LOCF CHEMISTRY

Learning Outcomes based Curriculum Framework (LOCF) for

(B. Sc. Honors in Chemistry)

NEP Scheme

Undergraduate Programme-2022-23

(Revised for I and II Sem)

Prepared by
BoS (UG) Chemistry
Tumkur University, Tumakuru

CURRICULUM

Name of the Degree Program: B.Sc (Honors) Chemistry

Discipline Core: Chemistry

Total Credits for the Program: 176

Year of implementation: 2021-22

Program Outcomes:

By the end of the program the students will be able to:

1. **PO. 1:** To create enthusiasm among students for chemistry and its application in various fields of life.
2. **PO. 2:** To provide students with broad and balanced knowledge and understanding of key concepts in chemistry.
3. **PO. 3:** To develop in students a range of practical skills so that they can understand and assess risks and work safely measures to be followed in the laboratory.
4. **PO. 4:** To develop in students the ability to apply standard methodology to the solution of problems in chemistry.
5. **PO. 5:** To provide students with knowledge and skill towards employment or higher education in Analytical chemistry or multi-disciplinary areas involving chemistry.
6. **PO. 6:** To provide students with the ability to plan and carry out experiments independently and assess the significance of outcomes and to cater to the demands of chemical Industries of well-trained graduates.
7. **PO. 7:** To develop in students the ability to adapt and apply methodology to the solution of unfamiliar types of problems.
8. **PO. 8:** To instill critical awareness of advances at the forefront of chemical sciences, to prepare students effectively for professional employment or research degrees in chemical sciences and to develop an independent and responsible work ethics.

Curriculum Structure for the Undergraduate Degree Program
B.Sc (Honors) Chemistry

Total Credits for the Program: 176
Year of implementation: 2021-22
Name of the Degree Program: B. Sc (Honors)
Discipline/Subject: Chemistry

Program Articulation Matrix:
This matrix lists only the core courses. Core courses are essential to earn the degree in that discipline/subject. They include courses such as theory, laboratory, project, internships etc. Elective courses may be listed separately.

Semester	Title/Name of the course	Program outcomes that the course addresses (not more than 3 per course)	Pre-requisite course(s)	Pedagogy	Assessments
I	**CHEDSC01: (Chemistry -I)**	• The concepts of chemical analysis, accuracy, precision and statistical data treatment • Understand the preparation of alkanes, alkenes and alkynes, their reactions, etc. • Understand the mechanism of nucleophilic, electrophilic reactions.	P.U.C with Chemistry	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHEDSC01P: (Chemistry Practicals-I)	• Handle the glassware, prepare and dilute the solutions and perform experiments with prepared reagents. • Determine the analyte through volumetric and gravimetric analysis and understand the chemistry involved in each method of analysis. • Prepare organic compounds and calculation of percentage yield.	-	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
II	**CHEDSC02: (Chemistry-II)**	• Understanding the Bohr's theory of atomic structure • Quantum numbers and their necessity in explaining the atomic structure	-	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

		• The concept of unit cell, symmetry elements, Nernst distribution law.			
	CHEDSC02P: (Chemistry Practicals-II)	• To prepare standard solutions • Techniques like precipitation, filtration, drying and ignition • Various titrimetric techniques and gravimetric methods		Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
III	**CHEDSC03: (Chemistry - III)**	• The structures of molecules/compounds/ions based on different models/theories and concept of mechanism and its importance will be taught. • The fundamentals of thermodynamics, surface chemistry, will be taught. • Principle, instrumentation and applications of spectrophotometry, nephelometry and turbidometry will be taught.	**DSC-1 & DSC-2**	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHEDSC03P: (Chemistry Practicals-III)	• Impart skills related to preparation of stock and working solutions and handling instruments • Techniques to identify the bi-functional groups in organic compound. • To impart skills related to instrumental analysis			
IV	**CHEDSC04: (Chemistry - IV)**	• Properties of compounds based on bonding, structure, stereochemistry and its importance will be taught. • Electrochemistry dealing with electrolytes in solution. Conductance measurements and applications. • Principle, types and		Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

		applications of solvent extraction and chromatography will be taught.			
	CHEDSC04P: (Chemistry Practicals-IV)	• Analytical skills in detecting the type of ions present in inorganic samples. • Determining rates of chemical reactions. • Physical characteristics of electrolytes using conductivity measurements in solution.			
V	**CHEDSC05: Selected topics in Inorganic Chemistry** **CHEDSC05P: Inorganic Chemistry Practical's** **CHEDSC06: Selected topics in Organic Chemistry** **CHEDSC06P: Organic Chemistry Practical's**	Will be updated once syllabus from state committee is received.	**DSC-3 and DSC-4**	MOOCs, Problem solving	Internal tests, Assignments, Quiz
VI	**CHEDSC07: Selected topics in Physical Chemistry** **CHEDSC07P: Physical Chemistry Practical's.** **CHEDSC08: Spectroscopy** **CHEDSC08P: Analytical and Industrial Chemistry Practical's**	Will be updated once syllabus from state committee is received.		MOOCs, Problem solving	Internal tests, Assignments, Quiz

VII	**CHEDSC09: Analytical Techniques-I** **CHEDSC09P: Analytical Chemistry.** **CHEDSC10: Applied Chemical Analysis.** **CHEDSC10P: Analytical Chemistry.** **CHEDSC11: Enviornmental and Nanomaterial Chemistry.**	Will be updated once syllabus from state committee is received.	**DSC-5, DSC-6, DSC-7 & DSC-8**	MOOCs, Problem solving	Internal tests, Assignments, Seminar, Debate, Quiz
VIII	**CHEDSC12: Analytical Techniques-II** **CHEDSC13: Separation and Electroanalytical Techniques.** **CHEDSC14: Analysis of food and pharmaceuticals**	Will be updated once syllabus from state committee is received.		Project work, Industrial Visit	Internal tests, Assignments, Seminar, Debate, Quiz

Pedagogy for student engagement is predominantly lectures. However, other pedagogies enhancing better student engagement to be recommended for each course. The list includes active learning/ course projects/ problem or project based learning/ case studies/self study like seminar, term paper or MOOCs. Every course needs to include assessment for higher order thinking skills (Applying/ Analyzing/ Evaluating/ Creating). However, this column may contain alternate assessment methods that help formative assessment (i.e. assessment for learning).

This matrix lists only the open elective courses (OEC)

Open elective courses (OEC) are offered for students who have not opted Chemistry as a major course. One OEC has to be opted per semester in the first four semesters. Two types of OEC's are offered- progressive OEC and non-progressive OEC (NPR). Progressive OECs [OEC(PR)] are meant for those students who opt to study chemistry as their OEC in all the four semesters. The courses offered for progressive OECs are practical oriented and the courses are fixed for each semester. The students are expected to take the course in the order OEC (PR)-I to OEC (PR)-IV respectively in semester I to IV. Non-progressive OECs are designed for those students who wish to opt chemistry as OEC in any one of the semester/s. The student may opt any one of the OEC (NPR)-5 to OEC (NPR)-10 in any one of the first to four semesters. These courses are non-practical oriented. OECs credit pattern/s

is given in the course at a glance table.

