Sri Sai University, Palampur

Syllabus for B.Sc. (Honours) in Chemistry

Choice Based Credit System (CBCS)

Course Effective from Academic Year 2022-23

Contents

Ability Enhancement Compulsory Courses (AEC)

Skill Enhancement Courses (SEC)

Generic Elective (GE) Courses (offered to other Departments)

1. DURATION OF THE PROGRAMME

(a) The degree programme leading to the award of Bachelor of Science (B.Sc.) in chemistry shall be of three years duration and include six continuous semesters under Choice Based Credit System (CBCS).

(b) The programme shall be completed in a maximum of five years (10 Semesters), consecutively, from the date of admission to the programme.

2. PROGRAMME STRUCTURE

(a) The syllabi for B.Sc. (Honours) in Chemistry is drafted as per the UGC guidelines for Learning Outcomes based Curriculum Framework (LOCF) based approach with an aim to equip the students with knowledge, skill, values and attitude.

(b) Usually a course refers to a 'paper' and is a component of an academic programme.

(c) The programmes shall include:

(i) **Core Course**: A core course is a compulsory paper to be studied by all the students to complete the requirements for the undergraduate degree.

(ii) **Elective Course**: Elective course is a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.

1. *Discipline Specific Elective (DSE) Course*: Elective courses offered by the main discipline/subject of study is referred to as Discipline Specific Elective.
2. *Generic Elective (GE) Course*: An elective course chosen generally from other discipline(s)/subject(s), with an intention to seek exposure is called a Generic Elective.

(iii) **Ability Enhancement Courses:** The Ability Enhancement Courses may be of two kinds:

1. *Ability Enhancement Compulsory Courses (AE)*: The courses which leads to knowledge enhancement such as Environmental Science, English Communication etc. These courses are mandatory.
2. *Skill Enhancement Courses (SE)*: These courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc. These courses are mandatory and shall be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge.

(d) To acquire a B.Sc. (Hons.) Chemistry degree, a student shall have to study 14 (fourteen) Core Courses, 4 (four) Discipline Specific Elective (DSE) courses, 4 (four) Generic Elective (GE) courses, 4 (four) Skill Enhancement Courses (SE) along with 2 (two) Ability Enhancement Compulsory Courses (AE).

(e) The student will study two Core Courses each, in Semesters I and II, three Core Courses each in Semesters III and IV and two Core Courses each in Semesters V and VI.

(f) The programme offers several Discipline Specific Elective (DSE) Courses, of which the student will study two in each of the Semesters V and VI. The students are required to take 2 courses from each group A and B respectively.

(g) Different Generic Elective courses are offered to students of B.Sc. (Hons) Chemistry Programme by other Departments of the University/College and the student will have the option to choose one GE course each in Semesters I, II, III, and IV. The students may choose four Generic Elective papers either exclusively from one discipline *OR* two papers each from two different disciplines but in both the cases excluding his/her own discipline. Some Universities in India require at least two mathematics papers to be studied by the student for admission into M.Sc. (Chemistry), thus students are advised to choose accordingly.

(h) Students are required to select at least 2 (two) SEC of total 4 credits from his/her concerned discipline to be offered in semester I to IV. For remaining 4 credits, he/she may select course(s) from either from his/her own discipline or other under-graduate disciplines of Science and Technology in the College/University.

(i) The Ability Enhancement Compulsory Courses (AEC) are English Communication, Hindi Sikshan and Environmental Studies and the student will study one each in Semesters I and II.

(j) The number of credits is given in the form L:T:P, where L, T and P indicates lecture, tutorial and practical laboratory credits respectively. Each lecture credit corresponds to one lecture hour per week, each tutorial credit corresponds to one tutorial hour per week while each laboratory credit corresponds to two laboratory hours per week. For example, 4:0:2 credits indicate that the course has 4 lectures, no tutorial session and two laboratory hours each week.

(k) The total credit required to complete the programme shall be a minimum of **144 credits**. Students may pursue courses for additional 12 credits on their own (please refer to "SRI SAI UNIVERSITY REGULATIONS FOR CHOICE BASED CREDIT SYSTEM FOR UNDER- GRADUATE COURSES, 2022").

(l) The detailed structure of courses under B.Sc. (Honours) with Chemistry Programme shall be:

Sl. No.	Details of Courses	Credits		
		Theory	Practical	TOTAL
I	**Core Courses** (6 Credits) (**14 Courses**)	14 X4 = 56	14 X 2 = 28	84
II	**Elective Courses** (6 Credits) (**8 Courses**)			
	(a) Discipline Specific Elective (DSE) Courses (**4 Courses**)	4 X 4 = 16	4 X 2 = 8	24
	(b) Generic Elective (GE) Courses (**4 Courses**)	4 X 4 = 16	2 X 2 = 4	20
III	**Ability Enhancement Courses**			
	(a) Ability Enhancement Compulsory Courses (AE) (4 Credits) (**2 Courses**)	2 X 4 = 8		8
	(b) Skill Enhancement Courses (SE) (2 Credits) (**4 Courses**)	4 X 2 = 8		8
Grand Total Credit				**144**

(m) Scheme for Choice Based Credit System (CBCS) in B.Sc. (Honours) with Chemistry

Semester	Core Course (CC)	Elective Course		Ability Enhancement Course	
		Discipline Specific Course (DSE)	Generic Elective (GE)	Ability Enhancement (AE) Compulsory Course	Skill Enhancement (SE) Course
I	CC I, CC II		GE I	AE I	SE I
II	CC III, CC IV		GE II	AE II	SE II
III	CC V, CC VI, CC VII		GE III		SE III
IV	CC VIII, CC IX, CC X		GE IV		SE IV
V	CC XI, CC XII	DSE I, DSE II			
VI	CC XIII, CC XIV	DSE III, DSE IV			

3. CONVERSION OF PERCENTAGE INTO CREDIT(S) AND GRADE(S)

(a) Under the absolute grading system adopted by the University, the marks shall be converted to grades based on pre-determined class intervals. The grading system with the following letter grades shall be adopted in awarding the grades and CGPA under the credit-based semester system.

% of Marks	Grade Point	Grade Letter
95-100	10	O (Outstanding)
85-94	9	A++ (Excellent)
75-84	8	A+ (Very Good)
65-74	7	A (Good)
55-64	6	B+ (Above Average)
45-54	5	B (Average)
35-44	4	C (Pass)
34 and less	0	D (Fail)
Absent	0	AB (Absent)

(b) Conversion to grade point to percentage = Grade Point 10.0.

(c) A student obtaining Grade D shall be considered failed and shall be required to reappear in the examination, as provided in the ordinance(s) of the university.

(d) Computation of SGPA and CGPA:

(i) **Semester Grade Point Average (SGPA)** is the sum of the products of the course credit and grade points scored by a student divided by the sum of all course credits offered by the student. It can be calculated in the following manner:

$$SGPA\ (Si) = \frac{\sum(Ci\ x\ Gi)}{\sum Ci}$$

Where, C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course.

(ii) **Cumulative Grade Point Average (CGPA)** is the sum of the products of the total number of credits of all courses taken by a student in a semester with the SGPA in that semester divided by the total number of credits of all courses taken. It can be calculated in the following manner:

$$CGPA\ = \frac{\sum(Ci\ x\ Si)}{\sum Ci}$$

Where, S_i is the SGPA of the i^{th} semester and C_i is the number of credits in that semester.

(e) Illustration of computation of SGPA and CGPA

Course	**Marks Obtained** (Internal Assessment + End semester exam)	**Grade Letter**	**Grade Point (G)**	**Credit (C)**	**Credit Point**	**SGPA**
Semester I						
CC I	78	A+	8	6	8 x 6 = 48	**6.90** (152/22)
CC II	85	A++	9	6	9 x 6 = 54	
GE I	73	A	7	4	7 x 4 = 28	
AE I	52	B	5	4	5 x 4 = 20	
SE I	62	B+	6	2	6 x 2 = 12	
			Total	**22**	**152**	
Semester II						
CC III	79	A+	8	6	8 x 6 = 48	**6.92** (166/24)
CC IV	63	B+	6	6	6 x 6 = 36	
GE II	57	B+	6	6	6 x 6 = 36	
AE II	70	A	7	4	7 x 4 = 28	
SE II	89	A++	9	2	9 x 2 = 18	
			Total	**24**	**166**	
Semester III						
CC V	79	B	5	6	5 x 6 = 30	**5.85** (152/26)
CC VI	63	A	7	6	7 x 6 = 42	
CC VIII	53	B	5	6	5 x 6 = 30	
GE III	57	A	7	6	7 x 6 = 42	
SE III	89	C	4	2	4 x 2 = 08	
			Total	**26**	**152**	
Semester IV						
CC VIII	80	A+	8	6	8 x 6 = 48	**7.58** (182/24)
CC IX	70	A	7	6	7 x 6 = 42	
CC X	77	A+	8	6	8 x 6 = 48	
GE IV	84	A+	8	4	8 x 4 = 32	
SE IV	60	B+	6	2	6 x 2 = 12	
			Total	**24**	**182**	
Semester V						
CC XI	79	A+	8	6	8 x 6 = 48	**8.25** (198/24)
CC XII	86	A++	9	6	9 x 6 = 54	
DSE I	81	A+	8	6	8 x 6 = 48	
DSE II	76	A+	8	6	8 x 6 = 48	
			Total	**24**	**198**	
Semester VI						
CC XIII	87	A++	9	6	8 x 6 = 54	**8.50** (204/24)
CC XIV	86	A++	9	6	9 x 6 = 54	
DSE III	75	A+	8	6	8 x 6 = 48	
DSE IV	76	A+	8	6	8 x 6 = 48	
				24	204	

Thus $CGPA = \frac{(22X6.90) + (24X6.92) + (26X5.85) + (24X7.58) + (24X8.25) + (24X8.50)}{144}$

4. SEMESTER-WISE DISTRIBUTION OF COURSES FOR B.SC. (HONOURS) CHEMISTRY PROGRAMME UNDER CBCS AND CREDIT DISTRIBUTION

(a) Core Courses

Semester	Course Code	Course Title	Credit (L:T:P)	Total Credit
I	CHEM-CC-311	Fundamentals of Inorganic Chemistry	4:0:2	6
	CHEM-CC-312	Fundamentals of Organic Chemistry	4:0:2	6
II	CHEM-CC-321	Chemistry of *s* and *p* block elements	4:0:2	6
	CHEM-CC-322	States of Matter and Ionic Equilibria	4:0:2	6
III	CHEM-CC-331	Transition elements & Coordination Chemistry	4:0:2	6
	CHEM-CC-332	Chemistry of Functional Groups	4:0:2	6
	CHEM-CC-333	Chemical Thermodynamics and Colligative properties	4:0:2	6
IV	CHEM-CC-341	Advanced Inorganic Chemistry	4:0:2	6
	CHEM-CC-342	Chemistry of N, S Containing Compounds, Heterocyclics, Polycyclic and Carbohydrates	4:0:2	6
	CHEM-CC-343	Phase Equilibria and Electrochemistry	4:0:2	6
V	CHEM-CC-351	Chemistry of Biomolecules	4:0:2	6
	CHEM-CC-352	Conductance, Photochemistry and Chemical Kinetics	4:0:2	6
VI	CHEM-CC-361	Advanced Organic Chemistry	4:0:2	6
	CHEM-CC-362	Advanced Physical Chemistry	4:0:2	6

(b) Discipline Specific Elective (DSE) Courses

Semester	Course Code	Course Title	Credit (L:T:P)	Total Credit
V (Any two for DSE I and DSE II)	CHEM-DSE-353	Analytical Techniques in Chemistry	4:0:2	6
	CHEM-DSE-354	Industrial Chemicals and Environment	4:0:2	6
	CHEM-DSE-355	Research Methodology for Chemists	5:1:0	6
	CHEM-DSE-356	Polymer Chemistry	4:0:2	6
VI (Any two for DSE III and DSE IV)	CHEM-DSE-363	Analytical and Instrumental Methods of Chemical Analysis	4:0:2	6
	CHEM-DSE-364	Nanoscale Materials and Their Applications	4:0:2	6
	CHEM-DSE-365	Applications of Computers in Chemistry	4:0:2	6
	CHEM-DSE-366	Dissertation	0:1:5	6

(c) Generic Elective (GE) Courses

(i) Please refer to the syllabus of following departments/disciplines for GE 1 to GE 4

1. Mathematics
2. Physics
3. Computer Science

(ii) The students may choose either four Generic Elective papers exclusively from one department/ discipline *OR* two papers each from two different departments/disciplines.

(iii) Some Universities in India require at least two mathematics papers to be studied by the student for admission into M.Sc. (Chemistry), thus students are advised to choose accordingly.

(d) Ability Enhancement Courses (AEC)*

Semester	Course Code	Course Title	Credit (L:T:P)	Credit
I	ENG-AE-011	Technical Writing and Communication in English	3:1:0	4
II	EVS-AE-021	Environmental Studies	4:0:0	4

(e) Skill Enhancement Courses (SEC)*

Semester		Course Title	Credit (L:T:P)	Credit
I & III	CHEM-SE-011	Water Treatment and Analysis I	1:0:1	2
	CHEM-SE-013	Fertilizers and Pesticides Chemistry	1:0:1	2
	CHEM-SE-015	Pharmaceutical Chemistry	1:0:1	2
II & IV	CHEM-SE-012	Water Treatment and Analysis II	1:0:1	2
	CHEM-SE-014	Chemistry of Foods, Cosmetics and Perfumes	1:0:1	2

(i) A student shall select at least 2 (two) SEC of total 4 credits from his/her concerned discipline.

(ii) For remaining 4 credits, he/she may select course(s) from either from his/her own discipline or other under-graduate disciplines of Science and Technology in the College/University.

(f) Generic Elective (GE) Courses offered to other Departments/Disciplines*

Semester	Course Code	Course Title	Credit (L:T:P)	Credit
I	CHEM-GE-001	General Chemistry- I	4:0:2	6
II	CHEM-GE-002	General Chemistry-II	4:0:2	6
III	CHEM-GE-003	General Chemistry-III	4:0:2	6
IV	CHEM-GE-004	General Chemistry-IV	4:0:2	6

**These Generic Elective (GE) courses are intended to be studied by students from other departments/disciplines.*

Distribution of MARKS

Course Code	Title of Course	Marks				Credits			
		Theory	Practical	Internal Assessment	Total	L	T	P	
	SEMESTER-I								
CHEM-CC-311	Fundamentals of Inorganic Chemistry	60	50	40	150	4	0	2	**6**
CHEM-CC-312	Fundamentals of Organic Chemistry	60	50	40	150	4	0	2	**6**
ENG-AE-011	Technical Writing and Communication in English	60	0	40	100	3	1	0	**4**
……	**Generic Elective (GE) Course-I***	60	50/0	40	150/100	4/5	0/1	2/0	**6**
……	**Skill Enhancement Courses-I (SE)***	**20**	**10**	**20**	**50**	**1**	**0**	**1**	**2**
	SEMESTER-II								
CHEM-CC-321	Chemistry of *s* and *p* block elements	60	50	40	150	4	0	2	**6**
CHEM-CC-322	States of Matter and Ionic Equilibria	60	50	40	150	4	0	2	**6**
ENV-AE- 021	Environmental Studies	60	0	40	100	4	0	0	**4**
……..	**Generic Elective (GE) Course-II***	60	50/0	40	150/100	4/5	0/1	2/0	**6**
……	**Skill Enhancement Courses-II (SE)***	**20**	**10**	**20**	**50**	**1**	**0**	**1**	**2**
	SEMESTER-III								
CHEM-CC-331	Transition elements & Coordination Chemistry	60	50	40	150	4	0	2	**6**
CHEM-CC-332	Chemistry of Functional Groups	60	50	40	150	4	0	2	**6**
CHEM-CC-333	Chemical Thermodynamics and Colligative properties	60	50	40	150	4	0	2	**6**
……..	**Generic Elective (GE) Course-III***	60	50/0	40	150/100	4/5	0/1	2	**6**
……	**Skill Enhancement Courses-III (SE)***	**20**	**10**	**20**	**50**	**1**	**0**	**1**	**2**
	SEMESTER-IV								
CHEM-CC-341	Advanced Inorganic Chemistry	60	50	40	150	4	0	2	**6**
CHEM-CC-342	Chemistry of N, S Containing Compounds, Heterocyclics, Polycyclic and Carbohydrates	60	50	40	150	4	0	2	**6**
CHEM-CC-343	Phase Equilibria and Electrochemistry	60	50	40	150	4	0	2	**6**
……	**Generic Elective (GE) Course-IV**	60	50/0	40	150/100	4/5	0/1	2	**6**
……	**Skill Enhancement Courses-IV (SE)***	**20**	**10**	**20**	**50**	**1**	**0**	**1**	**2**

SEMESTER – V									
CHEM-CC-351	Chemistry of Biomolecules	60	50	40	150	4	0	2	**6**
CHEM-CC-352	Conductance, Photochemistry and Chemical Kinetics	60	50	40	150	4	0	2	**6**
…….	**Discipline Specific Elective (DSE)-I**	60	50	40	150	4	0	2	**6**
…….	**Discipline Specific Elective (DSE)-II**	**60**	**50**	**40**	**150**	**4**	**0**	**2**	**6**
SEMESTERS – VI									
CHEM-CC-361	Advanced Organic Chemistry	60	50	40	150	4	0	2	**6**
CHEM-CC-362	Advanced Physical Chemistry	60	50	40	150	4	0	2	**6**
…….	**Discipline Specific Elective (DSE)-III**	60	50	40	150	4/5	0/1	2	**6**
…….	**Discipline Specific Elective (DSE)-IV**	**60**	**50**	**40**	**150**	**4**	**0/1**	**2/5**	**6**

Core Courses

SEMESTER-I

CHEM-CC-311: Fundamentals of Inorganic Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	The objective of this course is to teach the basic concept, reasoning for atomic size and ionic size, chemical and physical properties of s, p and d block elements.
Course Outcomes	Students are able to: • Understand the core criteria of the periodic table; preparation, physical, chemical properties, structure and uses of compounds of elements belonging to s, p, d and f blocks. • Explain the bonding fundamentals for ionic and covalent compounds.

