engagement & Field Work	Credit
I	2x4=8	1x4=4		1x3=3	1x4=4		1x3=3		22
II	2x4=8		1x4=4	1x3=3	1x4=4	1x3=3			22
									44
III	3x4=12	1x4=4		1x3=3			1x3=3		22
IV	3x4=12		1x4=4					1x4=4	20
									42
V	3x3=12	1x4=4				1x3=3	1x3=3		22
VI	2x4=8		1x4=4			1x3=3	1x3=3		18
									40
Total	**15x4=60**	**3x4=12**	**3x4=12**	**3x3=9**	**2x4=8**	**3x3=9**	**4x3=12**	**1x4=4**	**126**

Note: In case a student opts for NCC and clears 'C' certificate additional 16 credits shall be awarded and total credit shall be 126+16= 142 credits

Table-IV: Course Table Structure for Three Years Degree Course with Double Major

Semester	*Core-I*	*Core-II*	*Multidisciplinary*	*AEC*	*SEC*	*VAC*	*Community Engagement & Field Work*	*Credit*
I	*2x4=8*	*2x4=8*	*1x3=3*	*1x4=4*		*1x3=3*		*26*
II	*2x4=8*	*2x4=8*	*1x3=3*	*1x4=4*	*1x3=3*			*26*
								52
III	*3x4=12*	*2x4=8*	*1x3=3*			*1x3=3*		*26*
IV	*3x4=12*	*2x4=8*					*1x4=4*	*24*
								50
V	*3x3=12*	*2x4=8*			*1x3=3*	*1x3=3*		*26*
VI	*2x4=8*	*2x4=8*			*1x3=3*	*1x3=3*		*22*
								48
Total	***15x4=60***	***12x4=48***	***3x3=9***	***2x4=8***	***3x3=9***	***4x3=12***	***1x4=4***	***150***

Table-V: Course Table Structure for Fourth Year Honours without Research

Semester	*Core-I*	*Core-II*	*Core-III*	*Multidisciplinary*	*AEC*	*SEC*	*VAC*	*Community Engagement & Field Work*	*Credit*
I	*2x4=8*	*1x4=4*		*1x3=3*	*1x4=4*		*1x3=3*		*22*
II	*2x4=8*		*1x4=4*	*1x3=3*	*1x4=4*	*1x3=3*			*22*
									44
III	*3x4=12*	*1x4=4*		*1x3=3*			*1x3=3*		*22*

IV	*3x4=12*		*1x4=4*					*1x4=4*	*20*
									42
V	*3x3=12*	*1x4=4*				*1x3=3*	*1x3=3*		*22*
VI	*2x4=8*		*1x4=4*			*1x3=3*	*1x3=3*		*18*
									40
VII	*4x4=16*	*1x4=4*							*20*
VIII	*4x4=16*	*1x4=4*							*20*
Total	***23x4=92***	***5x4=20***	***3x4=12***	***3x3=9***	***2x4=8***	***3x3=9***	***4x3=12***	***1x4=4***	***166***

Table-VI: Course Table Structure for Fourth Year Honours with Research

Semester	*Core-I*	*Core-II*	*Core-III*	*Multidisciplinary*	*AEC*	*SEC*	*VAC*	*Community Engagement & Field Work*	*Credit*
I	*2x4=8*	*1x4=4*		*1x3=3*	*1x4=4*		*1x3=3*		*22*
II	*2x4=8*		*1x4=4*	*1x3=3*	*1x4=4*	*1x3=3*			*22*
									44
III	*3x4=12*	*1x4=4*		*1x3=3*			*1x3=3*		*22*

IV	*3x4=12*		*1x4=4*					*1x4=4*	*20*
									42
V	*3x3=12*	*1x4=4*				*1x3=3*	*1x3=3*		*22*
VI	*2x4=8*		*1x4=4*			*1x3=3*	*1x3=3*		*18*
									40
VII	*3x3=12*	*2x4=8*							*20*
VIII	*2x4=8*							***Research 12***	*20*
Total	***20x4=80***	***5x4=20***	***3x4=12***	***3x3=9***	***2x4=8***	***3x3=9***	***4x3=12***	***16***	***166***