OEC(PR) pattern:

L	T	P	Cr
2	-	2	3

OEC(NPR) pattern:

L	T	P	Cr
3	-	-	3

Semester	Title/Name of the course	Program outcomes that the course addresses (not more than 3 per course)	Pre-requisite	Pedagogy	Assessments
I	**CHEOEC01: General Chemistry-I**	• Importance and scope of Chemistry • Elements in periodic table; physical and chemical characteristics, periodicity. • Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHEOEC01P: General Chemistry Practicals-I	• how to handle the glassware, prepare and dilute solutions and perform the experiments with prepared reagents • The students will be able to determine the analyte through volumetric and gravimetric analysis and understand the chemistry involved in each method of analysis. • The students will be able to determine the melting and boiling points of the organic compounds/liquids and detect the elements present.	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
II	**CHEOEC02: General Chemistry-II**	• Prediction of structure/geometry of different molecules • Calculation of lattice energies • Concept of second and third law of thermodynamics and prediction of spontaneity of a process	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHEOEC02P: General Chemistry Practicals-II	•Techniques like precipitation, filtration, drying and ignition. •Various titrimetric techniques and gravimetric methods •Determination of enthalpy	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
*I and II Sem	**CHEOEC03: Chemistry of Water**	• Physical and chemical properties of water • Understand the water quality parameters • Water pollution and its treatment methods.	PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

	CHEOEC04: Chemistry of Elements	• The arrangement of elements in the periodic table • Physical and chemical properties of elements • periodicity	PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHEOEC05: Industrial Chemistry	• Structure and uses of dyes • Classification of drugs and its importance • Use and harmful effects of cosmetics.	PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
*III Sem	**CHEOEC06: Chemistry of Food Nutrition and Preservation**	• Understand the human physiological system and food science • Nutrition and its importance • Food preservation and its utility.	PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHEOEC07: Chemistry in Daily Life	• Classification of carbohydrates • Correlate enzyme with drug action • Biological importance of lipids.	PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHEOEC08: Environmental Chemistry	• Understanding environment, • Awareness about air, water, thermal, noise and radioactive, pollution • Remedies for various types of pollution	PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

***Note: For NPR OEs, Any two out of three papers can be offered in I and II semester and any one out of three papers in III semester.**

This matrix lists only the skill enhancement courses (SEC)

Skill enhancement courses (SEC) may be opted by any students who have or have not elected Chemistry as a major course. One SEC has to be opted per semester in the first to sixth semesters. Some of the courses offered are practical oriented. These courses are meant to enhance the basic skills of students in performing chemistry experiments. SECs have the following credit pattern (total 2 credits).

SEC pattern (Practical oriented)

L	T	P	Cr
1	-	2	2

SEC pattern (Non Practical Oriented)

L	T	P	Cr
2	-	-	2

Semester	Title/Name of the course	Program outcomes that the course addresses (not more than 3 per course)	Pre-requisite	Pedagogy	Assessments
I-VI	**CHESEC01: General Biochemistry**	• Structure and properties of proteins • Biological significance of DNA and RNA. • Composition and functions of blood.	Science (biology as one of the subject) discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHESEC01P: Lab-General Biochemistry Practicals-I	• Understand the qualitative analysis of biomolecules • Estimation of biomolecules • Isolation and separation of biomolecules	Science (biology as one of the subject) discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHESEC02: Separation and Chromatographic Techniques	• Separate different compounds using solvent extraction methods. • Principles and types of chromatography • Learn different applications of	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

		chromatography			
	CHESEC02P: Lab- Separation and Chromatographic Techniques	• Separation of solid-solid mixture, binary mixture, non-volatile liquids and solids.	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHESEC03: Titrimetric methods	• Enhance the knowledge and skills in different titrimetric methods.	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHESEC03P: Lab- Titrimetric methods	• Learn the handling of glassware and equipments • Volumetric, conductometric and potentiometry titrations.	Science discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHESEC04: Biofertilizers	• Identify the different forms of biofertilizers and their uses • Green manuring and organic fertilizers	Student should have studied science (biology as one of the subject) discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams
	CHESEC05: Fermentation science and Technology	• Employ the process for maintenance and preservation of microorganisms • Various aspects of fermentation technologies.	Science (biology as one of the subject) discipline in PUC/10+2	Assignment Desk work	Internal Exams, Continuous Evaluation, Sem Exams

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Course Structure at a Glance

(L: Lecture [1h = 1 credit (Cr)]; T: Tutorial; P: Practicals (2h = 1 credit)

Core Courses (DSC)

Code	Name of the coursey	Type of course	Semester	L	T	P	Credits
CHEDSC01	CHEMISTRY-I	Core	I	4	-	4	**6**
CHEDSC02	CHEMISTRY-II	Core	II	4	-	4	**6**
CHEDSC03	CHEMISTRY-III	Core	III	4	-	4	**6**
CHEDSC04	CHEMISTRY-IV	Core	IV	4	-	4	**6**

Open Elective Courses (OEC)

Code	Name of the course	Type of course	Semester	L	T	P	Credits
Progressive							
CHEOEC01	General Chemistry-I	Open elective	I	2	-	2	3
CHEOEC02	General Chemistry-II	Open elective	II	2	-	2	3
Non-Progressive							
CHEOEC03	Chemistry of Water	Open elective	I-II	3	-	-	3
CHEOEC04	Chemistry of Elements	Open elective	I-II	3	-	-	3
CHEOEC05	Industrial Chemistry	Open elective	I-II	3	-	-	3
CHEOEC06	Chemistry of Food, Nutrition and Preservation	Open elective	III	3	-	-	3
CHEOEC07	Chemistry in Daily life	Open elective	III	3	-	-	3
CHEOEC08	Environmental Chemistry	Open elective	III	3	-	-	3

Skill Enhancement Courses (SEC)

Code	Name of the course	Type of course	Semester	L	T	P	Credits
CHESEC01	General Biochemistry	Skill Enhancement	I - VI	1	-	2	2
CHESEC02	Separation and Chromatographic Techniques	Skill Enhancement	I - VI	1	-	2	2
CHESEC03	Titrimetric Methods	Skill Enhancement	I - VI	1	-	2	2
CHESEC04	Biofertilizers	Skill Enhancement	I - VI	2	-	-	2
CHESEC05	Fermentation Science and Technology	Skill Enhancement	I - VI	2	-	-	2

DISCIPLINE CORE COURSES (DSC)

There are two courses in first year. These courses have the following credit pattern (total 6 credits).

L	T	P	Cr
4	-	4	6

CHEDSC01: CHEMISTRY PAPER-I 60h

(Revised for NEP-2022-23 onwards)

Unit-I

Atomic Structure - 1 **15h**

Bohr's theory of hydrogen atom: Its assumptions and limitations, expressions for radius and energy of hydrogen atom and hydrogen atom like ions (no derivations), explanation of atomic spectrum of hydrogen atom (occurrence of different series in spectrum), numerical problems on calculation of wave numbers of spectral lines.

Wave Mechanics

Need for a new approach to atomic structure, de Broglie hypothesis (statement and equation), Heisenberg's uncertainty principle (statement and equation) and its significance, numerical problems on de' Broglie equation and Heisenberg's uncertainty principle. Concept of orbits and orbitals. Time independent Schrödinger's wave equation (cartesian coordinate only, no derivation)–one dimensional and three dimensional equations, significance of Schrödinger's wave equation.

Wave Functions: characteristics of well-behaved wave functions (few simple examples should be discussed), significance of ψ and ψ^2 (or $\psi\psi^*$) (probabilistic approach), normalized and orthogonal wave functions, normalization condition. Quantum numbers and their significances. Time independent Schrodinger wave equation for hydrogen atom and its solution (R, θ and φ equations in Cartesian and polar coordinates; only expressions, no derivations). Radial and angular wave functions for hydrogen atom, spherical harmonics. Radial and angular distribution curves: Shapes of *s, p, d* and *f* orbitals, radial distribution functions (probability diagrams) for 1s, 2s, 2p, 3s, 3p and 3d orbitals (only graphical representation), radial and angular nodes, nodal planes.