DETAILED CONTENT

Module I

Atomic Structure: Recapitulation of Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance, Normal and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations.

Module II

Periodicity of Elements: The long form of periodic table *(s, p, d, f* block elements). Detailed discussion on properties of the elements in periodic table: Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, atomic radii (Van der Waals), Ionic and crystal radii, Covalent radii, Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy. Applications of ionization enthalpy, Electron gain enthalpy, trends of electron gain enthalpy, Electronegativity, Pauling's/ Mulliken's/ and Allred Rochow's/ electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio. Inert pair effect, Relative stability of different oxidation states, anomalous behaviour of first member of each group and diagonal relationship. Allotropy and catenation. Complex forming ability of *s* and *p* block elements.

Module III

Ionic Bond: General characteristics of ionic compounds, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation, its derivation and application. Madelung constant, Born-Haber cycle and its application, solvation energy.

Module IV

Covalent Bond: Valence bond theory (VBT) (Heitler-London approach). Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach), and bond lengths. Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital energy level diagrams of diatomic (homo and hetero) and simple polyatomic molecules and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

Module V

Metallic Bond and Weak Interactions: Qualitative idea of valence bond and band theories to metallic bond. Semiconductors and insulators, defects in solids. Weak Van der Waal's, ion-dipole, dipole-dipole, induced dipole interactions, instantaneous dipole induced dipole interactions. Repulsive forces, Hydrogen bonding. Effects of chemical bonding on melting and boiling points.

Recommended Texts:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E. and Mc Daniel, D.H., *Concepts & Models of Inorganic Chemistry*, Oxford, 1970
3. Atkins, P.W. & Paula, J. *Physical Chemistry*, Oxford Press, 2006.
4. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications 1962.

PRACTICAL

Fundamentals of Inorganic Chemistry (CHEM-CC-311P)

Course Objectives	This Course will prepare the students to demonstrate the basic laboratory technique of titration as well as use of apparatus.
Course Outcomes	After conducting this experiment, students should be able to: • Prepare the standard solution. • Determine the concentration of solution.

(A) Titrimetric Analysis

(i) Calibration and use of apparatus.

(i) Preparation of solutions of different Molarity/Normality of titrants.

(B) Acid- Base Titrations

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

(C) Oxidation- Reduction Titrimetry

(i) Estimation of Fe (II) and oxalic acid using standardized $kmno_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe (II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS.
2. Gulati, S., Sharma, J.L. *Practical Inorganic Chemistry*, CBS.

SEMESTER-I

CHEM-CC-312: Fundamentals of Organic Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	The objectives of present course is to introduce the fundamental concepts of organic chemistry, provide an overview of the chemistry of organic functional groups and give a mechanistic understanding of various elementary organic reactions. The course is infused with the recapitulation of fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space. Further, to establish the applications of these concepts, the different functional groups- alkanes, alkenes, alkynes and aromatic hydrocarbons are also introduced.
Course Outcomes	On completion of the course, the student will be able to: • Understand and explain the different nature and behaviour of organic compounds based on fundamental concepts learnt. Understand nature and reactivity of various functional groups. • Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved. • Understand the fundamental concepts of stereochemistry. • To describe stereo chemical like chiral reagents and catalysts • Learn and identify many organic reaction mechanisms including Free Radical substitution, electrophilic addition and electrophilic Aromatic Substitution.

DETAILED CONTENT

Module-I

Structure and Bonding: Organic compounds: Classification and Nomenclature, Hybridization, shapes of molecules, influence of hybridization on bond properties. Electronic displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Mechanism of organic reactions: Homolytic and heterolytic fission with suitable examples. Curly arrow rules, formal charges; electrophiles and nucleophiles; nucleophlicity and basicity; Types, shape and their relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions and their mechanism: addition, elimination and substitution reactions.

Module II

Basic Principles of Stereochemistry: Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules.
Optical Isomerism: Optical activity, Specific rotation, chirality/asymmetry, enantiomers, molecules with two or more chiral-centres, distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

Module III
Cycloalkanes and Conformational Analysis: Methods of formation, types and relative stability of cycloalkanes, baeyer strain theory and its limitations, ring strain in small rings (cyclopropane and cyclobutane), conformation analysis of alkanes: relative stability: energy diagrams of cyclohexane: chair, boat and twist boat forms; relative stability with energy diagrams. Conformations of cyclohexane derivative. Conformational effects on reactivity. Angle strain, torsional and stereoelectronic effects on reactivity.

Module IV
Saturated And Unsaturated Hydrocarbons: Chemistry of alkanes: formation and synthesis of alkanes, Wurtz & Wurtz- Fittig reactions, free radical substitutions: halogenation - relative reactivity and selectivity. Formation of alkenes and alkynes by elimination reactions, mechanism of E1, E2 and 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; allylic and benzylic bromination and mechanism, reactions of alkynes: acidity, electrophilic and nucleophilic additions. Hydration to form carbonyl compounds, alkylation of terminal alkynes.

Module V
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 Texts:
1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Jagdamba, S. & Yadav. L.D.S., *Undergraduate Organic Chemistry (Volume 1)*, Pragati Prakashan (India). Pvt. Ltd.

PRACTICAL
Fundamentals of Organic Chemistry (**CHEM-CC-312P)**

Course Objectives	This course aims to impart to the students: knowledge of 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; have hand on experience with different minor equipment for the determination of different physical properties; and to trained the students in chromatographic separation of mixtures
Course Outcomes	This course aims to impart to the student, knowledge of: • Ability to measure the physical properties of organic compounds • Experience in using different minor equipments.

DETAILED CONTENT

1. Accuracy and calibration of the thermometer.
2. Purification of organic compounds by crystallization using the following solvents:

A. Water
B. Alcohol
C. Alcohol-water (Different proportions)

3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100° C by distillation and capillary method).
6. Chromatography

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

Recommended Books:

1.Vogel A. I., Tatchell A.R., Furnis B.S., Hannaford A.J., Smith P.W.G.,Vogel's Text Book of Practical Organic Chemistry,5th Edn.,Pubs: ELBS, 1989.
2. Pavia D.L., Lampanana G.M., Kriz G.S. Jr., Introduction to Organic Laboratory Techniques, 3rd Edn., Pubs: Thomson Brooks/Cole,2005.
3. Mann F.G., Saunders. P.C.,Practical Organic Chemistry,Pubs:Green & Co. Ltd., London, 1978.

SEMESTER-II

CHEM-CC-321: Chemistry of *s* and *p* block elements

L	T	P	Credit
4	0	2	6

Course Objectives	This Course will Prepare the students to identify the common physical properties of metals and non- metals and explain how their uses relate to these properties and to explore in depth specialized areas of chemistry of materials, including ores, metals, acids and bases and to understand how metals are extracted from their ores. The student will be able to understand the trends in properties and reactivity of the s, p-block elements and noble gases and become familiar with some of the roles of inorganic polymer and its applications in day to day life.
Course Outcomes	By the end of the course, the student must be able to: • Recall general trends in the periodic table of elements. • Recall methods for the synthesis of the s & p block elements. • Recall the structures, the properties, applications, and the chemical reactivity of the s & p block elements. • Differentiate the different allotropes of the s & p block elements.

DETAILED CONTENT

Module-I

Hydrogen: Discussion regarding its position in the periodic table, ortho and para hydrogen, isotopes; Industrial production; Hydrides: classification (ionic, covalent and interstitial) and their chemistry; Heavy water.

Module- II

S-block elements: Production and uses of metals; chemical reactivity and trends in alkali and alkaline earth metals; structure and properties of oxides, halides and hydroxides, coordination complexes, Basic beryllium acetate and nitrate. Organometallic compounds of alkali metals, crown and cryptands.

Module-III

P-block Elements-I: Group III: Boron family: Chemical reactivity and trends. Boron: Structures of crystalline boron, electronic and/or crystal structures of borides, Bonding and structure of diborane and their chemistry. Boron halides (Lewis acid base strength). Boric acid, borates, boron-nitrogen compounds, $LiAlH_4$–its uses as a reducing and hydrogenating reagent, structure of alumina and aluminates. Organometallic compounds of Al, catalytic properties.

Group IV: Carbon family: Chemical reactivity and group trends. Carbon: Allotropic forms, graphitic compounds, graphite intercalation compounds, carbides. Silicon: Silicon carbides, silicides, silanes and silylamines structures of silicate mineral, organo silicon compounds and silicones. Tin and lead oxides, halides, Pb accumulators, organometallic compounds of Sn and Pb.
Group V: Nitrogen family: Chemical reactivity and group trends. Nitrogen: Introduction, types of covalence in nitrogen, stereochemistry, chemical reactivity, dinitrogen complexes (basic idea only), hydrides of nitrogen, liquid NH_3 as a solvent, nitrogen halides, oxides and oxoacids. Phosphorus, As, Sb and Bi : Stereochemistry of their compounds, production of elemental P and its allotropic forms, hydrides, halides, oxides and oxy-acids, phosphorus-nitrogen compounds, some organometallic compounds.

Module-IV

P-Block Elements-II: Group VI: Oxygen Family: Chemical reactivity, group trends & stereochemistry, dioxygen as a ligand (basic idea only), structure of ozone and H_2O_2, allotropic forms of S and Se, structures of halides, oxides and oxyacids of S, Se and Te, liquid SO_2 and 100% sulphuric acid as solvent, polyatomic cations of S, Se and Te, clathrate hydrates.

Group VII: Halogen Family: Chemical reactivity, group trends, chemistry of preparation of fluorine, hydrogen halides (acidic strength and chemical properties), HF as a solvent, inter-halogen compounds (their preparation and structures), pseudohalogens, polyhalide and polyhalonium ions; polyatomic cations of halogens, oxides and oxyacid of halogens.

Module-V

Noble gases: Discovery, occurrence & isolation of noble gases; preparation and properties, bonding & structure of XeF_2 and XeF_4, XeF_6, oxyfluorides and oxides of xenon; Clathrate hydrates of noble gases. Uses of noble gases.

Recommended Texts:

1. Greenwood, N.N. and Earnshaw, *Chemistry of the elements*, Butterworth-Heinemann, 1997.
2. Lee, J.D. *Concise Inorganic Chemistry*, ELBS (1991).
3. Canham, G.R. and Overton, T., *Descriptive Inorganic Chemistry*, Freeman &Co.2006
4. Cotton, F.A. and Wilkinson, G, *Advanced Inorganic Chemistry*, Wiley, VCH,1999.

PRACTICAL

Chemistry of *s* and *p* block elements (**CHEM-CC-321P)**

Course Objectives	The objective of this course is to provide practical knowledge and illustrative experiments about synthesis and characterization of inorganic complexes and estimation of metal ions.
Course Outcomes	After conducting this experiment, you should be able to:

- To apply previous knowledge for performing experiment scientifically and safety.
- To design experimental procedure on given experiment.
- Preparation of different inorganic complexes.
- Purification and crystallisation of inorganic compounds

DETAILED CONTENT

(A) Iodo / Iodimetric Titrations:
(i) Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (iodimetrically).
(ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations:
(i) Cuprous chloride, Cu_2Cl_2
(ii) Preparation of manganese (III) phosphate, $MnPO_4.H_2O$
(iii) Preparation of aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum)
(iv) Preparation of chrome alum.

Recommended Texts:

1. Vogel, A.I. A text book of quantitative Inorganic Analysis, ELBS. 1978.
2. Gulati, S., Sharma, J.L. *Practical Inorganic Chemistry*, CBS.

SEMESTER-II

CHEM-CC-322: States of Matter and Ionic Equilibria

L	T	P	Credit
4	0	2	6

Course Objectives	To Familiarize students with all the three states of matter viz solid, liquid and gases and to understand all the laws and properties related to these states.
Course Outcomes	On completion of this course, the students will be able to • Familiarize with various states of matter and laws related to describe these states. • Understand kinetic model of gas, Maxwell distribution and mean-free path of molecules. • Explain behavior of real gases, its deviation from ideal behavior, equation of state and law of corresponding states. • Understand the properties of liquid and liquid crystals. • Understand various symmetry elements and crystal structure of NaCl, KCl and CsCl, lattice parameters and their calculations. • Explain ionic equilibria of electrolytes, ionization, dissociation, salt hydrolysis and acid-base equilibria and its application in chemistry.

DETAILED CONTENT

Module I

Kinetic molecular model for ideal gas behaviour: Postulates and derivation of kinetic theory of gases. Collision parameters, their temperature and pressure dependence. Viscosity of gases (η). Relation between mean free path and coefficient of viscosity. Calculation of collision diameter (σ) from η. Variation of viscosity with temperature and pressure. Maxwell's distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy. Law of equipartition of energy. Degree of freedom. Concept of heat capacities.

Module II

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 Waals equation of state, its derivation and application in explaining real gas behaviour. Virial equation of state; Van der Waals equation expressed in virial form and calculation of Boyle temperature. P-V isotherms of real gases and their comparison with Van der Waals isotherms, continuity of states. Critical state, relationship between critical constants and Van der Waals constants. Law of corresponding states.

Module III

Liquid state: Qualitative treatment of the structure of the liquid state, radial distribution function. 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.

Module IV

Solid state: Types of solids. Laws of crystallography: law of constancy of interfacial angles, law of rational indices, Miller indices. Symmetry: law of symmetry, symmetry elements and symmetry operations. Qualitative idea of point and space groups, crystal systems and Bravais lattices. X-ray diffraction by crystals, Bragg's law, rotating crystal and powder methods (a simple account only). Determination of crystal structures of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

Module V

Ionic equilibria: Strong and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Dissociation of weak acids and bases, dissociation constants of mono-, di- and tri-protic acids. Ionic product, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson-Hasselbalch equation and its applications, buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry. Solubility and solubility product of sparingly soluble salts, applications of solubility product principle. Theory of acid – base indicators; selection of indicators and their limitations.

Recommended Texts:

1. Atkins, P. W. & Paula, J. De *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Kapil, P. N., *Physical Chemistry*, S. Dinesh & Co.
6. Puri, B. R., Sharma, L. R. & Pathania, M. S. *Principles of Physical Chemistry,* Vishal Publishing Co.

PRACTICAL

States of Matter and Ionic Equilibria (**CHEM-CC-322P)**

Course Objectives	To provide students practical knowledge and skills about various topics taught in theory class of physical chemistry and to impart training in operating different instruments used in the chemical analysis.

Course Outcomes	After completing all experiments, student will be able to • Design and develop experimental skills on experiments in Physical Chemistry using potentiometry and pH meter. • Determine the surface tension and viscosity of liquids. • Describe the principles behind the experiment performed in the laboratory.

DETAILED CONTENT

(I) **Surface tension measurements** (use of organic solvents excluded).

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

(II) **Viscosity measurement** (use of organic solvents excluded).

(a) Study the effect of the addition of solutes such as

(i) polymer (ii) ethanol (iii) Sodium chloride on the viscosity of water at room temperature.