COURSE AT A GLANCE (NEP-UG)

SUBJECT: CHEMISTRY **ACADEMIC SESSION: 2026-29**

CORE-I COURSE

Course Number	Semester	Course Title	Type of Paper P-Practical NP-Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	Semester-I	Atomic Structure, Periodicity of elements and Chemical Bonding	P	4	100
Paper-II		Fundamental Organic Chemistry	P	4	100
Paper-III	Semester-II	States of matter, and Ionic equilibrium	P	4	100
Paper-IV		Chemical thermodynamics, equilibrium, and Colligative property	P	4	100
Paper-V	Semester-III	Acids and Bases, Metallurgy, Chemistry of main group elements	P	4	100
Paper-VI		Chemistry of halogen, oxygen and Sulphur containing organic compounds	P	4	100
Paper-VII		Phase equilibrium, Chemical dynamics, catalysis and surface chemistry	P	4	100
Paper-VIII	Semester-IV	Coordination Chemistry, Chemistry of d- and f-block elements, Inorganic Reaction Mechanism and electron transfer reactions	P	4	100
Paper-IX		Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and	P	4	100

		Poly nuclear Hydrocarbons			
Paper-X		Conductance, electrochemistry, electrical properties of atoms and molecules	P	4	100
Paper-XI	Semester-V	Organic Spectroscopy	P	4	100
Paper-XII		Basic quantum chemistry, Molecular & electronic spectroscopy, and photochemistry	P	4	100
Paper-XIII		Chemistry of Organometallic Compounds	P	4	100
Paper-XIV	Semester-VI	Chemistry of Biomolecules	P	4	100
Paper-XV		Solid and porous materials, and Magneto chemistry and power cells	P	4	100
Paper-XVI	Semester-VII	Analytical Methods of Chemistry	NP	4	100
Paper-XVII		Polymer Chemistry	P	4	100
Paper-XVIII		Green Chemistry	P	4	100
Paper-XIX		Oxidation, Reduction, Reagents, Rearrangements and Name Reactions	NP	4	100
Paper-XX	Semester-VIII	Quantum chemistry & Statistical Thermodynamics	NP	4	100
Paper-XXI		Chemical group theory, electronic spectra of metal complexes, and nuclear chemistry	P	4	100
Paper-XXII		Pericyclic reactions, Photochemistry and Retrosynthesis	P	4	100
Paper-XXIII		Research Methodology for Chemistry	NP	4	100

CORE-II/CORE-III COURSE

Course Number	Semester Core-II/ Core-III	Course Title	Type of Paper P-Practical NP(Non-practical	Credit Hour	Maximum Weightage of Marks
Paper-I	Semester-I/II	Atomic Structure, Periodicity of elements and Chemical Bonding	P	4	100
Paper-II	Semester-III/IV	Fundamental Organic Chemistry	P	4	100
Paper-III	Semester-V/VI	States of matter, and Ionic equilibrium	P	4	100
Paper-IV	Semester-VII	Chemical thermodynamics, equilibrium, and Colligative property	P	4	100
Paper-V	Semester-VIII	Acids and Bases, Metallurgy, Chemistry of main group elements	P	4	100

ABILITY ENHANCEMENT COURSE (AEC) UNDER NEP-2020

Sl. No.	Semester	Course	Credit hour (CH)	Full Mark
Paper-I	I	Odia/Hindi/Sanskrit/Urdu	4	100
Paper-II	II	English	4	100

MULTIDISCIPLINARY COURSE:

NOTE: THIS IS APPLICABLE FOR STUDENT ADMISSION FOR THE 2026-27 BATCH.