Rules for filling up of electrons in various orbitals: Hund's rule of maximum multiplicity, Pauli's exclusion principle, Aufbau principle, variation of orbital energy with atomic number, stability of half filled and completely filled orbitals, concept of exchange energy, anomalous electronic configurations (Cr and Cu). Electronic configuration of elements (up to Z =30).

Unit-II **15h**

Basics of Organic Chemistry

Classification and nomenclature of organic compounds including bifunctional groups. Hybridization, types (*sp*, sp^2, sp^3), shapes of organic molecules, influence of hybridization on bond properties (w.r.t. acidic character, bond length and bond strength).

Nature of bonding in organic molecules

Types of chemical bonding, formation of covalent bond, localized and delocalized, conjugation and cross conjugation, electronic displacements: inductive effect, electromeric effect, resonance and hyper conjugation, explanation with examples.

Strengths of organic acid and bases: Relative study with emphasis on factors affecting pK_a and pK_b values.

Relative strengths of aliphatic and aromatic carboxylic acids-acetic acid and chloroacetic acid, acetic acid and propionic acid, acetic acid and benzoic acid. Relative strengths of amines: CH_3NH_2, $(CH_3)_2NH$, $(CH_3)_3N$; NH_3, $C_6H_5NH_2$. Steric effect- relative stability of trans and cis-2-butene.

Fundamentals of organic reaction mechanisms

Notations used to represent electron movements and directions of reactions–curly arrows, formal charges. Types of bonds breaking- homolytic and heterolytic. Types of reagents-electrophiles, nucleophiles. Types of organic reactions–substitution, addition, elimination, rearrangement and pericyclic reactions, explanation with examples.

Chemistry of Aliphatic Hydrocarbons

A. Carbon-Carbon σ bonds

Chemistry of alkanes: Introduction, natural sources, preparation – by catalytic hydrogenation of alkenes and alkynes, Wurtz reaction, Kolbe's electrolysis, Grignard reagents, Wurtz-Fittig reaction for alkyl arenes. Free radical substitutions–chlorination of methane and propane their mechanisms, stability of free radicals and ease of substitution in propane.

B. Carbon-carbon π bonds

Formation of alkenes and alkynes by elimination reaction. Mechanism of E1, E2, E1cb reaction. Saytzeff and Hofmann eliminations. Addition of HBr to alkene- mechanism of addition of HBr to propene (Markonikoff's and anti-Markonikoff's rules with examples), addition of halogens to alkenes-carbocation and halonium ion mechanism. Stereospecificity

of halogen addition. ozonolysis, mechanism of ozonolysis of propene, Significance. Regioselectivity and relative rates of addition. Hydrogenation, hydration, hydroxylation and epoxidation of alkenes, explanation with examples, 1,2 and 1,4- addition reactions in conjugated dienes. Diels-Alder reaction, allylic and benzylic bromination and mechanism in propene, 1-butene, 1-toluene and ethylbenzene.

Unit-III **15h**

Gaseous state

Elementary aspects of kinetic theory of gases, Ideal and real gases. Boyle's temperature (derivation not required), molecular velocity, collision frequency, collision diameter, collision cross section, collision number and mean free path.

Maxwell's Boltzmann distribution law of molecular velocities (Most probable, average and root mean square velocities). Relation between RMS, average and most probable velocity. Average kinetic energy. (Mathematical derivation not required; numerical problems), law of equipartition of energy.

Behaviour of real gases

Deviation 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 (no derivation) and application in explaining real gas behaviour. Critical phenomena– Andrews isotherms of CO_2, critical constants and their calculation from van der Waals equation, continuity of states, law of corresponding states. Numerical problems.

Liquid state

Surface Tension

Definition and its determination using stalagmometer, effect of temperature and solute on surface tension.

Viscosity

Definition, coefficient of viscosity, calculation of σ and η, variation of viscosity with temperature and pressure. Determination of viscosity of a liquid using Ostwald viscometer. Effect of size, weight, shape of molecules and intermolecular forces on viscosity, numerical problems.

Refraction

Specific and molar refraction- definition and advantages. Determination of refractive index by Abbes refractometer. Additive and constitutive properties.

Parachor

Definition: Atomic and structure parachor, elucidation of structure of benzene and benzoquinone, Numerical Problems.

Unit-IV **15h**

Language of analytical chemistry

Definitions of analysis, measurement, techniques and methods. Classification of analytical techniques. Choice of an analytical method–accuracy, precision, sensitivity, selectivity, method validation. Figures of merit of analytical methods and limit of detection (LOD), Limit of quantification (LOQ), linear dynamic range (working range).

Errors and treatment of analytical data: limitations of analytical methods–Errors: determinate and indeterminate errors, absolute error, relative error, minimization of errors. Statistical treatment of finite samples–mean, median, range, standard deviation and variance. External standard calibration– regression equation (least squares method), correlation coefficient (P). Numerical problems (error, mean, median, standard deviation).

Basic laboratory practices, calibration of glassware (pipette, burette and volumetric flask), sampling (solids and liquids), weighing, drying, dissolving, acid treatment, rules of work in analytical laboratory, general rule for performing quantitative determinations (volumetric and gravimetric), safety in chemical laboratory, rules of fire prevention and accidents, first aid. Precautions to be taken while handling toxic chemicals, concentrated/fuming acids and organic solvents.

Recommended Books/References:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J.D.Barnes and M.J.K. Thomas, Third Indian Reprint, Pearson Education Pvt. Ltd. 6th edition (2007).
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, Saunders College Publishing, New York, 8th edition (2005).
3. Analytical Chemistry, G.D. Christian, Wiley, 6th edition (2007).
4. Practical Volumetric Analysis, Peter A C McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
5. Organic Chemistry, R. T. Morrison, R. N. Boyd, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education) 7th edition (2010).
6. Organic Chemistry (Volume I), I. L. Finar, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education) (2002).
7. Fundamentals of Organic Chemistry, J. E. McMurry, Cengage Learning India Edition, 7th edition (2013).
8. Organic Reaction mechanism, V. K. AhIuwalia, K. Parashar ,Narosa Publishers, 4th edition (2018).

9. Organic Chemistry, S. M. Mukherji, S. P. Singh, R. K. Kapoor, New Age International Publishers Pvt. Ltd (2018).
10. A Guide book to Mechanism in Organic Chemistry, Peter Sykes. Pearson, 6th edition (2003).
11. Principles of Inorganic Chemistry, B. R. Puri, L.R Sharma, K.C. Kalia, Vishal Publishing Co, 33rd edition (2020).
12. Instrumental Methods of Chemical Analysis, Gurdeep R Chatwal, Sham K Anand, Himalaya Publishing House (2016).
13. College Chemistry-Vol-1, L. Indira and G.R. Chatwal, Himalaya Publishing House, New Delhi, 1st edition (2013).

CHEDSC01P: CHEMISTRY PRACTICALS-I
(Revised for NEP-2022-23 onwards)

4h/week

PART-A

1. Calibration of glassware, pipette, burette and volumetric flask.
2. Determination of sodium carbonate and sodium bicarbonate in a mixture.
3. Determination of alkali present in soaps/detergents.
4. Determination of iron(II) using potassium dichromate.
5. Determination of oxalic acid using potassium permanganate solution.
6. Determination of hardness of water using EDTA.
7. Determination of Fe^{2+} as Fe_2O_3.
8. Determination of Ni^{2+} as $Ni(DMG)_2$ complex.