(b) Study the effect of variation of viscosity of an aqueous solution with the concentration of solute.

(III) **pH measurements**

A) Measurement of pH of different solutions using pH-meter.

B) Preparation of buffer solutions

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

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

D) pH metric titrations of

(i) Strong acid and strong base

(ii) Weak acid and strong base

Recommended Texts:

1. Khosla, B. D., Garg, V. C. & Gulati A. *Senior Physical Chemistry,* R Chand & Co., New Delhi.
2. Saini, M.S. *Modern Approach to Senior Physical Chemistry, Vol-I, Modern Publishers.* Findlay, A. *Practical physical Chemistry*, Longman, green

SEMESTER-III

CHEM-CC-331: Transition elements & Coordination Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	The objective of this course is to teach the basic concepts of coordination chemistry and industrial chemistry.
Course Outcomes	Student will be able to: • Use Crystal Field Theory to understand the magnetic properties (and in simple terms the colour) of coordination compounds. • Calculate 10Dq, CFSE of transition metal complexes.

DETAILED CONTENT

Module I

Transition elements: General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and E.M.F. (Latimer and Ebsworth diagrams). Difference between the first, second and third transition series. Chemistry of 3d series transition metals (Ti, V, Cr Mn, Fe, Co, Ni and Cu) in various oxidation states (excluding their metallurgy).

Module II

Coordination Chemistry-I: Introduction, Werner's theory, types of ligands : classical ligands, non-classical ligands (π-bonding or π- acid ligands); The chelate and macrocyclic effects, multidentate ligands, conformation of chelate rings, stereochemistry and various coordination numbers, isomerism in coordination compounds, nomenclature, stability of coordination compounds, thermodynamic and kinetic stability, stability constants, experimental and statistical ratios of stability constants, factors which influence the stability constant and chelate effect. Polynuclear complexes.

Module III

Coordination Chemistry-II: Valence bond theory (inner and outer orbital complexes), electro-neutrality principle and back bonding. Crystal field theory, (Splitting of d orbital in octahedral and tetrahedral environment) measurement of 10 Dq (Δ_o), CFSE in weak and strong fields, pairing energies, factors effecting the magnitude of 10 Dq. Octahedral vs tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem (brief introduction only), square planar geometry. Qualitative aspect of ligand field and MO

theory. Stereochemistry of complexes with 4 and 6 coordination numbers. Labile and inert complexes.

Module IV

Industrial Chemistry: Cement Industry: Classification of cements, study of raw materials and their availability. Manufacture of Portland cement.

Glass industry: Definition. Study of raw materials, manufacture of glass in general by pot and tank furnaces, types of glass. Manufacture of special glasses viz: tempered glass, laminated glass, borosilicate glass and water glass.

Fertilizers: Classification of fertilizers. Study of raw materials for nitrogeneous, phosphatic and potash fertilizers. Manufacture of ammonium sulphate, urea, superphosphate. Compound fertilizers. Manufacture of phosphoric acid by wet process and electric furnace process.

Module V

Acids and bases: Various concepts of acids and bases (Arrhenius, Bronsted-Lowry, Lewis), measurement of acid-base strength (pH and dissociation constant), Lewis interactions in non-polar solvents, systematics of Lewis acid-base interactions, bond energies, steric effects, solvation effects and acid-base anomalies, classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength and hardness on the basis of HSAB concept.

Recommended Texts:

1. Purecell, K.F. and Kotz, J.C., *Inorganic Chemistry* W.B. Saunders Co. 1977.
2. Basolo, F, and Pearson, R.C., *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
3. Greenwood, N.N. & Earnshaw A., *Chemistry of the Elements*, Butterworth-Heinemann,1997.

PRACTICAL

Transition elements & Coordination Chemistry (CHEM-CC-331P)

Course Objectives	This course aims to impart to the student mastery over the preparation of solutions required for an experiment and various techniques involved in the preparation of coordination compounds.
Course Outcomes	Students are able to : • Prepare reagents required for analysis. • Apply their knowledge on accuracy, precession and error of readings.

DETAILED CONTENT

(A) Complexometric Titrations:

(i) Complexometric estimation of (i) Mg^{2+} (ii) Zn^{2+} using EDTA

(ii) Estimation of total hardness of water samples

(iii) Estimation of Ca^{2+} in solution by (substitution method) using Erio-chrome black-T as indicator.
(iv) Estimation of Ca/Mg in drugs and Biological samples.

(B) Argentometry:

Estimation of Cl^{-} (i) By Mohr's method, (ii) By Vohlard's method, (iii) By Fajan's method.

(C) Inorganic Preparations:

(i) Cis and trans $K[Cr(C_2O_4)_2(H_2O_2]$ Potassiumdioxalatodiaquachromate (III)
(ii) Pentaammine carbonato Cobalt (III) ion
(iii) Preparation of Mohr's (ferrous ammonium sulphate) salt.

(D) Water analysis:

(i) Determination of dissolved oxygen in water.
(ii) Determination of chemical oxygen demand (COD).
(iii) Determination of biological oxygen demand (BOD).

Recommended Texts:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
2. Gulati, S., Sharma, J.L. *Practical Inorganic Chemistry*, CBS.

SEMESTER-III

L	T	P	Credit
4	0	0	4

CHEM-CC-332: Chemistry of Functional Groups

Course Objectives	This course is designed in a manner that gives a better understanding of the organic functional groups, which include halogenated hydrocarbons and oxygen containing functional groups and their reactivity patterns. The detailed reactions mechanistic pathways for each functional group will be discussed to unravel the spectrum of organic chemistry and the extent of organic transformations. In addition, this course makes students familiar with the chemistry of Aromatic aldehyde, aromatic ketones and acids.
Course Outcomes	On completion of the course, the student will be able to: • Understand preparation, properties and reactions of haloalkanes, haloarenes and oxygen containing functional groups. • Use the synthetic chemistry learnt in this course to do functional group transformations. • To propose plausible mechanisms for any relevant reaction. • To explain the mechanism of few selected reactions of aldehyde ketones and carboxylic acid.

DETAILED CONTENT

Module I

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

Module II

Alcohols: Classification and nomenclature. Monohydric alcohols – nomenclature, methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters. Hydrogen bonding. Acidic nature. Reactions of alcohols. Dihydric alcohols – nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage $Pb(OAc)_4$ and HIO_4 and pinacol-pinacolone rearrangement. Trihydric alcohols – nomenclature and methods of formation, chemical reactions of glycerol.

Module III

Phenols: Preparation and properties; Acidity and factors affecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's – Schmidt Reactions, Fries and Claisen rearrangements with mechanism. Ethers and epoxide: Ethers and epoxides: Preparation,

physical properties and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

Module IV

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, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Module V

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

Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Jagdamba, S. & Yadav. L.D.S., *Undergraduate Organic Chemistry (Volume II)*, Pragati Prakashan (India). Pvt. Ltd.

PRACTICAL

Chemistry of Functional Groups (CHEM-CC-332P)

Course Objectives	This course aims to impart to the students, knowledge of preparation of organic compounds by various methods; identification the different functional groups present in a given organic molecule; different synthetic strategies for preparing various organic compounds of general interest; and various basic laboratory purification techniques.
Course Outcomes	On completion of the course, students should be able to: • Design and carry out experiments employing suitable techniques, accurately record and • analyze the results, calculate overall yield of the final product. Should be in a position to identify the functional group in a given organic compound • Should be in a position to synthesize organic compounds using the

methods learnt
- Should be in a position to purify organic compounds

DETAILED CONTENT

Organic preparations

1. 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).
2. Benzolyation of one of the following compounds: amines (aniline, o-, m-, p-toluidines and o-, m-, p- anisidine) and phenols (β-naphthol, resorcinol, pcresol) by Schotten-Baumann reaction
3. Hydrolysis of amides and esters to obtain benzoic acid
4. Derivatives of the carbonyl compounds:
   - 2,4-DNP of one the following compounds- acetone, ethyl methyl ketone, di-ethyl ketone, cyclohexanone
   - Semicarbazone of one the following compounds- acetone, ethyl methyl ketone, di-ethyl ketone, cyclohexanone
   - Oxime of one the following compounds- di-ethyl ketone, cyclohexanone
5. Nitration of one the following compounds: nitrobenzene, chlorobenzene, bromobenzene
6. Oxidation of the following compounds: benzaldehyde, benzyl alcohol, acetophenone to benzoic acid (by iodoform reaction)

The above derivatives should be prepared using 0.5-1g of the organic compound.
The solid samples must be collected and may used for recrystallization, melting point etc.

Recommended Books:

1.Vogel A. I., Tatchell A.R., Furnis B.S., Hannaford A.J., Smith P.W.G.,Vogel's Text Book of Practical Organic Chemistry,5th Edn.,Pubs: ELBS, 1989.
2. Pavia D.L., Lampanana G.M., Kriz G.S. Jr., Introduction to Organic Laboratory Techniques, 3rd Edn. Pubs: Thomson Brooks/Cole, 2005.
3. Mann F.G., Saunders. P.C., Practical Organic Chemistry, Pubs: Green & Co. Ltd., London, 1978.

SEMESTER-III

L	T	P	Credit
4	0	2	6

CHEM-CC-333: Chemical Thermodynamics and Colligative properties

Course Objectives	The main objective of the course is to impart knowledge of classical thermodynamics and solution chemistry, and to provide the understanding of basic laws of thermodynamics and their applications, chemical equilibria and colligative properties.
Course Outcomes	At the end of this course student will be able to • Understand basic concepts of system, variables, heat, work, and laws of thermodynamics. • Understand the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy, etc. • Understand the concept of entropy; reversible, irreversible processes. calculation of entropy using 3rd law of thermodynamics. • Describe the application of thermodynamics: Joule Thomson effects, partial molar quantities and its attributes. • Explain chemical equilibria and its applications. • Understand theories/thermodynamics of dilute solutions and assess colligative properties.

DETAILED CONTENT

Module I

First law of Thermodynamics and Thermochemistry: Introduction to thermodynamics, common thermodynamic terms: intensive and extensive properties, state and path functions, isolated, closed and open systems. Zeroth law of thermodynamics. First law: Concept of heat *q*, work *w*, internal energy *U*, statement of first law and its derivation. Enthalpy or heat content *H*. Heat capacities at constant volume and pressure and their relationship. calculations of *q*, *w*, *U* and *H* for the expansion of gases (ideal and Van der Waals) under isothermal and adiabatic conditions for reversible and irreversible process.

Standard states; standard enthalpy of formation. Enthalpy of combustion and its applications. Heat of reactions at constant volume and constant pressure. Bond energy and calculation of bond energy. Kirchhoff's equations (variation of heat of reaction with temperature). Adiabatic flame and explosion temperature.

Module II

Second Law of Thermodynamics: Need of second law, concept of entropy, thermodynamic scale of temperature, statement of the second law of thermodynamics. Molecular and statistical interpretation of entropy. Entropy changes for reversible and irreversible processes.

Free energy functions: Gibbs and Helmholtz energy. Criteria for reversible and irreversible processes. Joule-Thomson effect: Joule-Thomson coefficient and its relation in terms of enthalpy, inversion temperature. Gibbs- Helmholtz equation, Maxwell relations; thermodynamic equation of state.

Module III

Third Law of Thermodynamics: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules. Partial molar quantities, dependence of thermodynamic parameters on composition; Chemical potential; Gibbs-Duhem equation, chemical potential of ideal gases, change in thermodynamic functions in mixing of ideal gases.

Module IV

Chemical Equilibrium: Criteria of thermodynamic equilibrium, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient (Van't Hoff reaction isotherm). Equilibrium constants and their quantitative dependence on temperature, pressure and concentration, thermodynamic derivation of relations between the various equilibrium constants K_p, Kc and K_x. Le Chatelier's principle (quantitative treatment).

Module V

Solutions and Colligative Properties: Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Colligative properties (i) relative lowering of vapour pressure (ii) elevation of boiling point (iii) Depression in freezing point, (iv) osmotic pressure. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties and amount of solute. Van't Hoff factor and its applications in calculating molar masses of normal dissociated and associated solutes in solution.

Recommended Texts:

1. Atkins, P. W. & Paula, J. De *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
3. Engel, T. & Reid, P. *Thermodynamics, Statistical Thermodynamics, & Kinetics* Pearson Education, Inc: New Delhi (2007).
4. Mcquarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
5. Kapil, P. N., *Physical Chemistry*, S. Dinesh & Co.
6. Puri, B. R., Sharma, L. R. & Pathania, M. S. *Principles of Physical Chemistry,* Vishal Publishing Co.

PRACTICAL
Chemical Thermodynamics and Colligative properties (CHEM-CC-333P)

Course Objectives	To provide practical knowledge of the concepts of thermochemistry and calorimetry taught in theory class of physical chemistry. This will include a detailed theoretical background, practical training and a critical understanding of the laboratory-based techniques.
Course Outcomes	Students will learn to • Determine heat of neutralization of strong acid by strong base. • Calculate solubility of salts at two different temperatures and to determine the heat of solution. • To determine heat capacity of calorimeter and calculation of enthalpy of ionization. • To determine heat of hydration by using thermometry.

DETAILED CONTENT

(I) **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) Study of the solubility of benzoic acid in water and determination of ΔH.

Recommended Texts:

1. Khosla, B. D., Garg, V. C. & Gulati A. *Senior Physical Chemistry,* R Chand & Co., New Delhi.
2. Findlay, A. *Practical physical Chemistry*, Longman, green.

SEMESTER – IV

CHEM-CC-341: Advanced Inorganic Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	The objective of the course is to appraise the students about the organometallic Chemistry. To learn about the 18 e rule and its violation. In order to study inner transition metals to understand the trends in properties and reactivity of the f-block elements. The course will provide students with a general overview of the many very fundamental tasks performed by inorganic elements in living organisms as well as the related methods. General overview of inorganic polymers as well as industrial chemistry.
Course Outcomes	Upon successful completion, students will have the knowledge and skills to: • Overview of the fundamental principles of organo transition-metal chemistry and know how chemical properties are affected by metals and ligands. • Use of modern methods to characterize organometallic compounds. • The students will be able to explain the fundamental concepts of inner-transition metals. • Understand how metal ions interact with biological environments and how these interaction influences the properties of metal centres able to understand the use of inorganic polymers in day today life have a good knowledge about role of chemistry in industry.

DETAILED CONTENT

Module I

Organometallic Compounds: Definition, importance and classification of organometallic compounds, EAN rule. Metal carbonyls: Preparation, properties, structure and bonding of mononuclear carbonyls. Π- acceptor behaviour of carbon monoxide, synergic effect (MO diagram of CO) Carbonylate anions. Ferrocene and its reactions.

Module II

Lanthanoids and actinoids: Electronic configuration, oxidation states, colour, spectral and magnetic properties. Lanthanide contraction, separation of lanthanides (ion-exchange method only). Chemistry of Thorium and Uranium.

Module III

Bioinorganic Chemistry: Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium/Potassium-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, Hemoglobin; Storage and transfer of iron. Nitrogen fixation.

Module IV

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

Module V

Industrial Chemistry-II: Water and its treatment: Sources of water, impurities in water. Hardness of water. Disadvantages of hard water. Water softening by lime-soda, zeolite and demineralization processes. Defects like scale and sludge formation, caustic embrittlement, corrosion, priming and foaming caused in boilers by impure water and their remedies.

Coal Chemicals: Ultimate and proximate analysis of coal and their significance. Role of different impurities like sulphur and ash in coal. Coking of coal by high temperature (By-product coke-oven) and low temperature process.

Recommended Texts:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
2. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
4. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry*. Wiley-VCH,1999.

PRACTICAL
Advanced Inorganic Chemistry (CHEM-CC-341P)

Course Objectives	This course aims to familiarize students with the principles of analytical chemistry and basic analytical techniques to analyse inorganic compounds.
Course Outcomes	After conducting this experiment, Student should be able to: • apply knowledge for performing experiment scientifically and safety. • Able to follow a classic analytical scheme to separate and identify the ions in a known mixture of salt.

DETAILED CONTENT

Qualitative analysis:

Using H_2S /PTC/ Thioacetamide or any other reagent. Identification of cations and simple anions in a mixture of salts containing not more than six ions (Three cations and three anions) interfering anions using semimicro scheme of analysis. If combination of cations or anions is

given in the mixture, insoluble should be avoided. Spot tests should be carried out for final identifications wherever feasible.