1. *A basket of semester wise MDC Courses (**Table-I**) have been approved by Sambalpur University, which will be applicable to all the U.G. programme in the affiliated colleges under Sambalpur University.*
2. *Students have to opt for one subject in each semester from the semester- wise subject list provided in the basket.*
3. *During the counselling, students are to be encouraged to opt for courses outside their discipline/faculty. (A Group of related subjects, i.e., Faculty: Science/Arts/Commerce).*
4. *The students are expected to choose MDC from the subjects other than their major subjects. For example, a Home Science student cannot be allowed to opt MDC from Home Science and have to choose from any other Department.*

NOTE: ***The student cannot opt for a course already chosen in earlier semester. Ex: The subject chosen by a student in the 1st Semester cannot be chosen in 2nd Semester and the subject chosen in 1st & 2nd semester cannot be chosen in 3rd semester.***

Table -1: List of MDC Course at UG level

SEMESTER-I

MULTIDISCIPLINARY COURSE (MDC) UNDER NEP-2020					
Sl. No.	**Department to teach**	**Semester Course**	**Type of Paper P-Practical NP-Non-practical**	**Credit hour (CH)**	**Full Mark**
1.	Chemistry	Environmental Chemistry	NP	3	100
2.	Botany	Gardening and Vermicomposting	NP	3	100
3.	Economics	Economics in Everyday Life	NP	3	100
4.	History	History of Education in Modern India	NP	3	100
5.	Odia	**Tulatmaka Sahitya**	NP	3	100
6.	Political Science	Political Process in India	NP	3	100
7.	English	Ethical Literature	NP	3	100
8.	Commerce	Financial literacy	NP	3	100
9.	Education	Educational Psychology	NP	3	100
10.	Mathematics	Discrete Mathematics	NP	3	100
11.	Sociology	Sociology for Social Workers	NP	3	100
12.	Physics	Biophysics	NP	3	100

SEMESTER-II

MULTIDISCIPLINARY COURSE (MDC) UNDER NEP-2020					
Sl. No.	**Department to teach**	**Semester Course**	**Type of Paper P-Practical NP-Non-practical**	**Credit hour (CH)**	**Full Mark**
1.	Statistics	Survival Analysis and Biostatistics	NP	3	100
2.	Zoology	Apiculture	NP	3	100
3.	Education	Gender and Education	NP	3	100
4.	Geography/Geology	Climatology	NP	3	100
5.	Philosophy	Vedic Culture	NP	3	100
6.	Hindi	विज्ञापन अवधारणा और प्रयोजनमूलक अय्यन	NP	3	100
7.	Home Science	Food Science and Nutrition	NP	3	100
8.	Commerce	Fundamentals of Entrepreneurship and E-Commerce	NP	3	100
9.	Economics	Demography	NP	3	100
10.	Mathematics	Introduction to Programming with MATLAB	NP	3	100
11.	Political Science	Indian Administration	NP	3	100
12.	History/Geography	Sustainable Tourism	NP	3	100

SEMESTER-III

MULTIDISCIPLINARY COURSE (MDC) UNDER NEP-2020					
Sl. No.	**Department to teach**	**Semester Course**	**Type of Paper P-Practical NP-Non-practical**	**Credit hour (CH)**	**Full Mark**
1.	Mathematics/Computer Science	Programming C++	NP	3	100
2.	Physics	Introduction to Spectroscopy	NP	3	100
3.	History/ Sanskrit	Indian Knowledge System	NP	3	100
4.	Political Science	Human Rights	NP	3	100
5.	Botany/Zoology	Environmental issues and Challenges	NP	3	100

6.	Commerce	Entrepreneurship Development and start up	NP	3	100
7.	Psychology	Health Psychology	NP	3	100
8.	Philosophy	Philosophy of Bhagavad Gita	NP	3	100
9.	Botany	Herbarium Preparations	NP	3	100
10.	Education	Educations Thinkers of Modern India	NP	3	100
11.	Sociology	Public Policy	NP	3	100
12.	Library & Information Science	Management of Libraries	NP	3	100

SKILL ENHANCEDMENT COURSE:

NOTE: THIS IS APPLICABLE FOR STUDENT ADMISSION FOR THE 2026-27 BATCH.