PART-B

1. Purification of organic compounds by recrystallization.
2. Preparation of acetanilide from aniline using Zn/acetic acid (Green method).
3. Synthesis of p-nitro acetanilide from acetanilide using nitrating mixture.
4. Preparation of p-bromoacetanilide from acetanilide.
5. Hydrolysis of methyl m-nitrobenzoate to m-nitrobenzoic acid.
6. Synthesis of diazoaminobenzene from aniline.
7. Preparation, recrystallization of meta-dinitrobenzene from nitrobenzene
8. Preparation, recrystallization of tri-bromophenol from phenol.

Recommended Books/References:

1. Vogel's Quantitative Chemical Analysis, J. A. Mendham, Pearson 6th edition (2009).

2. Vogel's Qualitative Inorganic Analysis, G. Svehala, Sivasankar, Pearson (2012).

3. Chemistry for Degree Students B.Sc First Year, R. L. Madan, S Chand Publishing Company, New Delhi (2010).

4. Practical Organic Chemistry, F. G. Mann, B.C. Saunders, Pearson Education Limited, 4th edition (2011).

CHEDSC02: CHEMISTRY -II (THEORY) 60h

(Revised for NEP-2022-23 onwards)

Unit-I **15h**

Periodic table and periodicity

Review of the modern periodic table (with respect to classification of elements based on outer electronic configuration)

Periodicity in *s* and *p*-block elements, trends in the periodic properties. Applications in predicting and explaining chemical behaviour with respect to a) electronic configuration b) effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, c) the atomic radii–the concept of various radii–ionic radii, covalent radii (octahedral and tetrahedral), van der Waal radii with examples; variation of the atomic radii across the period and down the groups, d) ionization enthalpy, successive ionization enthalpies and factors affecting ionization enthalpy, e) the electron affinity of atoms–definition, illustration, variation of the values along the periodic table and explanation of the trends, f) electronegativity (E.N)–the concept of electronegativity and its difference from electron affinity; E.N scale, the postulation of arithmetic and geometric mean in the determination of E. N. values, ionic characters of bonds and the E.N. difference, other E.N. scales–the Mulliken, Allred–Rochow scales (problems). Variation of electronegativity with bond order, partial charge and hybridization. Group electronegativity. Sanderson's electron density ratio. Diagonal relationship between beryllium and aluminium. Comparative study of elements of alkali and alkaline earth metals.

Trends in the chemistry of the compounds of groups 13 to 17 (hydrides, carbides, oxides and halides) are to be discussed (qualitative only).

Unit-II **15h**

Organic Chemistry

Nucleophilic substitution at saturated carbon. Mechanisms of S_N^1, S_N^2 and S_Ni reactions with suitable examples. Energy profile diagrams, Stereochemistry and factors effecting S_N^1 and S_N^2 reactions.

Aromaticity

Introduction and characteristics of aromatic hydrocarbons. Concept of resonance, romaticity, Huckel rule, anti-aromaticity explanation with examples. aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples (benzene, benzenoids, cyclopropyl carbocation, tropylium cation, cyclopentadienyl anion, furan, pyrrole and pyridine).

Preparations of i) benzene (a) from acetylene (b) by decarboxylation of benzoic acid, ii) naphthalene from (a) 3–phenyl-1-butene (b) α-tetralone, iii) anthracene from 1,4-naphthaquinone.

Aromatic electrophilic substitution reactions, mechanism of halogenation, nitration, sulphonation, Friedel-Crafts alkylation and acylation, chloromethylation, Gatterman-Koch reaction with their mechanism.

Activating and deactivating groups. Orientation influence, ortho-para ratio.

Side chain oxidation of toluene and cumene. Nitration and sulphonation of naphthalene with an account on stability of products.

Aromatic nucleophilic substitution reaction: S_NAr and benzyne mechanism with suitable examples.

Polycyclic arenes as carcinogens–definition of carcinogen, name and structure of benzo[a]anthracene and benzo[a]pyrene

Unit-III **15h**

Liquid crystals

Introduction, classification with examples–smetic, nematic, cholesteric, disc shaped and polymeric. Structures and molecular arrangements in nematic and cholesteric liquid crystals and their applications.

Solids

Forms of solids

Crystalline and non-crystalline solids [comparison with examples (glasses briefly explain)], unit cell and space lattice, anisotropy of crystals, size and shape of crystals.

Laws of crystallography: law of constancy of interfacial angles, law of rational indices, law of symmetry (symmetry elements), types of crystal systems, Bravais lattice types and identification of lattice planes.

Miller indices and its calculation, X–ray diffraction by crystals: Bragg's law and derivation of Bragg's equation, single crystal and powder diffraction methods (Structures of NaCl, KCl by rotation method). Defects in crystals: stoichiometric (Frenkel and Schotky) and non-stoichiometric defects (color centres qualitative treatment only). Numerical problems (no. of atoms in a unit cell, Bragg's law).

Distribution Law

Distribution Law: statement and its derivation, distribution constant, factors affecting distribution constant, validity of distribution law, modification of distribution law when

molecules undergo a) association b) dissociation. Application of distribution law in solvent extraction. Derivation for simple and multiple extraction. Principle of distribution law in Parkes process of desilverisation of lead. Numerical problems.

Unit-IV **15h**

Titrimetric Analysis

Basic principle of titrimetric analysis. Classification, preparation and dilution of reagents/solutions. normality, molarity and mole fraction, percentage (for solids and liquids). Use of $N_1V_1 = N_2V_2$ formula, preparation of ppm level solutions from source materials (salts), conversion factors (volume and weight). Numerical problems (normality, molarity, mole fraction, ppm and percentage).

Acid-base titrimetry

Indicators and its type, titrations of strong acid vs strong base, weak acid vs strong base and weak base vs strong acid. Quantitative applications–selecting and standardizing a titrant, inorganic analysis– alkalinity, acidity.

Complexometric titrimetry

Indicators for EDTA titrations-theory of metal ion indicators, titration methods employing EDTA–direct, back, displacement and indirect determinations, application–determination of hardness of water.

Redox titrimetry

Balancing redox equations (ion-electron, oxidation number method), calculation of the equilibrium constant of redox reactions, titration curves (potentiometry), theory of redox indicators, calculation of standard potentials using Nernst equation. Applications.

Precipitation titrimetry

Titration curves, titrants and standards, indicators for precipitation titrations involving silver nitrate- Volhard's and Mohr's methods and their differences.

Gravimetric Analysis

Requisites of precipitation, mechanism of precipitation, factors influencing precipitation, co-precipitation, post-precipitation. Advantages of organic reagents over inorganic reagents, reagents used in gravimetry [Mg^{2+} using 8-hydroxy quinoline (oxine) and Ni^{2+} using dimethyl glyoxime (DMG)].

Numerical problems (acid-base, redox, complexometric titrations and gravimetry).

Recommended Books/References:

1. Concise Inorganic Chemistry: J. D. Lee, Wiley, 4th edition (2021).
2. Fundamentals Concepts of Inorganic Chemistry, Vols. 1 and 2, Asim K. Das, CBS Publishers and Distributors, 2nd edition (2013).
3. Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson, P. L. Gaus, Wiley. India, 3rd edition (1995).
4. Inorganic Chemistry, Catherine E. Housecroft, A.G. Sharpe, Pearson Prentice Hall, 2nd edition (2005).
5. Atkin's Physical Chemistry, Peter Atkins, Julio De Paula, Oxford University Press, 8th edition (2006).
6. Elements of Physical Chemistry, Samuel Glasstone, David Lewis, Palgrave Macmillan, 2nd edition (1963).
7. A Text book of Physical Chemistry, A. S. Negi, S. C. Anand, New Age International Publishers (2007).
8. Principles of Physical Chemistry, Puri, Sharma, Pathania, Vishal Publishing Co., 47th edition (2020).
9. A Text Book of Physical Chemistry P. L. Soni, O. P. Dharmarha and, U. N. Dash, Sultan Chand and Sons (2016).
10. Advanced Physical Chemistry, Gurdeep Raj, Krishna Prakashan Media Publishers (2020).