Cation : Pb^{2+}, Bi^{3+} Cu^{2+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+} or Sn^{4+}, Fe^{2+} or Fe^{3+}, Al^{3+}, Cr^{3+},Co^{2+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^+, K^+

Anion : CO_3^{2-}, SO_3^{2-}, CO_3^{2-}, SO_3^{2-}, S^{2-}, NO_2^-, CH_3COO^-, NO^{3-}, Cl^-, Br^-, I^-,SO_4^{2-}, PO_4^{3-},BO_3^{3-}, F^-, $C_2O_4^{2-}$

Recommended Texts:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
2. Gulati, S., Sharma, J.L. *Practical Inorganic Chemistry*, CBS.

SEMESTER-IV

CHEM-CC-342: Chemistry of N, S Containing Compounds, Heterocyclics, Polycyclic and Carbohydrates

L	T	P	Credit
4	0	2	6

Course Objectives	This Course is infused with the details of Nitrogen and sulphur containing functional groups and introduction of polynuclear hydrocarbons, heterocyclic systems and carbohydrates. The chemical synthesis, properties and reactions of these compounds will be discussed in detail. This course will also cover some of the key applications of each class of compounds in diverse fields.
Course Outcomes	On completion of this course, the students will be able to: • Gain theoretical understanding of chemistry of compounds having nitrogen containing functional groups, heterocyclics, polynuclear hydrocarbons, carbohydrates which include various methods for synthesis through application of the synthetic organic chemistry concepts learnt so far. • Understand the applications of these compounds including their medicinal applications through their reaction chemistry. • Understand the fundamentals of functional group chemistry, polynuclear hydrocarbons and heterocyclic compounds through the study of methods of preparation, properties and chemical reactions with underlying mechanism.

DETAILED CONTENT

Module I

Nitrogen Containing Functional Groups: Preparation and important reactions of nitro and compounds, nitriles and Isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1^0, 2^0 and 3^0 amines with Hinsberg reagent and nitrous acid; Diazonium Salts: Preparation and their synthetic applications.

Module II

Sulphur containing compounds: Preparation and reactions of thiols, thioethers and sulphonic acids.

Module III

Polynuclear Hydrocarbons: Reactions of naphthalene, phenanthrene and anthracene. Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

Module IV

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, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

Module V

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, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Jagdamba, S. & Yadav. L.D.S., *Undergraduate Organic Chemistry (Volume II)*, Pragati Prakashan (India). Pvt. Ltd.

PRACTICAL

Chemistry of N, S Containing Compounds, Heterocyclics, Polycyclic and Carbohydrates (CHEM-CC-342P)

Course Objectives	Introduce basic synthetic methods and biochemical experiments; and to familiarize students with various organic preparations
Course Outcomes	• Students should be able to synthesize simple organic compound • Should acquire the skills to prepare different organic compounds and familiarity with various chemical estimations.

DETAILED CONTENT

Organic Preparations

1. Diels-Alder reaction between anthracene and maleic anhydride
2. Reduction: nitrobenzene to azobenzene (TLC of the mixture), mdinitrobenzene to m-nitroaniline
3. S-benzylisothiuranum salts of any one water soluble and one water insoluble acid: acetic acid, phenyl acetic acid, oxalic acid, benzoic acid, phthalic acid
4. Photochemical reduction of benzophenone to benzopinacol
5. Benzoin condensation of benzaldehyde (using thiamine hydrochloride)
6. Condensation of p-toluidine with benzaldehyde/salicylaldehyde/2-hydroxy- 3-methoxy benzadehyde to get Schiff's base (solventless condensation)

Estimation of:

1. Phenol and aniline by bromination with potassium bromate-potassium bromide method
2. Glycine by formylation method
3. Saponification value of an oil/fat

Recommended Books:

1.Vogel A. I., Tatchell A.R., Furnis B.S., Hannaford A.J., Smith P.W.G.,Vogel's Text Book of Practical Organic Chemistry,5th Edn.,Pubs: ELBS, 1989.
2. Pavia D.L., Lampanana G.M., Kriz G.S. Jr., Introduction to Organic Laboratory Techniques, 3rd Edn., Pubs: Thomson Brooks/Cole,2005.
3. Mann F.G., Saunders. P.C., Practical Organic Chemistry,Pubs:Green & Co. Ltd., London, 1978.

SEMESTER – IV

CHEM-CC-343: Phase Equilibria and Electrochemistry

L	T	P	Credit
4	0	2	6

Course Objectives	The aim of this course is to make students understand phase, co-existence of phases, phase diagram, CST and distribution law and concepts of electrochemical cells, electrode potential, electrochemical series and learn about Nernst equations.
Course Outcomes	By the end of the course, students will be able to: • Understand phase equilibrium, criteria, CST, Gibbs-Duhem-Margules equation. • Learn the working of electrochemical cells, galvanic cell, corrosion and happenings in surroundings related to electrochemistry.

DETAILED CONTENT

Module I

Phase equilibria: Concept of phases, components and degrees of freedom. Gibbs phase rule and derivation of Gibbs phase rule. Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria. Phase diagram for one component systems with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points. Three component systems; water-chloroform-acetic acid system, triangular plots.

Module II

Phase equilibria in binary solutions: Gibbs-Duhem-Margules equation and its derivation. Fractional distillation of binary liquid solutions (ideal and nonideal), Azeotropes and its types. Lever rule. Partial miscibility of liquids, CST, miscible pairs, Types of CST. Nernst distribution law: its derivation and applications.

Module III

Faraday's laws and Electrochemical Cells: 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. Electrochemical cells; reversible and irreversible cells with examples. Electromotive force of a cell and its measurement.

Module IV

Nernst Equation and its Applications: Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Electrochemical series and its applications. Concentration cells with and without transference, liquid junction potential.

Module V

Applications of Electrochemistry: Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction (ii) equilibrium constants (iii) pH values using hydrogen, quinone-hydroquinone and glass electrodes (iv) determination of activity coefficients and transport numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Recommended Texts:

1.Atkins, P. W. & Paula, J. De *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2.Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3.Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4.Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Kiran, S. *Modern Approach to Physical Chemistry,* Modern Publishers.
6. Kapil, P. N., *Physical Chemistry,* S. Dinesh & Co.
7. Puri, B. R., Sharma, L. R. & Pathania, M. S. *Principles of Physical Chemistry,* Vishal Publishing Co.

PRACTICAL

Phase Equilibria and Electrochemistry (CHEM-CC-343P)

Course Objectives	The objective of this course is to provide practical knowledge and illustrative experiments about various potentiometric titrations of strong acid base and weak acid base. It also helps students to construct phase diagram of mixture solution.
Course Outcomes	Students will learn how to • Perform Acid base titrations using a conductometer and potentiometer. • Describe the phase equilibria in two and three component systems.

DETAILED CONTENT

1. Study the equilibrium of at least one of the following reactions by the distribution method:
(i) $I_2(aq) + I^- \rightarrow I^{3-}(aq)$
(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)n^{2+}$

2. Perform the following potentiometric titrations (at least two):

(i) Strong acid with strong base
(ii) weak acid with strong base and
(iii) dibasic acid with strong base

3. Potentiometric titration of Mohr's salt with potassium dichromate.
4. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
5. Phase equilibria: Construction of the phase diagram of
(i) simple eutectic and
(ii) congruently melting systems, using cooling curves and ignition tube methods.

Recommended Texts:

1. Khosla, B. D., Garg, V. C. & Gulati A. *Senior Physical Chemistry,* R Chand & Co., New Delhi.
2. Findlay, A. *Practical physical Chemistry*, Longman, green.

SEMESTER – V
CHEM-CC-351: Chemistry of Biomolecules

L	T	P	Credit
4	0	2	6

Course Objectives	This core course aims to introduce the learner to the fascinating chemistry of some biomolecules, i.e., amino acids, peptides, proteins, carbohydrates, lipids and nucleic acids that work within biological systems. It aims to build the concept of metabolism by the study of chemistry and energetics of biological system. In addition, the core objective of present course is to familiarize the students with the structure and functional roles of biological macromolecules from a chemistry point of view.
Course Outcomes	On completion of this course, the students will be able to: • Understand and demonstrate how structure of biomolecules determines their reactivity and biological functions. • Gain insight into concepts of heredity through the study of genetic code, replication, transcription and translation. • Understanding the major role of nucleic acids as a storehouse of information and its role in protein synthesis • Demonstrate understanding of metabolic pathways, their inter-relationship, regulation and energy production from biochemical processes. • Should be familiar with mechanism and kinetics of enzyme action

DETAILED CONTENT

Module I

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

Module II

Amino acids, Peptides and Proteins: Amino acids, Peptides and their classification. A-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pka values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups - Solid-phase synthesis

Module 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.

Module IV

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

Module V

Alkaloids: Natural occurrence, Isolation and their classification. 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.

Recommended Texts:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry, Fourth Edition, W. H. Freeman.
5. Berg, J. M., Tymoczko, J. L. & Stryer, L. *Biochemistry*, Sixth Edition, W. H. Freeman.
6. Agarwal, O.P. *Natural Products (Volume I),* Krishna Prakashan Media, India Pvt. Ltd.
7. Agarwal, O.P. *Natural Products (Volume II),* Krishna Prakashan Media, India Pvt. Ltd.

PRACTICAL

Chemistry of Biomolecules (CHEM-CC-351P)

Course Objectives	The aim of this course is to make students know about some important organic reactions; about qualitative estimation of elements; and ascertain the type of functional groups present in the organic compounds.
Course Outcomes	After the competition of course the students will have • Knowledge on the technique of organic qualitative analysis. • Knowledge about the method of organic compound preparation.

DETAILED CONTENT

1. Systematic analysis of extra elements in the given unknown compounds.
2. Tests for following functional groups and unsaturation.
3. Qualitative analysis of the following types of unknown organic compounds.

- Carboxylic acids
- Phenols
- Alcohols
- Aldehydes

- Ketones
- Esters

Recommended Books:

1.Vogel A. I., Tatchell A.R., Furnis B.S., Hannaford A.J., Smith P.W.G.,Vogel's Text Book of Practical Organic Chemistry,5th Edn.,Pubs: ELBS, 1989.

2. Pavia D.L., Lampanana G.M., Kriz G.S. Jr., Introduction to Organic Laboratory Techniques, 3rd Edn. Pubs: Thomson Brooks/Cole,2005.

3. Mann F.G., Saunders. P.C., Practical Organic Chemistry,Pubs:Green & Co. Ltd., London, 1978.

SEMESTER – V

CHEM-CC-352: Conductance, Photochemistry and Chemical Kinetics

L	T	P	Credit
4	0	2	6

Course Objectives	The aim of this course is to make students understand conductance and application of conductance measurement, concepts of chemical kinetics, catalysis and surface reactions. Further the course gives a better understanding of photochemistry and photochemical laws.
Course Outcomes	On completion of the course, the student will be able to: • Explain the chemistry of conductance and its variation with dilution, migration of ions in solutions and applications of conductance measurement. • Understand the basics of chemical kinetics: determination of order, molecularity and all types of complex reactions viz reversible, consecutive and chain reactions. • Explain different theories viz. collision, Lindemann and transition theory and how these account for experimental observations. • Describe importance of adsorption process, Langmuir and BET model. • To learn about kinetics of catalytic reactions i.e., acid-base catalysis, heterogeneous catalysis and enzyme catalysis. • Explain photochemical laws, Beer-Lambert law and quantum yield of thermal and photochemical reactions.

DETAILED CONTENT

Module I

Principles of Conductance in Solutions: 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 theory of strong electrolytes and its equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Module II

Applications of Conductance: Ionic mobilities and their determinations. Transference/transport number and their relation to ionic mobilities. Determination of transport number using Hittorf's 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.

Module III

Chemical Kinetics: Rate of reaction and factors affecting rate of reaction, order and molecularity of a reaction. Rate law of a reaction, differential and integrated form of rate expressions up to second order reactions. Kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann theory, qualitative treatment of the theory of absolute reaction rates/ Transition state theory.

Module IV

Kinetics of Surface reactions and Catalysis: Kinetics of Surface reactions chemistry: Physical adsorption, chemisorption, adsorption isotherms. Types of adsorption isotherm. Catalysis: Types of catalyst, Mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Acid-base catalysis. Enzyme catalysis; Michaelis-Menten equation.

Module V

Photochemistry: Electromagnetic spectrum, interaction of radiation with matter. Lambert and Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry. Quantum yield, examples of low and high quantum yields. Jablonski's diagram. Actinometry. Photochemical equilibrium and kinetics of photochemical reactions, role of photochemical reactions in biochemical processes. Photosensitised reactions. Quenching. Photostationary states. Chemiluminescence.

Recommended Texts:

1. Atkins, P. W. & Paula, J. De *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa (2004).
4. Laidler, K. J. *Chemical Kinetics* Pearson Education: New Delhi (2004).
5. Kiran, S. *Modern Approach to Physical Chemistry,* Modern Publishers.
6. Kapil, P. N., *Physical Chemistry*, S. Dinesh & Co.
7. Puri, B. R., Sharma, L. R. & Pathania, M. S. *Principles of Physical Chemistry,* Vishal Publishing Co.

PRACTICAL

Conductance, Photochemistry and Chemical Kinetics (CHEM-CC-352P)

Course Objectives The aim of this course is to make students understand practical aspects of

	conductometric titrations and their advantages over volumetric titrations. This will also include to impart experimental skills and trainings to students for instrument handling.
Course Outcomes	After successful completion of experiments, students will be trained in • Determining the concentration by conductometric and potentiometric titrations. • Evaluating first and second order kinetic reactions.

DETAILED CONTENT

(I) To study changes in conductance in the following systems
(i) Strong acid-strong base
(ii) Weak acid-strong base and
(iii) Mixture of strong acid and weak acid-strong base

(II) Study the kinetics of the following reactions.
(i) Initial rate method: Iodide-persulphate reaction
(ii) Integrated rate method:
(a) Acid hydrolysis of methyl acetate with hydrochloric acid, volumetrically or conductometrically.
(b) Iodide-persulphate reaction
(c) Saponification of ethyl acetate.

Recommended Texts:

1. Khosla, B. D., Garg, V. C. & Gulati A. *Senior Physical Chemistry,* R Chand & Co., New Delhi.
2. Findlay, A. *Practical physical Chemistry*, Longman, green.

SEMESTER – VI

CHEM-CC-361: Advanced Organic Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	This course introduces the learner to instrumentations, principles and techniques for identifying and characterizing the organic compounds through their interactions with electromagnetic radiation viz. UV-Visible, IR and NMR spectroscopy. This course also deals with some classes of organic compounds finding applications in everyday life namely; macromolecules, dyes, and pharmaceutical compounds. The chemistry of these compounds in general will be explained through naturally occurring and synthetic compounds.
Course Outcomes	On completion of this course, the students will be able to: • Gain insight into the basic principles of UV, IR and NMR spectroscopic techniques. • Use spectroscopic techniques to determine structure and stereochemistry of known and unknown compounds. • Develop a sound understanding of the structure of Pharmaceutical Compounds. They will also understand the importance of different classes of drugs and their applications for treatment of various diseases. • Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers. • Learn about the theory of colour and constitution as well as the chemistry of dyeing. • Know applications of various types of dyes including those in foods and textiles.

DETAILED CONTENT

Module I

Electromagnetic Spectrum: Absorption Spectra: Ultraviolet (UV) absorption Spectroscopy: Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts and Woodward Rules. Applications of UV spectroscopy. Infrared (IR) absorption Spectroscopy: Types of molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effects on infrared absorption bands due to hydrogen bonding, conjugation, resonance and ring size. Significance of fingerprint region. Applications of IR spectroscopy.

Module II

Spectroscopy: Fundamentals of Nuclear Magnetic Resonance, chemical shift, factors influencing chemical shift; shielding and de-shielding effect; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics. Applications of NMR spectroscopy.

Module III

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); Triphenyl Methane Dyes - Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes – Phenolphthalein and Fluorescein; Natural dyes –structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

Module IV

Macromolecules: Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index. Polymerisation reactions - Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler- Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene).

Module V

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).

Recommended Texts:

1. Kemp, W. *Organic Spectroscopy*, Palgrave.
2. Kalsi, P. S. *Textbook of Organic Chemistry* (1st Ed.), New Age International (P) Ltd. Pub.
3. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
5. Gowariker, V. R., Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New Age International (P) Ltd. Pub.
6. Kalsi, P.S., *Spectroscopy of Organic Compounds.* New Age International.
7. Bhasin, S.K., Gupta, R. *Pharmaceutical Organic Chemistry*, Elsevier Health Science.