1. *A basket of Skill Enhanced Course for various disciplines has been approved by the Sambalpur University and will be applicable to all undergraduate programme in the affiliated colleges under Sambalpur University.*
2. *A student may opt one SEC course form the basket during a particular semester, ensuring no repetition. Details of the SEC courses for each semester are provided in table-2.*
3. ***Artificial Intelligence has been offered as a compulsory course at 2nd semester Skill Enhancement Course.***

TABLE-2: LIST OF THE SEC COURSE AT UG LEVEL

SKILL ENHANCEDMENT COURSE (SEC) UNDER NEP-2020			
	SEMESTER-II	Credit hour (CH)	Full Mark
Paper- I	PERSONALITY DEVELOPMENT **OR** ELECTION STUDIES AND PUBLIC OPINION **OR** QUANTITATIVE AND LOGIAL THINKING **OR** ANALYTICAL THINKING AND LOGICAL RESONING **OR** RENEWABLE ENERGY AND ENERGY HARVESTING **OR** VERMICOMPOSTING **OR** PROJECT MANAGEMENT	3	100

SKILL ENHANCEDMENT COURSE (SEC) UNDER NEP-2020 **SEMESTER-V**			
Paper-II	**ARTIFICIAL INTELLIGENCE** Compulsory for all (Arts, Science & Commerce)	**Credit hour (CH)** 3	**Full Mark** 100

SKILL ENHANCEDMENT COURSE (SEC) UNDER NEP-2020			
	SEMESTER-VI	**Credit hour (CH)**	**Full Mark**
Paper- III	LIFE SKILL EDUCATION **OR** QUANTITATIVE AND LOGICAL THINKING **OR** INCOME TAX E-RETURN FILING **OR** ORGANIC FARMING **OR** BIOFERTILIZERS **OR** TYPE SETTING IN LATEX **OR** FOOD FERMENTATION TECHNIQUES	3	100

VALUE ADDED COURSES (VAC)
UNDER NEP – 2020

1. ***The student will have to study one VAC course in each semester (I, III, V, VI) irrespective of their disciplines are reflected in Table-3.***

TABLE-3: LIST OF THE VAC COURSE AT UG LEVEL

VALUE ADDED COURSES (VAC) UNDER NEP – 2020				
Paper	**Semester**	**Course title**	**Credit**	**Marks**
PAPER I	Semester-I	Environmental Studies and Disaster Management	3	100
PAPER II	Semester-III	Ethics & Values	3	100
PAPER III	Semester-V	Understanding Odisha	3	100
PAPER IV	Semester-VI	Creative Writing	3	100

Semester-I

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

Course Title	Code	Credits	Credit distribution	
			Lecture	Practical
Atomic Structure, Periodicity of elements and Chemical 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 Inorganic Chemistry, 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.

Core- I (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 antihydroxylation (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.

Semester-II

CORE-I 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 powder pattern 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

CORE-I 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 Δ*G* derive the relationship between different equilibrium constants.
- Understand the basic concept of Solutions of non-volatile solutes, colligative properties. Calculate various thermodynamic properties ($\Delta H_{neutralization}$, $\Delta H_{hydration}$ & 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, GibbsHelmholtz 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.

Semester-III

CORE-I 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 LuxFlood 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.

Core- I (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 studyof nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis ofesters,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.

CORE-I 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 solidvapour 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 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 (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^- → I_3^-(aq)
- Cu^{2+}(aq) + nNH_3 → $Cu(NH_3)_n$

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

Semester-IV

CORE-I 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 fblock 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 period in 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 compounds have 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 important compounds of Cr, Mn, Fe and Co and their roles as laboratory reagents; Potassium dichromate, potassium permanganate, 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 transeffect (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

Text Books:

1. *Synthesis of hexamine nickel(II) complex, $[Ni(NH_3)_6]Cl_2$*
2. Synthesis of tetraamminecopper(II) sulphate, $[Cu(NH_3)_4]\ SO_4.\ H_2O$
3. Estimation of Ca and Mg from cement by EDTA method
4. Estimation of nickel (II) using dimethylglyoxime (DMG)

1. . 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).

Core- I (Paper-IX) Natural Products, Heterocyclic Compounds, Nitrogen containing compounds and Poly nuclear 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.

*DiazoniumSalt*s**:** 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, FiestBenary 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, isoprenerule; 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.