CHEDSC02P: CHEMISTRY PRACTICALS-II

(Revised for NEP-2022-23 onwards)

4h/week

PART-A

Titrimetry

1. Determination of carbonate and hydroxide present in a mixture.
2. Determination of oxalic acid and sodium oxalate in a given mixture using standard $KMnO_4$/NaOH solution.
3. Standardization of potassium permanganate solution and determination of nitrite in a water sample.
4. Standardization of silver nitrate and determination of chloride in a water sample (demonstration).
5. Determination of alkali content in antacids.
6. Determination of chlorine in bleaching powder using iodometric method.
7. Determination of zinc using EDTA.
8. Determination of magnesium using EDTA.

Gravimetry

8. Quantitative estimation of Ba^{2+} as $BaSO_4$.
9. Quantitative estimation of Cu^{2+} as CuSCN.

PART-B

1. Determination of density using specific gravity bottle and viscosity of liquids using Ostwald's viscometer (ethyl acetate, toluene, chlorobenzene or any other non-hazardous liquids).
2. Study of the variation of viscosity of sucrose solution with the concentration of a solute.
3. Determination of the density using specific gravity bottle and surface tension of liquids using Stalagmometer (ethyl acetate, toluene, chlorobenzene, any other non-hazardous liquids).
4. Study of variation of surface tension of detergent solution with concentration.
5. Determination of specific and molar refraction by Abbes Refractometer (ethyl acetate, methyl acetate, ethylene chloride).
6. Determination of the composition of liquid mixture by refractometry/viscometry method (toluene and alcohol, water and sucrose).
7. Determination of partition/distribution coefficient of i) acetic acid in between water and cyclohexane, ii) acetic acid in between water and butanol,
8. Determination of partition/distribution coefficient of i) benzoic acid in between water and toluene, ii) I_2 in between water and CCl_4.

Recommended Books/References:

1. Vogel's text book of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatehell, , Prentice Hall, 5th edition (1989).
2. Elementary Practical Organic Chemistry-Part-III: Quantitative Organic Analysis, Arthur I, Vogel, Pearson India (2011).
3. Laboratory manual of Organic Chemistry, B. B. Dey and M. V. Sitaraman, Laboratory manual of Organic Chemistry, B. B. Dey, M. V. Sitaraman, T. R. Govindachari, Allied Publishers, New Delhi (1996).
4. Practical Organic Chemistry, F. G. Mann, B.C. Saunders, Pearson Education Limited, 4th edition (2011).
5. Practical Volumetric Analysis, A. C. Peter, McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
6. L. Rakesh Sharma, Practical Inorganic Chemistry (for undergraduate students), Evincepub publishing, 1st edition (2021).

CHEDSC03: CHEMISTRY PAPER-III (THEORY) 60h

Unit – I **15h**

Structure and Bonding -I

Ionic Bond:

Recapitulation- energy considerations in ionic bonding, factors favoring the formation of ionic bond, general characteristics of ionic compounds.

Lattice energy – definition, factors affecting lattice energy, Born-Lande equation and explanation of the terms involved (derivation not required), Born-Haber cycle and its application for the calculation of lattice energy of NaCl and MgO, Kapustinskii equation, numerical problems. Solvation energy and solubility of ionic solids.Polarizing power and polarizability, Fajan's rules with applications. Definitions of bond moment and dipole moment by taking H_2, HCl, H_2O and CO_2 as examples.

Ionic radii, factors affecting the ionic radii, sizes of interstitial sites in ionic crystals. Radius ratio rules, limiting radius ratios, calculation of limiting radius ratio for coordination number-3 (planar triangle), coordination number-4 (tetrahedral and square planar), coordination number-6 (octahedral) and close packing.

Classification of ionic structures- shapes of ionic crystals of the type AX (ZnS, NaCl, CsCl), crystals of the type AX_2[(calcium fluoride (fluorite), rutile structure and cadmium iodide], limitations of radius ratio rule.

Covalent Bond:

Definitions of covalent bond and coordinate bond (dative bond). Lewis theory, octet rule, exceptions to the octet rule.

Valence Bond Theory (VBT)-assumptions, σ and π bonds (using H_2, HF, O_2 and N_2 molecules as examples), limitations of VBT. Sidgwick- Powell theory, Valence Shell Electron Pair Repulsion (VSEPR) theory, effect of lone pairs, electronegativity, isoelectronic principle. Shapes of the following based on VSEPR theory - BF_3 and BF_4^-, NH_3 and NH_4^+, H_2O, PCl_5, ClF_3, SF_4, I_3^- and I_3^+, SF_6 and IF_7. Limitations ofVSEPR.

Unit-II **15h**

Reaction Intermediates: **8h**

Generation, stabilityandstructure of carbocations, carbanions, free radicals, carbenes, nitrenes and arynes**.**

Reactions and mechanism of the following intermediatesto be discussed **:**

i. Carbocations: Dienone-phenol; and Pinacol-Pinacolone rearrangement reaction.

ii. Carbanions:Perkin reaction, Aldol condensation, Claisen-Schmidt condensation.

iii. Free Radicals: Sandmeyer Reaction.

iv. Carbenes and Nitrenes: Singlet and triplet states, their relative stability and Reimer –Tiemann reactions, cycloaddition, insertion and rearrangement reactions.

v. Arynes: Reactions of benzynes with water, ammonia and primary amines.

Methods for Identifying Reaction Mechanism: ` **7h**

Product analysis, isolation and identification of intermediates, stereo chemical evidences, effect of catalyst, crossover experiments, isotopic studies, kinetic studies (one example has to be discussed for each method)

UNIT III **15h**

First Law of Thermodynamics **10h**

Introduction –basic terminology, thermodynamic processes (isothermal, adiabatic, isobaric, isochoric, cyclic, reversible and irreversible processes), thermodynamic properties – intensive and extensive, state of a system, state variables, state functions, concept of heat and work – definition and sign convention, derivation of expression for work done in an isothermal and adiabatic expansion of an ideal gas, numerical problems. Internal energy (E) and change in internal energy (ΔE). First Law of thermodynamics, enthalpy of a system (H) and change in enthalpy (ΔH), relationship between ΔE and ΔH with examples. Joule-Thomson expansion, relation between Joule-Thomson co-efficient and other thermodynamic parameters.

Second Law of Thermodynamics: Need for second law of thermodynamics, concept of entropy and its significance, Thermodynamic scale of temperature, various statements of the Second Law of Thermodynamics, spontaneous and non-spontaneous processes, molecular and statistical interpretation of entropy, Calculation of entropy change for reversible and irreversible processes.

Free Energy Functions: Gibbs and Helmholtz energy, work function (A), Variation of S, G, A with T, V and P, numerical problems. Free energy change and spontaneity,

Gibbs-Helmholtz equation (derivation-differential form). Rate of change of free energy with respect to temperature and pressure, Derivation of van't Hoff isotherm and $\Delta G^\circ = - RT \ln (Kp)$, numerical problems.

Third Law of Thermodynamics: Statement of third law, Nernst heat theorem, concept of residual entropy, calculation of absolute entropy of molecules.

Surface Chemistry **5h**

Adsorption: Introduction, basic terminology, definitions, types of adsorption, adsorption isotherms. Freundlich adsorption isotherm (only equation) and its limitations. Langmuir adsorption isotherm (derivation to be done) and BET equation (derivation not included), applications of adsorption.