PRACTICAL

Advanced Organic Chemistry (CHEM-CC-361P)

Course Objectives	This course aims to familiarize students with some important organic reactions and to know about qualitative/physical techniques for identification of different functional groups present in the compounds
Course Outcomes	After the competition of course students will have a knowledge • on the techniques of organic qualitative analysis. • about the methods of preparation of different organic compounds

DETAILED CONTENT

1. Tests for following functional groups
2. Qualitative analysis of following types of unknown organic compounds
   - 1. Carbohydrates
   - 2. Primary, secondary and tertiary amines
   - 3. Nitro compounds
   - 4. Amides
   - 5. Aryl halides
   - 6. Hydrocarbons

Identification of the functional groups, C-C and C-N triple bonds, sp^3, sp^2 and sp hybridized C-H bonds by IR spectroscopy (IR spectra to be provided)

Recommended Books:

1.Vogel A. I., Tatchell A.R., Furnis B.S., Hannaford A.J., Smith P.W.G.,Vogel's Text Book of Practical Organic Chemistry,5th Edn.,Pubs: ELBS, 1989.

2. Pavia D.L., Lampanana G.M., Kriz G.S. Jr., Introduction to Organic Laboratory Techniques, 3rd Edn., Pubs: Thomson Brooks/Cole,2005.

3. Mann F.G., Saunders. P.C.,Practical Organic Chemistry,Pubs:Green & Co. Ltd., London, 1978.

SEMESTER – VI

CHEM-CC-362: Advanced Physical Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	To explain concept of quantum chemistry, uncertainty principle in quantum mechanics, operators, oscillators, wave function, time dependent Perturbation theory of small molecules. It also helps students to enhance their problem-solving skills through numerical problems.
Course Outcomes	At the end student are able to: • Understand the need for quantum mechanical formalism and basic principles. • Appreciate the importance and implication of generalized uncertainty principle in quantum mechanics. • Have a better understanding of the mathematical foundations of angular momentum of microscopic particles. • Apply Schrodinger wave equation and approximation methods for problem solving in quantum mechanics. • Rationalize the concept of bonding in conjugated polyenes.

DETAILED CONTENT

Module I

Quantum Treatment of Simple Systems: Postulates of quantum mechanics, quantum mechanical operators, eigen values and eigen functions. Schrödinger wave equation on the basis of postulates of quantum mechanics and simple wave motion and its application to free particle and particle-in-a-one dimensional box, quantization of energy levels, zero-point energy. Particle in two- and three-dimensional boxes, degeneracy. Heisenberg Uncertainty principle. Wavefunctions and its significance, Quantum numbers, nodal properties. Qualitative treatment of simple harmonic oscillator of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions, vibrational energy of diatomic molecules and zero-point energy.

Module II

Angular Momentum and Quantum Treatment of many-electron atoms: Angular momentum, commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule, Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up Schrödinger wave equation in spherical polar co-ordinates: separation of variables, spherical harmonics, discussion of solution.

Radial distribution functions of 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals. Average and most probable distances of electron from nucleus. Need for approximation methods: statement of variation and perturbation method and their application to particle-in-one- dimensional box.

Module III

Quantum Treatment of Chemical Bonding: Chemical bonding: covalent bonding, valence bond and molecular orbital approaches, Bonding and antibonding orbitals. LCAO-MO treatment of H_2^+ ion and qualitative extension to H_2 molecule. Comparison of LCAO-MO and VB treatments and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Simple Hückel Molecular Orbital (HMO) theory and its application to simple polyenes (ethene, butadiene).

Module IV

Rotation and Vibrational Spectroscopy: Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotational spectroscopy: rotational spectra in a rigid diatomic molecule, selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. Vibrational spectroscopy: vibrational spectra in simple harmonic oscillator, classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations. The anharmonic oscillator, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches. Degrees of freedom for polyatomic molecules, normal modes of vibration.

Module V

Advanced Techniques of Spectroscopy: Raman spectroscopy: Qualitative treatment of Raman effect; effect of nuclear spin, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion. Rotational Raman spectra, vibrational Raman spectra and rotational-vibrational Raman spectra. Electronic spectroscopy: Franck-Condon principle, electronic transitions, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift, spin-spin coupling, low- and high-resolution spectra. Interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) spectroscopy: Principle of ESR, selection rules, hyperfine structure, ESR of simple radicals.

Recommended Texts:

1. Banwell, C. N. & mccash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata mcgraw-Hill: New Delhi (2006).
2. Chandra, A. K. *Introductory Quantum Chemistry* Tata mcgraw-Hill (2001).
3. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).

4. Lowe, J. P. & Peterson, K. *Quantum Chemistry* Academic Press (2005).
5. Kiran, S. *Modern Approach to Physical Chemistry,* Modern Publishers.
6. Kapil, P. N., *Physical Chemistry*, S. Dinesh & Co.
7. Puri, B. R., Sharma, L. R. & Pathania, M. S. *Principles of Physical Chemistry,* Vishal Publishing Co.

PRACTICAL
Advanced Physical Chemistry (CHEM-CC-362P)

Course Objectives	This course aims to familiarize students with the kinetic study of different solution at different temperature, pKa value of different sets of buffers by pH metric titration, colourimetry measurement.
Course Outcomes	Students will learn • To conduct the experiment on various instrumental techniques. • To describe the principles behind the experiment performed in the laboratory. • To interpret the experimental results obtained by colourimetry, spectrophotometer, pH meter.

DETAILED CONTENT

i. Colorimetry
ii. Verification of Lambert-Beer's Law
iii. Determination of pK (indicator) for phenolphthalein or methyl red
iv. Study the formation of a complex between ferric and thiocyanate (or salicylate) ions.
v. Study the kinetics of interaction of crystal violet with sodium hydroxide colorimetrically.
vi. Analysis of the given vibration-rotation spectrum of HCl(g).
vii. Record the UV spectrum of p-nitrophenol (in 1:4 ethanol: water mixture). Repeat after adding a small crystal of NaOH. Comment on the difference, if any.
viii. Record the UV spectrum of a given compound (acetone) in cyclohexane.
   - Plot transmittance *versus* wavelength.
   - Plot absorbance *versus* wavelength.

Recommended Texts:

1. Khosla, B. D., Garg, V. C. & Gulati A. *Senior Physical Chemistry,* R Chand & Co., New Delhi.
2. Findlay, A. *Practical physical Chemistry*, Longman, green.

Discipline Specific Elective (DSE) Courses

SEMESTER-V
CHEM-DSE-353: Analytical Techniques in Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	The objective of this course is to teach the basic concept of analytical chemistry. Qualitative and quantitative analysis.
Course Outcomes	Students are able to: • Describe the different separation techniques such as distillation, Solvent and Solid Phase extraction. • To apply the basic statistical treatment of the analytical data for getting a correct result. • Explain the basic of chromatography.

DETAILED CONTENT

Module-I

Theoretical Principles: Theoretical principles and chemistry involved in qualitative analysis of mixture of cations and anions including interfering and insolubles. Introduction to quantitative techniques (volumetric, gravimetric and instrumental analysis).

Module-II

Data Analysis: Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, statistical test of data; (F, Q, and t test), rejection of data, and confidence intervals.

Module-III

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. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non- aqueous media.

Module-IV

Chromatography: Classification, principle and efficiency of various chromatographic techniques. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: Paper chromatography, thin layer chromatography, gas chromatography and High-performance liquid chromatography.

Module-V

Stereo isomeric separation and analysis: Measurement of optical rotation, calculation of enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, chiral solvents and chiral shift reagents chiral chromatographic techniques using chiral columns (GC and HPLC).

Recommended texts:

1. Vogel, Arthur I: *A Test book of Quantitative Inorganic Analysis* (Rev. By GH 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. Christian, Gary D; *Analytical Chemistry*, 6th Ed. New York- John Willy, 2004.
4. Harris, Daniel C: *Exploring Chemical Analysis*, 2nd Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry* New Age, International Publisher, 2009.

PRACTICAL

Analytical Techniques in Chemistry (**CHEM-DSE-353P)**

Course Objectives	The objective of this course is to provide practical knowledge and illustrative experiments about various separation techniques and inorganic preparations.
Course Outcomes	After conducting this experiment, you should be able to: • To apply previous knowledge for performing experiment scientifically and safety. • to separate the various substances that make up a mixture • Preparation of different inorganic complexes. • Purification and crystallisation of inorganic compounds

DETAILED CONTENT

Separation Techniques

(A) Chromatography:

Separation of mixtures:

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}

(ii) Paper Chromatographic separation of Ni (II) and Co(II); Cu(II) and Cd(II)

(iii) Separate and identify the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Report the Rf values.

(iv) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

(v) Chromatographic separation of the active ingredients of Plants, flowers and juices by TLC

(B) Solvent Extractions:

(i) To separate a mixture of Ni^{2+} & Fe^{3+} by complexing with DMG and extracting the Ni^{2+} DMG complex in chloroform, and determine its concentration with spectrophotometry.

(ii) Solvent extraction of zirconium with amberlite LA-1, separation from a mixture of irons and gallium.

(C) Ion exchange:

(i) Determination of exchange capacity of cation exchange resin and anion exchange resins.

(ii) Separation metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

(D) Inorganic Preparations:

(i) Tetraammine copper (II) sulphate, $[Cu(NH_3)_4]SO_4\ H_2O$

(ii) Potassium trisoxalatochromate (III), $K_3[Cr(C_2O_4)_3]$

Recommended Texts:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

2. Gulati, S., Sharma, J.L. *Practical Inorganic Chemistry*, CBS.

SEMESTER – V

L	T	P	Credit
4	0	2	6

CHEM-DSE-354: Industrial Chemicals and Environment

Course Objectives	The objective of this course is to make students aware about the concepts of different gases and their industrial production, uses, storage and hazards. Manufacturing, applications, analysis and hazards of the inorganic chemicals, preparation of ultra-pure metals for semiconducting technology, air and water pollution, control measures for air and water pollutants, catalyst and biocatalyst, energy and environment.
Course Outcomes	After completion of the course, the learner can be able to understand/check/solve problems related to: • The different toxic gases and their toxicity hazards. • Safe design systems for large scale production of industrial gases. • Manufacturing processes, handling and storage of inorganic chemicals. • Hazardous effects of the inorganic chemicals on human beings and vegetation. • The requirement of ultra-pure metals for the semiconducting technologies. • Composition of air, various air pollutants, effects and control measures of air pollutants. • Different sources of water, water quality parameters, impacts of water pollution, water treatment. • Different industrial effluents and their treatment methods. • Different sources of energy. • Generation of nuclear waste and its disposal. • Use of biocatalyst in chemical industries.

DETAILED CONTENT

Module I

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

Module II

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

Module III

Industrial Metallurgy: Preparation of ultrapure metals for semiconductor technology.

Module IV

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, effects of air pollution on living organisms and vegetation, controls of air pollution, techniques of measuring air pollutants. Climate change, Greenhouse effect, global warming.

Water Pollution: Hydrological cycle, water resources, aquatic ecosystems, sources and nature of water pollutants, techniques for measuring water pollution, impacts of water pollution on ecosystems. Water purification methods.

Module V

Energy and Environment: Sources of energy, Coal, petrol and natural gas. Nuclear Fusion/Fission, solar energy, hydrogen, geothermal, tidal and hydel etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Recommended Texts:

1. Manahan, S.E. (2017), Environmental Chemistry, CRC Press
2. Buchel, K.H.; Moretto, H.H.; Woditsch, P. (2003), Industrial Inorganic Chemistry, Wiley-VCH.
3. De, A.K. (2012), Environmental Chemistry, New Age International Pvt., Ltd.
4. Khopkar, S.M. (2010), Environmental Pollution Analysis, New Age International Publisher.

PRACTICAL

Industrial Chemicals and Environment (CHEM-DSE-354P)

Course Objectives	The aim of this course is to provide first hand experience in the observation of chemical processes occurring in the environment. The course will also prepare the students to demonstrate the basic laboratory techniques of titration.
Course Outcomes	By the end of the course, the students will be able to: • Do the water analysis by measuring DO, BOD and COD. • Choose appropriate technique to estimate the percentage of various constituents present in water samples.

DETAILED CONTENT

(i) Determination of dissolved oxygen in water.
(ii) Determination of Chemical Oxygen Demand (COD).
(iii) Determination of Biological Oxygen Demand (BOD).
(iv) Percentage of available chlorine in bleaching powder.
(v) Measurement of chloride, sulphate and salinity of water samples by simple titration method ($AgNO_3$ and potassium chromate).
(vi) Estimation of total alkalinity of water samples (CO_3^{2-}, HCO_3^-) using double titration method.
(vii) Measurement of dissolved CO_2.
(viii) Determination of hexavalent Chromium Cr (VI) concentration in tannery wastes/waste water sample using UV-Vis spectrophotometry technique.
(ix) Preparation of borax/ boric acid.

Practical Reference Books:

1. Vowles, P.D.; Connell, D.W. (1980), Experiments in Environmental Chemistry: A Laboratory Manual, Vol.4, Pergamon Series in Environmental Science.
2. Gopalan, R.; Anand, A.; Sugumar R.W. (2008), A Laboratory Manual for Environmental Chemistry, I. K. International.

SEMESTER – V

L	T	P	Credit
5	1	0	6

CHEM-DSE-355: Research Methodology for Chemists

Course Objectives	This course is introduced to impart knowledge about the basic concepts of research and to provide a road map for conducting research. Students are expected to identify, explain and apply basic concepts of research; acquire information, recognize various issues related to research and to learn instrumental methods required for research in chemistry.
Course Outcomes	After completion of this course, students will be able to: • Know about various print and e-resources, search engines needed for carrying out literature survey in a topic. • Have some idea about writing literature survey report, review and scientific article. • Learn about plagiarism and how to avoid it. • Learn about safe storage of chemicals, disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals. • Acquire basic understanding of data analyses.

DETAILED CONTENT

Module I

Literature Survey: Print: Sources of information-Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Module II

Resources and Writing Scientific Papers: Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Methods of Scientific Research and Writing Scientific Papers: Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation.

Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

Module III

Chemical Safety and Ethical Handling of Chemicals: Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory

ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Module IV

Data Analysis: The Investigative Approach: Making and recording measurements. SI units and their use. Scientific method and design of experiments. Analysis and presentation of data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse. Basic aspects of multiple linear regression analysis.

Module V

Chemistry Software: Chemdraw, origin and applications of molecular modelling, Hyperchem, Schrodinger etc.

TUTORIAL

Research Methodology for Chemists

Recommended Books

1. Kothari, C. K.; Garg, G. *Research Methodology-Methods and Techniques*, 3rd Ed., New Age International, New Delhi (2014).

2. Kumar, R. *Research Methodology–A Step-By-Step Guide for Beginners*; 2nd Ed., Pearson Education: New Delhi (2005).

3. Montgomery, D. C. *Design & Analysis of Experiments*; 8th Ed., Wiley India: Noida (2013).

4. Dean, J. R.; Jones, A. M.; Holmes, D.; Reed, R.; Weyers, J.; Jones, A. *Practical Skills in Chemistry*, 2nd Ed. Prentice-Hall, Harlow (2011).

5. Hibbert, D. B.; Gooding, J. J., *Data Analysis for Chemistry*. Oxford University Press (2006).

6. Topping, J., *Errors of Observation and their Treatment*, 4th Ed., Chapman Hall, London (1984).

7. Harris, D. C., *Quantitative Chemical Analysis*, 6th Ed., Freeman (2007) Chapters 3-5.

SEMESTER – V

L	T	P	Credit
4	0	2	6

CHEM-DSE-356: Polymer Chemistry

Course Objectives	The primary objective of this paper is to help the student to know about the synthesis, properties and applications of polymers.
Course Outcomes	By the end of this course, students will be able to: • Know about history of polymeric materials and their classification • Learn about different mechanisms of polymerization and polymerization techniques • Evaluate kinetic chain length of polymers based on their mechanism • Differentiate between polymers and copolymers • Learn about different methods of finding out average molecular weight of polymers • Differentiate between glass transition temperature (Tg) and crystalline melting point (Tm) • Know about solid and solution properties of polymers • Learn properties and applications of various useful polymers in our daily life.

DETAILED CONTENT

Module I

Introduction and history of polymeric materials, 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 Bifunctional systems, Poly-functional systems

Module II

Kinetics of Polymerization, Mechanism of step growth polymerization, kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic), Mechanism and kinetics of copolymerization, polymerization techniques

Module III

Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg). Crystallization and crystallinity:

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships.