Catalysis: Introduction**,** types of catalysis and theories with examples (intermediate compound theory and adsorption theory),theory of acid base catalysis. Heterogeneous catalysis: surface reactions, unimolecular, bimolecular surface reactions, autocatalysis with examples.

Unit-IV **15h**

Analytical Chemistry

Quantitative Analysis-Instrumental Methods

Electromagnetic spectrum, absorption of electromagnetic radiation, definition and units of frequency, wavelength, wave number, derivation of Beer-Lambert law, limitations of Beer-Lambert law, numerical problems. Construction of calibration graph with example (Plot of absorbance versus concentration). Evaluation Procedures- standard addition, Internal standard addition, validation parameters-detection limits, dynamic/linearity range. Instrumentation of single beam and double beam spectrophotometers (UV-Vis), quantitative applications of colorimetry (determination of Fe^{2+}, Cu^{2+}, and PO_4^{3-}ions).

Nephelometry and Turbidimetry: Introduction, principle, instrumentations of nephelometry and turbidimetry; effects of concentration, particle size and wavelength on scattering; choice between nephelometry and turbidimetry, applications of nephelometry and turbidimetry (determination of SO_4^{2-} and PO_4^{3-})

References :

1. Inorganic Chemistry (4thedition): J.E Huheey, E.A Keiter and R.L. Keiter (1993); Harper Collins.
2. Introduction to modern inorganic chemistry (4thedition): K.M. Mackay and R.A Mackay (1989): Blackie.
3. Advanced inorganic Chemistry (5thedition): F.A Cotton and G.Wilkinson (1990): Wiley.Concise
4. Inorganic Chemistry (5thedition): J.D. Lee (2000); Blackwell Science.
5. Concepts and Models in Inorganic Chemistry (3rdedition) B.E.Dougglas, D.H. Mc Daniel and Alexander. (2001): Wiley.
6. Chemistry of the Elements: Greenwood and Earnshaw. (1986): Pergamon Press.
7. Inorganic Chemistry (3rdedition): Shriver, Atkins and Langford (1999); Oxford University
8. Press.Organic Reaction Mechanism by V.K.Ahluwalia and R.K.Parashar (Narosa Publishers).
9. Organic Chemistry by S.M.Mukherji,S.P.Sinh and R.K.Kapoor (Narosa Publishers).
10. Morrison R.N and Boyd R.N, Organic Chemistry,Darling Kindersley(India) Pvt.Ltd.(Pearson Education).
11. Finar I.L,Organic Chemistry(Volume I);
12. Peter Atkins & Julio De Paula, Physical Chemistry, 9th Ed., Oxford University Press (2010).
13. G W Castellan, Physical Chemistry, 4th Ed., Narosa (2004).
14. R G Mortimer, Physical Chemistry 3rd Ed., Elsevier: Noida, UP (2009)
15. B R Puri, L R Sharma and M S Pathania, Principal of Physical Chemistry, Vishal Publishing Co.
16. B S Bahl, G D Tuli and Arun Bahl, Essentials of Physical chemistry, S Chand & Company Ltd.
17. A S Negi and S C Anand, A textbook of Physical Chemistry, New Age International Publishers.
18. B N Bajpai, Advanced Physical chemistry, S Chand and Company ltd.
19. R L Madan, Chemistry for Degree Students, Semester I, II, III and IV, S Chand and Company Ltd.
20. P L Soni, O P Dharmarha and U N Dash, Textbook of Physical Chemistry, Sultan Chand and Sons.
21. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
22. Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
23. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd.NewDelhi(2009).
24. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007).

CHEDSC03P: CHEMISTRY PRACTICALS-III

4h/week

PART-A

1) Colorimetric determination of copper using ammonia solution.

2) Colorimetric determination of iron using thiocyanate solution.

3) Colorimetric determination of nickel using DMG solution.

4) Colorimetric determination of titanium using hydrogen peroxide.

5) Colorimetric determination of nitrite in a water sample (diazo coupling Reaction/Griess reagent)

6) Colorimetric determination of phosphate as ammonium phosphomolybdate

7) Determination of the enthalpy of neutralization of a strong acid with strong base.

8) Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

(PART-B)

Qualitative analysis of mono / bifunctional Organic compounds such as 1) Salycilic acid , p-Nitro benzoic acid, Antranilic acid, p-Chloro benzoic acid 2) o-Cresol, p-Cresol, Resorcinol,o-Nitrophenol,p-nitophenol 3)o-Nitro aniline,p-Nitroaniline,p-Toluidine,p-Chloroaniline,p-Bromoaniline, 4) Ethyl Salicylate, Salicylaldehyde, Actophenone, p-Dichlorobenzene, p-Nitro toluene, Benzamide etc.(At least 6-8 compounds to be analysed in a semester)

References

1)Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007)

2) Vogels Text Book of Qualitative Chemical Analysis, ELBS.

CHEDSC04: CHEMISTRY-IV (THEORY) 60h

Unit - I **15h**

Structure and Bonding -II **3h**

Concept of resonance and resonating structures in various inorganic compounds: CO, CO_2, CO_3^{2-}, SO_2, SO_4^{2-}, NO_3^-, resonance energy. Hybridization, types of hybridization-*sp*, sp^2, sp^3, sp^3d, sp^3d^2,sp^3d^3 (Eg. $BeCl_2$, BF_3, SiF_4, PCl_5, SF_6, IF_7) and energetics of hybridization-Bent's rule.

Molecular Orbital theory: **7h**

Drawbacks of VBT**,** salient features of Molecular Orbital Theory, rules for linear combination of atomic orbitals, LCAO concept: *s-s, s-p, p-p, p-d and d-d* combinations of orbitals, non-bonding combinations of orbitals. Bonding, non-bonding and anti-bonding molecular orbitals. Molecular Orbital energy level diagrams of homonuclear diatomic molecules/ions - H_2, H_2^+, He_2, He_2^+, Li_2, Be_2, B_2, C_2, N_2, N_2^+,O_2, O_2^+, O_2^{2+},$O_2^-$and O_2^{2-} (molecular orbital configuration, bond order and magnetic properties in each case to be discussed).M.O. energy level diagrams of heteronuclear diatomic molecules (NO, NO^+, CO and HCl). Relationship between bond order, bond energy and bond length based on MOT. Comparison of VB and MO approaches.

Metallic Bonding: **5h**

General properties of metals: Conductivity, lustre, malleability, ductility and cohesive forces. Crystal structures of metals and bond lengths. Theories of bonding in metals: Free Electron Theory, Valence Bond Theory, Molecular Orbital (band theory) of solids. Predictionof conducting properties of conductors, insulators and semiconductors. Extrinsic and intrinsic semiconductors using M.O. theory, superconductors-definition and examples.

Unit-II **15h**

UNIT II -Stereochemistry of Organic Compounds:

Configuration and conformation – definition with examples. Newmann, sawhorse and Fischer projection formulae for ethane and the inter-conversions using lactic acid, glyceraldehyde and 2,3-dichlorobutane.

Geometrical Isomerism: Introduction, definition, conditions for geometric isomerism, differences between cis and trans isomers by taking butenedioic acid and 1,2-dichloroethene as examples, inter-conversion of cis-trans isomers. Methods of distinguishing geometric isomers using melting point, solubility, cyclisation and heat of hydrogenation. Syn-anti

isomerism in oximes and alicyclic compounds (1,3 and 1,4-dimethyl cyclohexanes), assigning E - Z notations with CIP rules.