Module IV

Determination of molecular weight of polymers (Mn, Mw, etc.) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index.

Polymer Solution Criteria for polymer solubility and Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy and free energy change of mixing of polymers solutions. Polymer Degradation Thermal, oxidative, hydrolytic and photodegradation

Module V

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties) Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novolac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers: polyacetylene, polyaniline, poly(p-phenylene sulphide, polypyrrole, polythiophene

Recommended Texts:

1. Carraher,C. E. Jr. (2013), Seymour's Polymer Chemistry, Marcel Dekker, Inc.
2. Odian, G. (2004), Principles of Polymerization, John Wiley.
3. Billmeyer, F.W. (1984),Text Book of Polymer Science, John Wiley.
4. Ghosh, P. (2001),Polymer Science & Technology, Tata Mcgraw-Hill.
5. Lenz, R.W. (1967),Organic Chemistry of Synthetic High Polymers, Intersecience (Wiley).

PRACTICAL

Polymer Chemistry (CHEM-DSE-356P)

Course Objectives	The primary objective of this practical paper is to help the student to the synthesise and characterise different types of polymers
Course Outcomes	By the end of this course, students will be able to: • Know about history of polymeric materials • Find out glass transition temperature (Tg) and crystalline melting point (Tm) • Determine molecular weight and solution properties of polymers • Study the thermal properties of polymers • Synthesise different types of thermosetting and thermoplastic polymers

DETAILED CONTENT

(A) Polymer synthesis

(i) Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA)/MethylAcrylate (MA).
(ii) Preparation of nylon 6,6
(iii) Redox polymerization of acrylamide
(iv) Precipitation polymerization of acrylonitrile
(v) Preparation of urea-formaldehyde resin
(vi) Preparations of novalac resin/resold resin.
(vii) Microscale Emulsion Polymerization of Poly(methylacrylate).

(B) Polymer characterization

(i) Determination of molecular weight of polyvinyl propylidene in water by viscometry
(ii) Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of head-to-head monomer linkages in the polymer.
(iii) Determination of molecular weight by end group analysis of polymethacrylic acid.

(C) Polymer analysis

(i) Estimation of the amount of HCHO in the given solution by sodium sulphite method
(ii) IR studies of polymers
(iii) DSC (Differential Scanning Calorimetry) analysis of polymers
(iv) TG-DTA (Thermo-Gravimetery-Differential Thermal Analaysis) of polymers

Practical Reference Books:

1. Allcock, H.R.; ; Lampe, F. W.; Mark, J. E.(2003),*Contemporary Polymer Chemistry*, Prentice Hall.
2. Fried, J.R. (2003), *Polymer Science and Technology*, Prentice-Hall.
3. Munk, P.; Aminabhavi, T. M. (2002), *Introduction to Macromolecular Science*, John Wiley & Sons.
4. Sperling, L.H.(2005),*Introduction to Physical Polymer Science*, John Wiley & Sons

SEMESTER – VI

L	T	P	Credit
4	0	2	6

CHEM-DSE-363: Analytical and Instrumental Methods of Chemical Analysis

Course Objectives	This course provides students with advanced training in analytical techniques. This will include a detailed theoretical background, practical training and a critical understanding of the laboratory-based techniques they will apply during their research projects. The course will deliver an in-depth examination of the specific analytical techniques relevant to their research projects. Volumetric and Gravimetric Analytical Chemistry course provide students with the necessary background of quantitative analysis of different compounds using different tools of analysis and its application.
Course Outcomes	Upon successful completion, students will have the knowledge and skills to: • Recognize the principles of volumetric and gravimetric analysis in analytical chemistry. • Explain the theoretical aspects of key analytical techniques and instruments used in IR, UV-Vis and Atomic spectroscopy. • Undertake the correct sample preparation and characterization prior to analysis by the chosen techniques or instruments.

DETAILED CONTENT

Module I

Volumetric and Gravimetric Methods of Analysis: Theory of volumetric and gravimetric methods of analysis, equivalent points, standard solutions, Primary and Secondary standards, and point detection, theory of indicators and their selection for volumetric analysis, precipitation methods, purity of precipitates, optimum conditions for precipitation, washing and filtration of precipitates, drying and ignition of precipitates important organic precipitants, estimation of nickel by the use of organic precipitants, Determination of inorganic salts in mixtures like mixtures of carbonates with hydroxides and bicarbonates.

Module II

UV-Visible Spectroscopy: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.
Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principle 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.

Module III

Infrared Spectroscopy: 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.

Module IV:

Atomic Spectroscopy: Flame Atomic Absorption and Emission Spectroscopy: 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.
Atomic Fluorescence Spectroscopy: Principle, Instrumentation and applications.

Module V:

Electrochemical Techniques: Introduction to pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence point. Techniques used for the determination of pka values.

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

Recommended texts:

1. Vogel, Arthur I: *A Test book of Quantitative Inorganic Analysis* (Rev. By GH 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. Christian, Gary D; *Analytical Chemistry*, 6th Ed. New York- John Willy, 2004.
4. Harris, Daniel C: *Exploring Chemical Analysis*, 2nd Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry* New Age, International Publisher, 2009.

PRACTICAL

Analytical and Instrumental Methods of Chemical Analysis (**CHEM-DSE-363P)**

Course Objectives	The objective of this course is to provide practical knowledge and illustrative experiments about various analytical techniques and titrations.
Course Outcomes	After conducting this experiment, you should be able to: • To apply previous knowledge for performing experiment scientifically and safety.

- Able to explain gravimetric, spectrophotometric, pH metric analysis.

DETAILED CONTENT

(A) Gravimetric Analysis:

(i) Estimation of nickel (II) using Dimethylglyoxime as the precipitant.

(ii) Estimation of copper as CuSCN.

(iii) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$ through (a) Heterogeneous and (b) Homogeneous media.

(iv) Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

(B) Spectrophotometric analysis:

(i) Determination of Na Ca, Li in cola drinks and fruit juices using flame photometric techniques.

(ii) Determination of pka values of indicator using spectrophotometry.

(iii) Structural characterization of compounds by Infra-Red spectroscopy.

(iv) Spectrophotometric estimation of Ferrous ions by using 1,10-Phenanthroline

(C) pH metric titrations:

(i) Acid-base titrations

(ii) Determine the pH of given aerated drinks fruit juices, shampoos and soaps.

(D) Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

(iii) Estimation of calcium, magnesium, phosphate, nitrate

Recommended Texts:

1. Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.

2. Gulati, S., Sharma, J.L. *Practical Inorganic Chemistry*, CBS.

SEMESTER – VI

L	T	P	Credit
4	0	2	6

CHEM-DSE-364: Nanoscale Materials and Their Applications

Course Objectives	The aim of this course is to introduce materials at nanoscale, their preparation, characterization and applications.
Course Outcomes	By the end of the course, the students will be able to: • Understand the concept of nanodimensions. • Know the various methods of preparation of nanomaterials. • Know the different characterization techniques used for the analysis of nanomaterials and understand the basic principle behind these techniques. • Understand the optical and conducting properties of nanostructures. • Appreciate the real life applications of nanomaterials.

DETAILED CONTENT

Module I

Introduction to nanodimensions 0D, 1D, 2D nanomaterials, Quantum Dots, Nanoparticles, Nanostructures (nanowires, thin films, nanorods), carbon nanostructures (carbon nanotubes, carbon nanofibers, fullerenes), Size Effects in nano systems, Quantum confinement and its consequences, Semiconductors.Band structure and band gap.

Module II

Preparation of nanomaterials Top down and Bottom up approach, Photolithography. Ball milling.Vacuum deposition.Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Thermal decomposition, Chemical reduction, SolGel synthesis, Hydrothermal synthesis, Spray pyrolysis,Electrochemical deposition, Pulsed Laser deposition.

Module III

Characterization techniques (Basic working principles and interpretation of experimental data using these techniques need to be covered) UV-visible spectroscopy, X-ray diffraction (Powder and Single Crystal), Raman Spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Energy Dispersive X-ray Spectroscopy (EDX), X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM), Dynamic light scattering (DLS), Brunauer-Emmett-Teller (BET) Surface area measurement and Thermogravimetric analysis (TG).

Module IV

Optical Properties Surface plasmon resonance, Excitons in direct and indirect band gap semiconductor nanocrystals. Radiative processes: General absorption, emission and luminescence (fluorescence and photoluminescence).

Conducting properties Carrier transport in nanostructures.Tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

Module V

Applications Nanomaterials as Catalysts, semiconductor nanomaterials as photocatalysts,Nanocomposites as catalysts. Carbon nanostructures as catalytic nanoreactors, metal and metal oxides confined inside carbon nanostructures, Nanowires and thin films for photonic devices (LEDs, solar cells, transistors).

Recommended Texts:

1. West, A. R.(2014),Solid State Chemistry and Its Application, Wiley
2. Smart, L. E.; Moore, E. A.(2012),Solid State Chemistry An Introduction, CRC Press Taylor & Francis.
3. Rao, C. N. R.; Gopalakrishnan, J.(1997),New Direction in Solid State Chemistry, Cambridge University Press.
4. Poole, Jr.; Charles P.; Owens, Frank J.;(2003), Introduction to Nanotechnology, John Wiley and Sons.
5. Chattopadhyay, K.K.; Banerjee, A. N. (2009), Introduction to Nanoscience and Technology, PHI

PRACTICAL

Nanoscale Materials and Their Applications (**CHEM-DSE-364P)**

Course Objectives	The aim of this course is to introduce materials at nanoscale, their preparation, characterization and applications.
Course Outcomes	By the end of the course, the students will be able to: • Understand the concept of nanodimensions • Correlate properties of nanostructured with their size, shape and surface characteristics • Choose appropriate synthesis technique to prepare nanostructures and nanomaterials of desire size, shape and surface property.

DETAILED CONTENT

At least 04 experiments from the following:

(i) Synthesis of metal nanoparticles by chemical reduction method.

(ii) Synthesis of semiconductor nanoparticles.

(iii) Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
(iv) XRD pattern of nanomaterials and estimation of particle size. (Students can be provided with XRD patterns of known materials and asked to interpret the data.)
(v) To study the effect of size on color of nanomaterials.
(vi) To prepare composite of CNTs with other materials.
(vii) Growth of quantum dots by thermal evaporation.
(viii) Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
(ix) Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.

Practical Reference Books:

1. Smart, L. E.; Moore, E. A.(2012),Solid State Chemistry An Introduction, CRC Press Taylor & Francis.
2. Rao, C. N. R.; Gopalakrishnan, J.(1997),New Direction in Solid State Chemistry, Cambridge University Press.
3. Poole, Jr.; Charles P.; Owens, Frank J.;(2003), Introduction to Nanotechnology, John Wiley and Sons.
4. Chattopadhyay, K.K.; Banerjee, A. N.(2009),Introduction to Nanoscience and Technology, PHI

SEMESTER-VI

CHEM-DSE-365: Applications of Computers in Chemistry

L	T	P	Credit
4	0	2	6

Course Objectives	This course intends to make learners familiar with basics of computer language, computer programming, and handling of experimental data, curve fitting, etc. to analyse experimental results. This basic knowledge will help the students to perform and interpret results of various chemistry practical.
Course Outcomes	On completion of this course, students will be able to: • Review the basics of computer, bits, bytes, binary & ASCII formats, etc. • Have a glimpse on various numerical methods and mathematics pertaining to computers. • Get introduced to the elementary idea of molecular modelling. • Do simple numerical using computers.

DETAILED CONTENT

Module I

Basics of Computers: Basics, Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts.

Module II

Numerical Methods I: Matrix addition and multiplication. Statistical analysis. Roots of equations: Numerical methods for roots of equations, Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi. Differential calculus: Numerical differentiation.

Module III

Numerical Methods II: Integral calculus: Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.
Simultaneous equations: Matrix manipulation: addition, multiplication. Gauss-Siedal method. Interpolation, extrapolation and curve fitting: Handling of experimental data.

Module IV

Molecular Modelling: Conceptual background of molecular modelling: Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Recommended Books

1. Jansen, F. A., Introduction to Computational Chemistry, 2nd Ed., Wiley (2007).
2. Balagurusamy, E., *Numerical Methods*, Tata McGraw Hill, New Delhi (1999).
3. Noggle, J. H., *Physical Chemistry on a Microcomputer*, Little Brown & Co. (1985).
4. Venit, S. M., *Programming in BASIC: Problem Solving with Structure and Style*. Jaico Publishing House: Delhi (1996).

PRACTICAL
Applications of Computers in Chemistry (**CHEM-DSE-365P)**

1. Computer programs based on numerical methods for roots of equations: (e.g., volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g., entropy/ enthalpy changes from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

Recommended Books

1. Balagurusamy, E., *Numerical Methods*, Tata McGraw Hill, New Delhi (1999).
2. McQuarrie, D. A., *Mathematics for Physical Chemistry*, University Science Books (2008).
3. Mortimer, R., *Mathematics for Physical Chemistry*. 3rd Ed., Elsevier (2005).
4. Yates, P., *Chemical Calculations*, 2nd Ed. CRC Press (2007).
5. Venit, S. M. *Programming in BASIC: Problem solving with structure and style,* Jaico Publishing House, Delhi (1996).

SEMESTER – VI

L	T	P	Credit
0	1	5	6

CHEM-DSE-366: Dissertation

Course Objectives	This course is introduced to provide an opportunity to the UG final semester students to have some experience in chemistry research by taking small projects. Apart from the experimental works, students will also learn to write scientific reports on the project work carried out.
Course Outcomes	On completion of this course the students will be able to: • Define aims, objectives and work plan of Research proposal in a scientific manner. • Generate good research hypothesis, design appropriate experiments, collect and interpret the data to validate their experiments. • Process the data using computer software, analyze the data and critically examine the hypothesis and the conclusions. • Write research report and research articles.

Ability Enhancement Compulsory Courses (AEC)

SEMESTER-I

ENG-AE-011: Technical writing and communication in English

L	T	P	Credit
4	0	0	4

Course Objectives	This course is designed to help students became proficient in listening, speaking, reading and writing skills, help students to become independent users of English language, develop vital communication skills, in students integral to their personal, social and professional interaction and teach them the appropriate language of professional communication
Course Outcomes	At the end of course, student will be able to • Acquire basic proficiency in reading, listening, writing and speaking skills • Understand spoken and written English language, particularly the language of their chosen technical field. • Converse fluently. • Produce their own clear and coherent texts. • Become proficient in professional communication such as interviews, group discussion, office environment, important reading skills as well as writing skills and thereby will have better job prospects

DETAILED CONTENT

Module I

Communication: Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing.

Module II

Writing skills: Selection of topic, thesis statement, developing the thesis, introductory, developmental, transitional and concluding paragraphs, linguistic Moduley, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

Module III

Technical writing: Scientific and technical subjects, formal and informal writings, formal writings/reports, handbooks, manuals, letters, memoranda, notices, agenda, minutes, common errors to be avoided.

Recommended Texts:

1. Frank, M *Writing as thinking: A guided process approach.* Englewood Cliffs, Prentice-Hall (1989).
2. Hamp-Lyons, L. & Heasely, B. *Study writing.* Cambridge University Press (1987).
3. Quirk, R., Greenbaum, S., Leech, G. & Svartvik, J. *A comprehensive grammar of the English Language.* Harlow: Longman: London (1985).
4. Riordan, D. G. & Pauley, S. A. *Technical report writing today* 8th Ed. (2004).
5. Allen, J. P. B. & Widdowson, H. G. *English in focus: English in Physical Science.* Oxford University Press (1974).
6. Rosa, A. & Eschholz, P. W. *Writer's Brief Handbook* 6th Ed. Longman (2007).

SEMESTER- II

L	T	P	Credit
4	0	0	4

ENV-AE-021: Environmental Studies

Course Objectives	Understand how much environment is crucial for the sustenance of life on earth.
Course Outcomes	• Knowing the composition of atmosphere and different reaction pathways for environmentally relevant chemical processes. • Learning the mitigation strategies for the pollution problems. • Realizing the importance of green chemistry and sustainability

DETAILED CONTENT

Module I

Multidisciplinary nature of environmental studies: Definition, scope and importance, Need for public awareness.