Optical Isomerism: Introduction, definition, chirality, specific rotation, elements of symmetry (plane, centre and axis of symmetry with relevant examples), asymmetry, dissymmetry –stereogenic centres (2^n- formula for calculating the number of stereo isomers). Optical isomerism in glyceraldehyde, lactic acid and tartaric acid. Enantiomers, diastereomers, mesocompounds –definition with tartaric acid and 2,3-dichlorobutane as examples. Racimization, Racemic mixture – definition with suitable examples. Resolution – definition, biological and chemical method of resolution. Threo and erythro isomers – definition with examples. Configuration - definition, relative and absolute configurations, D, L - configuration by taking glyceraldehyde and other suitable examples, demerits of D, L configuration.Absolute configuration – R and S notation, CIP sequence rules with suitable examples (glyceraldehyde, tartaric acid, amino acids, etc.). Optical activities in compounds without asymmetric carbon atoms (biphenyls and allenes). Enantiomeric excess, asymmetric synthesis, stereo specific and stereo selective reactions.

UNIT III **15h**

Chemical Kinetics **7h**

Introduction, basic terminology–rate and rate constant, factors affecting the rate of a reaction,units for rate and rate constant (zero, first and second order reactions). Order and molecularity. Differential and integrated form of rate expressions zero, First and second order reactions. Derivation of expression of rate constant of second order reaction (a=b and $a \neq b$), half-life of a reaction (for zero, first and second order), problems on rate constant (a=b). Methods of determination of order of a reaction (Integration, Half-life and Ostwald's isolation method). Temperature dependence of reaction rates; Arrhenius equation, activation energy, numerical problems on Arrhenius equation in calculating energy of activation and rate constants. Collision theory of reaction rates, Lindemann's theory, qualitative treatment of the theory of absolute reaction rates.Experimental determination of kinetics of inversion of cane sugar by polarimetric method.

Electrochemistry – I **8h**

Introduction, basic terminology, Arrhenius theory of electrolytic dissociation,merits and demerits. Conductance, specific conductance, equivalent conductance, molar conductance and their variation with dilution. Molar conductivity at infinite dilution. Numerical problems.

Kohlrausch's law of independent migration of ions and its applications, Debye-Hückel-Onsager equation (derivation not required).

Ionic mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods.

Applications of conductance measurement: (i) Degree of dissociation of weak electrolytes (ii)Ionic product of water (iii) Solubility and solubility product of sparingly soluble salts sodium acetate and ammonium chloride (iv) Conductometric titrations (acid base titrations only) and (v) Hydrolysis constants of salts (salt of strong acid and weak base, weak acid and strong base). Numerical problems.

Unit-IV **15h**

Analytical Chemistry

Separation Methods

Solvent Extraction: Definition, types, principle and efficiency of extraction, sequence of extraction process, factor affecting extraction-pH, oxidation state, modifiers, synergetic, masking and salting out agent, techniques-batch and continuous extraction, application.

Fundamentals of Chromatography: General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phase.

Column Chromatography-Introduction, column efficiency, factors affecting the column efficiency, van Deemter's equation and its modern version.

Thin Layer Chromatography (TLC): Mechanism, R_f value, efficiency of TLC plates, methodology–selection of stationary and mobile phases, development, identification and detection by physical and chemical methods, qualitative applications.

Ion Exchange Chromatography: Resins, types with examples- cation exchange and anion exchange resins, mechanism of cation and anion exchange process and applications(softening of hard water, separation of lanthanides or any other industrial applications).

References:

1. Undergraduate Organic Chemistry, Volume 1, Jagdamba Singh, L.D.S.Yadav. A pragathi edition.
2. Inorganic Chemistry (4thedition): J.E Huheey, E.A Keiter and R.L. Keiter (1993); Harper Collins.

3. Introduction to modern inorganic chemistry (4thedition): K.M. Mackay and R.A Mackay (1989): Blackie.
4. Advanced inorganic Chemistry (5thedition): F.A Cotton and G.Wilkinson (1990): Wiley.Concise
5. Inorganic Chemistry (5thedition): J.D. Lee (2000); Blackwell Science.
6. Concepts and Models if Inorganic Chemistry (3rdedition) B.E.Dougglas, D.H. Mc Daniel and Alexander. (2001): Wiley.
7. Chemistry of the Elements: Greenwood and Earnshaw. (1986): Pergamon Press.
8. Inorganic Chemistry (3rdedition): Shriver, Atkins and Langford (1999); Oxford University
9. Finar I.L Volume II) Stereochemistry and the Chemistry of Natural Products.,Dorling Kindersley(India)Pvt.Ltd.(Pearson Education).
10. Kalsi P.S.Stereochemistry, conformation and Mechanism,New age International.
11. Eliel E.L and wilenS.H,Stereochemistry of Organic Compounds,Wiley,(London).
12. Peter Atkins & Julio De Paula, Physical Chemistry, 9th Ed., Oxford University Press (2010).
13. G W Castellan, Physical Chemistry, 4th Ed., Narosa (2004).
14. R G Mortimer, Physical Chemistry 3rd Ed., Elsevier: Noida, UP (2009)
15. 4. B R Puri, L R Sharma and M S Pathania, Principal of Physical Chemistry, Vishal Publishing Co.
16. B S Bahl, G D Tuli and Arun Bahl, Essentials of Physical chemistry, S Chand & Company Ltd.
17. A S Negi and S C Anand, A textbook of Physical Chemistry, New Age International Publishers.
18. B N Bajpai, Advanced Physical chemistry, S Chand and Company ltd.
19. R L Madan, Chemistry for Degree Students, Semester I, II, III and IV, S Chand and Company Ltd.
20. P L Soni, O P Dharmarha and U N Dash, Textbook of Physical Chemistry, Sultan Chand and Sons.
21. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, Saunders College Publishing, New York (2005).
22. Analytical Chemistry, G.D. Christian, 6th edition, Wiley-India (2007).
23. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, PHI Learning Pvt Ltd.NewDelhi(2009).
24. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D.Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint, Pearson Education Pvt.Ltd.(2007).

CHEDSC04P: CHEMISTRY PRACTICALS-IV 4h/week

Part A

Qualitative semi-micro analysis of mixtures containing two anions and two cations.

Emphasis should be given to the understanding of different reactions. The following cations and anions are suggested.

Cations: NH_4^+, Pb^{2+}, Bi^{3+}, Cu^{2+}, Al^{3+}, Fe^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Zn^{2+}, Mn^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Mg^{2+}, Na^+, K^+ and Li^+.

Anions: CO_3^{2-}, CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, SO_4^{2-}, $C_2O_4^{2-}$ and PO_4^{3-}

Spot tests and flame tests to be carried out wherever possible.

Part B

1. The study of kinetics of potassium persulphate and potassium iodide volumetrically.
2. Determination of velocity constant for acid catalyzed hydrolysis of methyl acetate.
3. Determination of velocity constant for the saponification of ethyl acetate (a = b) volumetrically.
4. Determination of equivalent conductivity of strong electrolyte and verification of DHO equation.
5. Determination of dissociation constant of weak acid by conductivity method.
6. Conductometric titration of strong acid and strong base.
7. Conductometric titration of weak acid and strong base.
8. Determination of the hydrolysis constant of aniline hydrochloride conductometrically.
9. Determination of solubility product of sparingly soluble salt conductometrically.

References

1. Vogel's Qualitative analysis, Revised by G. Svehla, Pearson education, 2002

2. J B Yadav, Advanced Physical Chemistry, Krishna Prakashan Media (P) Ltd, Meerut.

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).

5. Halpern, A. M. &McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

OPEN ELECTIVE COURSES

OEC(PR) pattern:

L	T	P	Cr
2	-	2	3

CHEOEC01: GENERAL CHEMISTRY-I 30h

INORGANIC CHEMISTRY 15h

General Introduction

Importance of Chemistry. Dalton's atomic theory: concept of elements, atoms and molecules.