Module II

Renewable and non-renewable resources: Natural resources and associated problems- a) Forest resources : Use and over-exploitation, deforestation, case studies; timber extraction, mining, dams and their effects on forest and tribal people; b) Water resources : Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems; c) Mineral resources : Use and exploitation, environmental effects of extracting and using mineral resources, case studies; d) Food resources : World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies; e) Energy resources : Growing energy needs, renewable and non renewable energy sources, use of alternate energy sources. f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources; equitable use of resources for sustainable lifestyles**.**

Module III

Ecosystems: Concept of an ecosystem. Structure and function of an ecosystem. Producers, consumers and decomposers; Energy flow in the ecosystem. Ecological succession. Food chains, food webs and ecological pyramids. Introduction, types, characteristic features, structure and function of the following ecosystem: a) Forest ecosystem; b) Grassland ecosystem; c) Desert ecosystem; d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

Module IV

Biodiversity and its Conservation: Introduction – Definition: genetic, species and ecosystem diversity. Biogeographical classification of India. Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values. Biodiversity at global, National and local levels. India as a mega-diversity nation. Hot-sports of biodiversity. Threats to biodiversity - habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India. Conservation of biodiversity - In-situ and Ex-situ conservation of biodiversity.

Module V

Environmental Pollution: Definition, cause, effects and control measures of: - Air pollution; Water pollution; soil pollution; Marine pollution; Noise pollution; Thermal pollution; nuclear hazards and solid waste management: causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution. Pollution case studies. Disaster management: floods, earthquake, cyclone and landslides.

Module VI:

Social issues and the environment: From unsustainable to sustainable development; urban problems related to energy; Water conservation, rain water harvesting, watershed management; Resettlement and rehabilitation of people; its problems and concerns. Case Studies; Environmental ethics: Issues and possible solutions; Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation. Consumerism and waste products. Environment protection act. Air (prevention and control of pollution) act, water (prevention and control of Pollution) act; Wildlife protection act, forest conservation act, issues involved in enforcement of environmental legislation, public awareness.

Module VII:

Human population and the environment: Population growth, variation among nations; Population explosion – Family welfare programme. Environment and human health; Human rights. Value education; HIV/AIDS, Women and child welfare, Role of information technology in environment and human health.

Module VIII:

Field Work: Visit to a local area to document environmental assets river/forest/ grassland/hill/ mountain; Visit to a local polluted site-urban/rural/industrial/agricultural; Study of common plants, insects, birds; Study of simple ecosystems-pond, river, hill slopes, etc.

(**Field work = 5 lecture hours)**

Text Books

1. Mhaskar A.K., Matter Hazardous, Techno-Science Publication

2. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. Clark R.S., Marine Pollution, Clanderson Press Oxford

3. Trivedi R. K. And P.K. Goel, Introduction to air pollution, Techno-Science Publication

4. Agarwal, K.C. Environmental Biology, Nidi Publ. Ltd. Bikaner.

Reference Books

1. *Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad – 380 013, India,*
2. *Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. Environmental Encyclopedia, Jaico Publ. House, Mumabai,*
3. *De A.K., Environmental Chemistry, Wiley Eastern Ltd.*

Skill Enhancement Courses (SEC)

CHEM-SE-011: Water Treatment and Analysis-I

L	T	P	Credit
1	0	1	2

Course Objectives	The objective of the course is to develop a basic understanding of water qualities and ability to use principles of water chemistry for water treatment and water quality control in the natural systems
Course Outcomes	After the completion of the course, the students will be able to: • Learn about various parameters measured for determining the water quality such as alkalinity, hardness, total dissolved solids etc. • Apply knowledge of basic water chemistry to solve problems associated with water/ wastewater treatment and natural water quality • Understand various water treatment processes. • Acquire basic practical knowledge for water sample analyses.

DETAILED CONTENT

Module I

Water Quality Parameters and Purification: Characteristics of water, alkalinity. Hardness: unit of hardness, total solids, oxidation, transparency, silica content.

Purification of water for drinking purpose: potability of water, clarification, coagulation, contact and electrochemical coagulation, sterilization and disinfection of water, precipitation, aeration, ozonisation, chlorination.

Module II

Water Treatment: Water softening methods: Clark's process, lime soda process, modified lime soda process, permutit or zeolite process, ion exchange process, demineralization of water.

Determination of hardness of water: titration method, complexometric method using EDTA. Problems to determine temporary and permanent hardness.

Recommended Books

1. Sharma, B. K., *Industrial Chemistry (including Chemical Engineering)*, Goel Publishing House, Meerut (2000).
2. Varashney, C. K., *Water Pollution and Management*, 2nd Ed, New Age International (2018).
3. Srivastava, A., *Waste Water Treatment and Water Management: Water Treatment and Management*, Notion Press (2018).

PRACTICAL

Water Treatment and Analysis I (CHEM-SE-011P)

1. Water analysis: Sampling techniques for water analysis.
2. Preliminary examination: alkalinity (bicarbonate, carbonate, hydroxide, acidity), chloride, nitrate, sulphate and calcium; temperature, pH and conductivity.

3. Analysis of solids present in water: suspended solids, dissolved solids, free Mg, Fe, Mn, Ag and Zn.

Recommended Books

1. APHA, *Standard Methods for the Examination of Water, Sewage and Industrial Wastes*. 20th Ed., American Public Health Association: Washington, USA (1995).

CHEM-SE-012: Water Treatment and Analysis-II

L	T	P	Credit
1	0	1	2

Course Objectives	The objective of the course is to develop basic understanding of hard water, its treatment and analyses of water samples.
Course Outcomes	After the completion of the course, the students will be able to: • Learn about hard water, its effect and industrial methods of water softening. • Learn about various desalination processes for water treatment. • Analyse water for chemical and biological substances present therein. • Determine hardness, dissolved oxygen and TDS of water practically.

DETAILED CONTENT

Module I

Hard Water and their Treatment: Hard water and industries, industrial water treatment, boiler feed water method of softening, prevention of plumbo solvency, scales in boilers and consequences, internal conditioning methods.

Desalination of brackish water: elecrodialysis, reverse osmosis, removal of Fe, Mn and silicic acid, effluent treatment of water from paper industry, petrochemical, fertilizer industry and power station.

Module II

Analysis of Water: Analysis of chemical substances affecting health: NH_3, nitrate, nitrite, cyanide, sulphate, sulphide, chloride, fluoride. Measurement of toxic chemical substances, analysis of chemical substances indicative of pollution, dissolved oxygen, bio chemical oxygen demand (BOD), chemical oxygen demand (COD).

Bacteriological examination of water: total count test, E-coli test, E-coli index, most probable number method, biological examination of water, physical examination of water. Radioactivity of water: methods of removing radioactivity from water.

Recommended Books

1. Sharma, B. K., *Industrial Chemistry (Including Chemical Engineering)*, Goel Publishing House, Meerut (2016).
2. Varashney, C. K. *Water Pollution and Management*, 2nd Ed, New Age International, New Delhi (2018).
3. Srivastava, A., *Waste Water Treatment and Water Management: Water Treatment and Management*, Notion Press (2018).

PRACTICAL
Water Treatment and Analysis II (**CHEM-SE-012P)**

---

1. Determination of hardness of water.
2. Determination of dissolved oxygen in water.
3. Determination of chemical oxygen demand (COD).
4. Determination of Biological oxygen demand (BOD).

Recommended Books

1. APHA, *Standard Methods for the Examination of Water, Sewage and Industrial Wastes*. 20th Ed., American Public Health Association: Washington, USA (1995).

CHEM-SE-013: Fertilizers and Pesticides Chemistry

L	T	P	Credit
1	0	1	2

Course Objectives	The objective of the course is to make the students aware of the importance and effect of fertilizer and manure on plant growth. In addition, it aims to Imparts knowledge on pesticides and their effect on environment.
Course Outcomes	After the completion of the course, the students will be able to: • Learn the effect of N, P and K on plant growth. • Have fair knowledge on different types of fertilizers and manures and their method of production. • Acquire knowledge on different pesticides, insecticides & herbicide and their adverse effect on the environment. • Learn how N content of urea can be estimated practically. • Learn to synthesize simple organophosphates, carbamates etc.

DETAILED CONTENT

Module I

Fertilizers and Manures: *Fertilizers*: Effect of nitrogen, potassium and phosphorous on plant growth, classification of fertilizers, requisites of a good fertilizers, nitrogenous fertilizers, phosphatic fertilizers, super phosphate of lime, triple super phosphate, NPK fertilizers, ill effects of fertilizers, effect of mixed fertilizers on soil pH. Commercial method of preparation of urea and triple superphosphate.

Manures: Organic manures, farmyard manure, handling and storage of: oil cakes, bone meal, meat meal, fish meal, blood meal and green manures.

Module II

Pesticides: 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).

Recommended Books

1. Ghosh, J., *Fundamental Concept of Applied Chemistry*, S. Chand & Company, New Delhi (2010).

2. Cremlyn R., *Pesticide: Preparation and Modes of Action*, John Wiley & Sons, New York (1978).

PRACTICAL

Fertilizer and Pesticide Chemistry (CHEM-SE-013 P)

---

1. Estimation of available N in Urea and commercial fertilizers.
2. Calculation acidity/alkalinity in a given sample of commercial pesticide as per BIS specification.

3. Preparation of simple organophosphates and diethyldithiocarbamate

Recommended Books

1.Mendham, J.; Denney, R. C.; Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Ed., Pearson Education, New Delhi (2009).

2. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut, Meerut (2013).

CHEM-SE-014: Chemistry of Foods, Cosmetics and Perfumes

L	T	P	Credit
1	0	1	2

Course Objectives	This course is designed to provide students the basic idea on the analysis of food products and cosmetics by different analytical techniques.
Course Outcomes	After the completion of the course, the students will be able to: • Learn about food processing, food preservations and adulteration and analyses of food products. • Have idea about constituents of deodorants and antiperspirants. • Determine constituents of talcum powder practically.

DETAILED CONTENT

Module I

Analysis of Food Products: Nutritional value of foods, idea about food processing and food preservations and adulteration. Identification of adulterants in some common food items. Analysis of preservatives and colouring matter. Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI.

Module II

Analysis of Cosmetics and Perfumes: 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. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Recommended Books

1. Srilakshmi, B., *Food Science*, 7th Ed., New Age International, New Delhi (2018).

2. Subhalakshmi, G.; Udipi, S. A., *Food Processing and Preservation*, New Age International, New Delhi (2018).

3. Potter, N. N.; Hotchkiss, J. H., *Food Science*, 5th Ed., Springer (1999).

4. Sharma, B. K., *Industrial Chemistry (Including Chemical Engineering)*, Goel Publishing House, Meerut (2016).

PRACTICAL

Chemistry of Food, Cosmetics and Perfumes (CHEM-SE-014P)

1. Analysis of Food Products: (a) Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

(b) Determination of moisture content in food, ash content and determination of calcium, iron, vitamin C.

(c) Quantitative estimation of sugars (glucose, lactose, starch).

(d) Estimation of acid values, iodine value, saponification value of fats.

2. Analysis of cosmetics: Major and minor constituents and their function (e) Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.

(f) Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Recommended Books

1. Mendham, J.; Denney, R. C.; Barnes, J. D.; Thomas, M.; Sivasankar, B., *Vogel's Textbook of Quantitative Chemical Analysis*, 6th Ed., Pearson Education, New Delhi (2009).

2. Raj, G., *Advanced Practical Inorganic Chemistry*, Krishna Prakashan, Meerut, Meerut (2013).

CHEM-SE-015: Pharmaceutical Chemistry

L	T	P	Credit
1	0	1	2

Course Objectives	The objective of this paper is to develop basic understanding of drugs discovery, drug design, development and their side effects. It also covers the synthesis of major classes of drug. The course is also designed to give an overview of fermentation process and production of certain dietary supplements.
Course Outcomes	After the completion of the course, the students will be able to: • Gain an insight into the synthetic approaches of different classes of drugs. • Understand the fermentation processes and production of ethanol, citric acids, antibiotics and a few of vitamins. • Carry out laboratory syntheses of a few drug molecules. • Determine ascorbic acid content in vitamin C tablets by iodometric or coulometric titrations.

DETAILED CONTENT

Module 1

Drugs and Pharmaceuticals: 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), antibiotics (chloramphenicol), antibacterial and antifungal agents (sulphonamides, sulphanethoxazol, sulphacetamide, trimethoprim), antiviral agents (acyclovir), central nervous system agents (phenobarbital, diazepam), cardiovascular (glyceryl trinitrate), antilaprosy (dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Module II

Fermentation: Aerobic and anaerobic fermentation. Production of (i) ethyl alcohol and citric acid, (ii) antibiotics; penicillin, cephalosporin, chloromycetin and streptomycin, (iii) lysine, glutamic acid, vitamin B2, vitamin B12 and vitamin C.

Recommended Books

1. Lemke, T. L.; Zito, S. W.; Roche, V. F.; Williams, D. A., Essentials of *Foye's Principles of Medicinal Chemistry*. Wolters Kluwer India, New Delhi (2016).
2. Patrick, G. L., *An Introduction to Medicinal Chemistry*. 5th Ed.; Oxford University Press, New Delhi (2013).
3. Singh, H.; Kapoor, V. K., *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, New Delhi (2012).

PRACTICAL
Pharmaceutical Chemistry (CHEM-SE-015P)

---

1. Preparation and analysis of aspirin, paracetamol, magnesium bisilicate (Antacid), sulphanilamide, sulphaguanidine etc.
2. Determination of ascorbic acid in vitamin C tablets by iodometric or coulometric titrations.
3. Synthesis of ibuprofen.

Recommended Books

1. Ahluwalia, V. K.; Aggarwal, R., *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, Universities Press (2000).

GENERIC ELECTIVE (GE) COURSES

SEMESTER-I

CHEM-GE-001: General Chemistry- I

L	T	P	Credit
4	0	2	6

Course Objectives	This course mainly reviews the basic concepts of chemistry. It discusses structure of atoms, periodic properties of elements (especially the s- and p-block elements) elaborately. It also provides basic knowledge of chemical bonding (ionic and covalent), along with an introduction to weak chemical forces that determines many physical properties of molecules. The course will also introduce the students with the basic concepts of chemical kinetics and various terms related to rates of reaction. Further the course gives a better understanding of basic concepts of organic chemistry such as classification of organic compounds, electronic displacement, bond fission and types of organic reactions.
Course Outcomes	On completion of this course the students will be able to: • Understand quantum mechanical model of atom, quantum numbers, electronic configuration, radial and angular distribution curves, shapes of s, p and d orbitals and periodic trends of the properties of elements. • Understand the underlying concepts of covalent and ionic bonds and attractive forces as well as theories (VBT, MOT) explaining those. • Draw MO diagrams for simple homo & hetero-nuclear diatomic molecules and to calculate the bond order. • Understand the importance of inter and intramolecular weak chemical forces and their effect on common physical properties. • Understand the basics of chemical kinetics: determination of order, molecularity and all types of factors affecting rate of reactions. • Explain different theories viz. collision and transition state theory and how these account for experimental observations. • Understand the role of various electronic factors in stability, polarity, acidity, basicity etc. of different organic species both neutral and charged in nature.

Module I

Atomic Structure: Bohr's theory and its limitations, atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, 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.

Module II

Periodicity of Elements: s, p, d and f-block elements, the long form of periodic table. Detailed discussion of the various properties of the elements of s and p-block; Effective

nuclear charge, shielding or screening effect, Slater rules, Ionization enthalpy, Electron gain enthalpy, Electronegativity, electronegativity scales (Pauling, Mülliken, Allred-Rochow and Mulliken-Jaffé), Sanderson's electron density ratio.

Ionic bond: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy- their importance in the context of stability and solubility of ionic compounds. Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Weak chemical forces: van der Waals forces, H-bonding and its types.

Module III

Covalent Bonding: Covalent bond: Characteristics and properties, valence bond theory. Application of hybridisation (sp, sp^2, sp^3, dsp^2 and d^2sp^3) to explain structure of simple molecules. Bent's rule, resonance and resonance energy. Polarity in covalent molecules, dipole moment, percentage ionic character and electro negativity difference. Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Molecular orbital theory, molecular orbital diagrams of diatomic (N_2, O_2, CO, NO, and their ions).

Module IV

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).

Module V

Basics of Organic Chemistry: Organic Compounds: Classification and Nomenclature, Hybridization, shapes of molecules, influence of hybridization on bond properties. Electronic Displacements: inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications. Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. 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.

Recommended Books

1. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Wiley India (2008).
2. Housecroft, C. E; Sharpe, A. G., Inorganic Chemistry, 5th Ed., Pearson Education (2018).
3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., Shriver Atkins's Inorganic Chemistry, 6th Ed., Oxford University Press India (2015).
4. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., Inorganic Chemistry: Principles of Structures and Reactivity, 4th Ed., Pearson Education India (2006).
6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley India (2007).
7. Puri, B. R.; Sharma, L. R.; Kalia, K. C., Principles of Inorganic Chemistry, 33rd Ed., Vishal Publishing (2017).
8. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).

9. Puri, B. R.; Sharma, L. R.; Pathania, M. S., Principles of Physical Chemistry, 47th Ed., Vishal Publishing (2017).
10. Bruice, P. Y., Organic Chemistry, 7th Ed., Pearson Education India (2013).
11. Bahl, B. S.; Bahl, A., A Textbook of Organic Chemistry, 22nd Ed., S. Chand and Company (2016).

PRACTICAL General Chemistry-I (CHEM-GE-001P)

---

1. Acid-Base Titrations
(a) Determination of alkali content of antacid tablets using HCl.
(b) Estimation of calcium content in chalk as calcium oxalate.
(c) Estimation of carbonate and hydroxide present together in mixture.
2. Oxidation-Reduction Titrations
(a) Estimation of oxalic acid by titrating it with $KMnO_4$.
b) Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
(c) Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
3. Purification of organic compounds by crystallization using Water /Alcohol /Alcohol-Water and determination of their melting points.
4. Viscosity measurement using Ostwald's viscometer (use of organic solvents excluded).
(a) Study the effect of the addition of solutes such as
(i) Ethanol (iii) Sodium chloride on the viscosity of water at room temperature.

Recommended Books

1. Raj, G., Advanced Practical Inorganic Chemistry, Krishna Prakashan, Meerut, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson Education India (2009).
3. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson Education India (2003).
4. Clarke, H. T., A Handbook of Organic Analysis: Qualitative and Quantitative, 4th Ed., CBS Publishers India (2007).
5. Khosla, B. D.; Garg, V. C.; Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).

SEMESTER-II

CHEM-GE-002: General Chemistry- II

L	T	P	Credit
4	0	2	6

Course Objectives	This course is designed to make students understand a few more basic chemistry topics that will help them to understand their honours course better. Students will learn about various theories used to explain acid & base chemistry including the Pearson acid-base concept. It also encompasses concepts on dissociation of strong and weak electrolytes, hydrolysis of salts, solubility and solubility product of sparingly soluble salts, pH, buffers and various applications of ionization. Further it will revisit the fundamental concepts of organic chemistry of aliphatic and aromatic hydrocarbons in details.
Course Outcomes	On completion of this course the students will be able to: • Understand various theories of acids and bases. • Have idea on Pearson's HSAB principle and its applications. • Derive relationships between Kp, Kc and Kx for reactions involving ideal gases. • Explain the concept of ionization of electrolytes with emphasis on weak acids and bases and hydrolysis of salt. • Have clear idea on aromaticity and its influence in stabilizing ring compounds and ions. • Have idea on syntheses, properties and reactions of various classes of aliphatic and aromatic hydrocarbons. • Have practical knowledge of detection of elements present in an organic compound. • Prepare buffer solutions of varied pH.

Module I

Acid-Base Chemistry: Arrhenius, Bronsted-Lowry and Lewis concepts of acids and bases. Proton transfer equilibria in water, solvent levelling. Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength. Theoretical basis of hardness and softness, Concept of electronegativity related to hardness and softness. Applications of acid base chemistry in qualitative analysis and catalysis, superacids and superbases.

Module II

Chemical & Ionic Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG°. Le Chatelier's principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases. 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 the principle of solubility product.

Module III

Chemistry of Aliphatic Hydrocarbons: Alkanes: (Up to five carbons) Preparation: Catalytic hydrogenation, Würtz Reaction, Würtz Fittig Reactions, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical substitutions, halogenation. Alkenes: (Up to five

carbons) Preparation: Elimination reactions, dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule), cis-alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions of alkenes: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), addition of HX (Markownikoff's and anti Markownikoff's addition), hydration, ozonolysis, oxymecuration-demercuration, hydroboration-oxidation. Alkynes: (Upto five carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes, by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$.

Module IV

Aromatic Hydrocarbons: Benzene: Preparation from phenol, from decarboxylation, from acetylene, from benzene sulphonic acid. Reactions of benzene: electrophilic substitution, nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto four carbons on benzene). Side chain oxidation of alkyl benzenes (upto four carbons on benzene).

Module V

Alkyl and Aryl Halides: Alkyl Halides (Upto five Carbons): Preparation: from alkenes and alcohols. Types of Nucleophilic Substitution (SN1, SN2 and SNi). hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: elimination vs substitution. Aryl Halides: Preparation of Chloro, bromo and iodo-benzene from phenol, Sandmeyer & Gattermann reactions. Reactions of aryl halide: Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent in chlorobenzene. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

Recommended Books

1. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., Shriver Atkins's Inorganic Chemistry, 6th Ed., Oxford University Press India (2015).
2. Atkins, P. W.; de Paula, J.; Keeler, J., Physical Chemistry, 11th Ed., Oxford University Press India (2018).
3. Bahl, A.; Bahl, B. S.; Tuli, G. D., Essentials of Physical Chemistry, S. Chand and Company (2010).
4. Negi, A. S.; Anand, S. C., Physical Chemistry, New Age International Publishers (2007).
5. Puri, B. R.; Sharma, L. R.; Pathania, M. S., Principles of Physical Chemistry, 47th Ed., Vishal Publishing (2017).

PRACTICAL General Chemistry- II (CHEM-GE-002P)

1. Distribution of acetic/ benzoic acid between water and cyclohexane.
2. pH-measurements
(a) Study the effect of pH on 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
3. Detection of elements (nitrogen, sulphur and halogens) in unknown organic compounds.

Recommended Books

1. Viswanathan, B.; Raghavan, P. S., Practical Physical Chemistry, Viva Books India (2014).
2. Yadav, J. B., Advanced Practical Physical Chemistry, Krishna Prakashan, Meerut (2015).

3. Agarwal, O. P., Advanced Practical Organic Chemistry, Krishna Prakashan, Meerut (2014).
4. Ahluwalia, V. K.; Aggarwal, R., Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press (2000).

SEMESTER-III

CHEM-GE-003: General Chemistry-III

L	T	P	Credit
4	0	2	6

Course Objectives	The course reviews the general properties of the s- and p-block elements. Students will learn about the phase, co-existence of phases, phase diagram and distribution law. The course will enable the students to understand conductance, conductivity, chemical cells, Nernst equation, and applications of EMF measurements in determining various physical chemistry parameters. They will also learn chemistry of organic molecules bearing a few common functional groups, which include alcohols, phenols aldehydes and ketones.
Course Outcomes	On completion of this course the students will be able to: • Learn about structure, bonding, preparation, properties and uses of compounds of s- and p block Elements. • Understand phase equilibrium, phase rule, phase diagram clearly. • Understand Nernst distribution law, its applications in extraction processes and limitations. • Understand conductance and conductivity, application of conductance measurement in determining various physical chemistry parameters. • Understand standard electrode potential of half cells and calculation of EMF of a cell using Nernst equation. • Have knowledge on concentration cell. • Learn about the property, reactivity and synthetic importance of O-containing functional groups like alcohols, phenols, carbonyl group. • Learn detection of O-containing functional groups in organic compounds.

Module I

Compounds of s- and p-block Elements: Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. (a) Boron: Boric acid and borates, boron nitrides, borohydrides (diborane). (b) Carbon: Types of carbide, CaC_2, SiC, Al_4C_3, their preparation, properties and uses. (c) Silicon: Silane, silicon halides, silicones and siloxanes. (d) Nitrogen & Phosphorus: ammonia-manufacture (Haber's process), oxides and oxoacids of nitrogen and phosphorus. (e) Sulphur: Sulphuric acid and its properties as dehydrating agent, oxidizing property and action on metals and non-metals, peroxo acids of sulphur. (f) Halogen: interhalogen compounds, polyhalide ions, pseudo halogens and basic properties of halogens.

Module II

Phase Equilibria: Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria. Phase diagram of one component systems (water and sulphur) and two component systems (silver-lead and KI-H_2O). Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. Nernst distribution law and its limitations, thermodynamic derivation. Modification of distribution law in case of association and dissociation of solute and complex formation. Applications of Nernst distribution law.

Module III

Electrochemistry & Conductance: Reversible and irreversible cells. Concept of EMF of a cell, measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only). Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference/transport number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements, Conductometric titrations (only acid base).

Module IV

Alcohols and Phenols: Alcohols: Properties and relative reactivity of 1°, 2°, 3° alcohols, general methods of preparation of monohydric alcohols. Bouveault-Blanc Reduction. Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. Phenols: Preparation from cumene hydroperoxide and from diazonium salts. Reactions of phenol: Electrophilic substitution, nitration, halogenation and sulphonation. Reimer-Tiemann reaction, Gattermann-Koch reaction, Houben-Hoesch condensation, Schotten-Baumann reaction.

Module V

Ethers and Carbonyl Compounds: Ethers (aliphatic and aromatic): Cleavage of ethers with HI. Aldehydes and Ketones (aliphatic and aromatic): Formaldehye, acetaldehyde, acetone and benzaldehyde. Preparation: from acid chlorides and from nitriles. Reactions: with HCN, ROH, $NaHSO_3$, ammonia group derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation, Clemensen reduction and Wolff-Kishner reduction, Meerwein-Ponndorf-Verley reduction.

Recommended Books

1. Greeves, N.; Clayden, J.; Warren, S., Organic Chemistry, 2nd Ed., Oxford University Press India (2014).
2. Smith, M. B.; March, J., March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 7th Ed., Wiley India (2015).
3. Solomons, T. W. G.; Fryhle, C. B., Organic Chemistry, 11th Ed., Wiley India (2015).
4. Bruice, P. Y., Organic Chemistry, 7th Ed., Pearson Education India (2013).
5. Ghosh, S. K., Advanced General Organic Chemistry, Part-I & Part-II, 3rd Ed., New Central Book Agency (2010).
6. Bhal, B. S.; Bhal, A., A Textbook of Organic Chemistry, 22nd Ed., S. Chand and Company (2016).
7. Nasipuri D., Stereochemistry of Organic Compounds: Principles and Applications, 3rd Ed., New Age International Publishers (2018).
8. Sengupta, S., Basic Stereochemistry of Organic Molecules, 2nd Ed., Oxford University Press India (2018).

PRACTICAL General Chemistry-III (CHEM-GE-003P)

---

1. Detection of elements (nitrogen, sulphur and halogens) in unknown organic compounds.
2. Chromatography
(a) Checking the purity of supplied organic sample using paper/thin layer chromatographic technique.
(b) Determination of the number of components present in a supplied organic mixture using paper/thin layer chromatographic technique.
(c) Separation of a mixture of two amino acids by paper chromatography and determination of R_f.
(d) Separation of a mixture of o-and p-nitrophenol or o- and p-aminophenol by thin layer chromatography (TLC) and determination of R_f of each of the component.
3.(a) To study changes in conductance in the following systems
(i) Strong acid-strong base
(ii) Weak acid-strong base and
(b) Determination of cell constant using conductance.
(c) Determination of limiting molar conductance of strong electrolytes: NaCl, KCl.

Recommended Books

1. Agarwal, O. P., Advanced Practical Organic Chemistry, Krishna Prakashan, Meerut (2014).
2. Ahluwalia, V. K.; Aggarwal, R., Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press (2000).
3. Furniss, B. S.; Hannafold, A. J.; Smith, P. W. G.; Tatchell, A. R., Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson Education India (2003).
4. Clarke, H. T., A Handbook of Organic Analysis: Qualitative and Quantitative, 4th Ed., CBS Publishers India (2007). 20 SEMESTER II CHE-CC-122 Physical Chemistry II.
5. Khosla, B. D.; Garg, V. C.; Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
6. Yadav, J. B., Advanced Practical Physical Chemistry, Krishna Prakashan, Meerut (2015).

SEMESTER-IV

CHEM-GE-004: General Chemistry-IV

L	T	P	Credit
4	0	2	6

Course Objectives	The course introduces the students to coordination compounds which find manifold applications in diverse areas like qualitative and quantitative analysis, metallurgy, catalysis, paints and pigments. It also aims to introduce the learners to the application of spectroscopic techniques (UV-visible and IR) in the structure determination of simple organic molecules and to understand the underlying concepts and principles therein. Further the course gives a better understanding of conceptual knowledge of solid-state chemistry. It helps students to understand different methods used for crystal determination.
Course Outcomes	On completion of this course, students will be able to: • Understand the important properties of transition metals such as variable oxidation states, colour, magnetic and catalytic properties; use of Latimer diagrams in identifying reducing, oxidizing and undergoing disproportionation nature of species. • Learn about different terminologies like ligand, denticity of ligands, chelate, coordination number etc. and nomenclature of coordination compounds. • Have ideas on various types of isomerism possible in complexes with 4 and 6 coordination numbers. • Predict the structure and magnetic behaviour of metal complexes using Valence Bond Theory. • Have clear understanding of the terms Δ_o, Δ_t, pairing energy, CFSE, high spin and low spin as well as the effect of CFSE on thermodynamic properties like lattice enthalpy and hydration enthalpy. • Have knowledge on preparation, properties and shapes of compounds of noble gases as well as polymers of B, Si & P. • Describe various terms and laws of crystallography. Also learn about X-ray diffraction methods to analyze the structure of crystals. • Explain the importance and properties of defects in solid. • Learn basic principles of various spectroscopic techniques and their importance in structure elucidation of compounds. • Study and interpret UV-Vis spectra.

Module I

d- and f-Block Elements: General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties and ability to form complexes. Stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Difference between the first, second and third transition series. Lanthanoids and actinoids: electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Module II

Coordination Chemistry: Introduction to coordination chemistry, classification of ligands, Werner's theory, nomenclature of coordination compounds. Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6).

Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature. Crystal field theory: Crystal field effect, octahedral symmetry, Crystal field stabilization energy (CFSE), crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

Module III

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, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Module IV

Noble Gases: Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6, bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory.

Inorganic Polymers: Types of inorganic polymers and comparison with organic polymers, structural features, classification and important applications of silicates. Synthesis, structural features and applications of silicones. Borazines and cyclophosphazenes – preparation, properties and reactions.

Module V

Application of Spectroscopy to simple Organic Molecules: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λ_{max} & ε_{max}, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{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 Books

1. Lee, J. D., Concise Inorganic Chemistry, 5th Ed., Wiley India (2008).
2. Housecroft, C. E; Sharpe, A. G., Inorganic Chemistry, 5th Ed., Pearson Education (2018).
3. Atkins, P.; Overton, T.; Rouke, J.; Weller, M.; Armstrong, F.; Hagerman, M., Shriver Atkins's Inorganic Chemistry, 6th Ed., Oxford University Press India (2015).
4. Miessler, G.; Tarr, D. A., Inorganic Chemistry, 3rd Ed., Pearson Education India (2008).
5. Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K., Inorganic Chemistry: Principles of Structures and Reactivity, 4th Ed., Pearson Education India (2006).
6. Cotton, F. A.; Wilkinson, G.; Gaus, P. L., Basic Inorganic Chemistry, 3rd Ed., Wiley India (2007).
7. Puri, B. R.; Sharma, L. R.; Kalia, K. C., Principles of Inorganic Chemistry, 33rd Ed., Vishal Publishing (2017).
8. Lampman, G. M.; Pavia, D. L.; Kriz, G. S.; Vyvyan, J.R., Introduction to Spectroscopy, 5th Ed., Cengage Learning India, New Delhi (2015).
9. Kemp, W., Organic Spectroscopy, 3rd Ed., Macmillan Publishers India, New Delhi (2011).
10. Puri, B. R.; Sharma, L. R.; Pathania, M. S., Principles of Physical Chemistry, 47th Ed., Vishal Publishing (2017).

11. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).

PRACTICAL General Chemistry-IV (**CHEM-GE-004P)**

---

1. Inorganic preparations
(a) Copper(I) chloride from copper (II) chloride
(b) Preparation of Manganese (III) phosphate, $Mn_3(PO_4)_2 \cdot H_2O$
(c) Preparation of chrome alum $[K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O]$ and potash alum $[K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O]$.
2. UV/Visible spectroscopy
(a) Study the absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1}, kJ mol^{-1}, cm^{-1}, eV)
3. Surface tension measurements (use of organic solvents excluded).
(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.

Recommended Books

1. Raj, G., Advanced Practical Inorganic Chemistry, Krishna Prakashan, Meerut, Meerut (2013).
2. Mendham, J.; Denney, R. C., Barnes, J. D.; Thomas, M.; Sivasankar, B., Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson Education India (2009).
3. Khosla, B. D.; Garg, V. C.; Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co., New Delhi (2011).
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).