Classification of elements

Need for classification, early attempts at classification of elements (Dobereiner's- Triads, Newland's law of octaves, Mendeleev's periodic table), Modern periodic law and the present form of periodic table, gradation in properties, valency, atomic number, metallic and non-metallic properties.

Group -1 and 2 Elements

General introduction, electronic configuration, general trends in physical (atomic radii, ionization energy, enthalpy, electron affinity and electronegativity) and chemical properties of elements (reaction with water, oxygen and halogens). Anomalous properties of the first element of each group and diagonal relationship.

Group -13 to Group 18 Elements

General Introduction: Electronic configurations and general trends in physical properties (atomic radii, ionization energy, enthalpy, electron affinity and electronegativity) of elements across the period and down the group.

Redox Reactions

Concept of oxidation and reduction, oxidation number, redox reactions, balancing redox reactions in terms of loss and gain of electron and change in oxidation numbers, applications of redox reactions.

ORGANIC CHEMISTRY 15h

Introduction

Organic compounds: General classification and nomenclature (in brief), hybridization, structure and shapes of ethane, ethene and ethyne.

Bond cleavage

Homolysis and heterolysis with examples. Electrophilic and nucleophilic reagents with examples.

Electronic effects

Inductive effect– definition, +I and –I effect with suitable examples. Resonance effect–definition, +R and –R effect with suitable examples. Electromeric effect–definition with examples. Hyperconjugation–definition, explanation for the stability of carbocations and alkenes by Hyperconjugation .

Strength of organic acids and bases

Comparative study with emphasis on inductive effect affecting pK_a values (Examples: Comparison of acetic acid, mono, di and trichloro acetic acids; fluoro, chloro, bromo and iodo acetic acids; 2–chloro and 3-chloropropanoic acids).

Basicity of amines

Comparative study with emphasis on inductive and resonance effects affecting pK_b values (Examples: Comparison of basicity of methyl amine, ammonia: methyl amine, dimethyl amine, tri methyl amine, and aniline, ammonia).

Aromaticity–conditions for aromaticity, Huckel's rule (examples: cyclopentadienyl anion and benzenoids), aromaticity of pyrrole and pyridine.

Aliphatic nucleophilic substitution reactions

Definition, types, examples. Nucleophilic substitution reactions of alkyl halides with i) aqueous KOH, ii) ammonia, iii) sodium ethoxide, iv)AgCN, v) KNO_2.

Addition reactions

Definition, types, examples. Addition to C=C multiple bonds involving electrophiles, nucleophiles. Markownikoff's rule and anti-Markownikoff's rule.

Additions reactions to carbonyl compounds

Addition of water, alcohol, sodium bisulphite and HCN.

Elimination reactions

Definition, types, examples. Hofmann and Saytzeff eliminations.

Aromatic electrophilic substitution reactions

Definition, examples. Mechanism of nitration, halogenation, sulphonation, Friedel-Crafts alkylation and acylation.

Recommended Books/References:

1. Concise Inorganic Chemistry, J. D. Lee, Wiley, 5th edition (2008).
2. Concepts and Models of Inorganic Chemistry, B. E. Douglas, D.H. McDaniel, J.J. Alexander John Wiley and Sons, 3rd edition (1999).
3. Atkin's Physical Chemistry, P.W. Atkins, J. De Paula, Oxford University Press, 6th edition (2014).
4. Inorganic and Solid State Chemistry, G.E. Rodger, Cengage Learning, 3rd edition (2011).

5. College Chemistry-Vol-1, L. Indira and G.R. Chatwal, Himalya Publishing House, New Delhi.
6. Chemistry for Degree Students B.Sc. First Year, R L Madan, S Chand Publishing Company, New Delhi (2010).
7. Inorganic Chemistry: Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Pearson Education India, 4th edition (2006).
8. Organic Chemistry, R.T. Morrison, R.N. Boyd, Pearson India Pvt. Ltd., 6th edition (2017).
9. Organic Chemistry, S.H. Pine, McGraw Hill, 5th edition (2007).
10. Organic Chemistry, F.A. Carey, Tata McGraw Hill, 7th edition (2008).
11. Organic Chemistry, J. Clayden, N. Greeves, S. Warren, Oxford University Press, 2nd edition (2012).
12. Advanced Organic Chemistry, Part A: Structure and mechanism, F.A. Carey, R. J. Sundberg, Springer Publisher, 5th edition (2008).

CHEOEC01P: GENERAL CHEMISTRY PRACTICALS-I 2h/week

Equal weightage to be given to both inorganic and organic practicals.

INORGANIC CHEMISTRY PRACTICALS

Titrimetric analysis

Conditions for volumetric analysis, terms involved, modes of expressing concentrations, equivalent masses of compounds, Normality, molarity and molality equations.

Preparation of commonly used standard solutions (primary and secondary standard).

Preparation of standard normal solutions (acids and bases-HCl, H_2SO_4, $H_2C_2O_4$, NaOH, KOH).

Types of titrations (acid alkali, redox, iodometric).

Calibration and use of apparatus (pipette, burette).

Apparatus used in volumetric analysis (volumetric glassware, how to use a burette, pipette).

Acid-Base Titrations

1. Estimation of carbonate and bicarbonate present together in a mixture.
2. Estimation of strength of strong base using weak acid (oxalic acid)
3. Estimation of a given strong acid using strong base.
4. Estimation of Fe(II) using standardized potassium permanganate solution.
5. Estimation of Fe(II) using standardized potassium dichromate solution.
6. Estimation of oxalic acid using standardized potassium permanganate solution.
7. Estimation of the strength of strong acid (hydrochloric acid) using standard solution of sodium carbonate.
8. Estimation of free alkali present in different soaps/detergents.

ORGANIC CHEMISTRY PRACTICALS

1. Purification of organic solids by recrystallization (from water and alcohol) and determination of melting point.
2. Purification of organic liquids by distillation and determination of boiling point.
3. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements).
4. Preparation of meta-dinitrobenzene from nitrobenzene.
5. Preparation of tribromophenol by bromination of phenol.
6. Preparation of 2, 4-dinitrophenylhydrazone from benzaldehyde.
7. Identification and separation of the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper

chromatography.

8. Identification and separation of the sugars present in the given mixture by paper chromatography.

Recommended Books/References:

1. J. A. Mendham, Vogel's *Quantitative Chemical Analysis*, Pearson, 6th edition (2009).
2. G. Svehala, I.B, Sivasankar, Vogel's Qualitative Inorganic Analysis, Pearson India, 7th edition (2012).
3. Chemistry for Degree Students B.Sc. First Year, R L Madan, S Chand Publishing Company, New Delhi (2010).
4. Vogel' text book of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatehell, 5th edition (2016).
5. Elementary Practical Organic Chemistry, Part-III: Quantitative Organic Analysis, A. I. Vogel., Pearson education, 2nd edition (2010).
6. Laboratory manual of Organic Chemistry, B. B. Dey, M. V. Sitaraman, Laboratory manual of Organic Chemistry, B. B. Dey, M. V. Sitaraman, T. R. Govindachari, Allied Publishers, New Delhi, (1996).
7. F. G. Mann, Saunders, Practical Organic Chemistry, Pearson education, 4th edition (2011).

CHEOEC02: GENERAL CHEMISTRY-II 30h

INORGANIC CHEMISTRY 15h

Chemical Bonding and Molecular Structure 11h

Valence electrons, formation of an ionic bond (examples: NaCl, $MgCl_2$), factors favouring the formation of ionic bond, general characteristics of ionic compounds.

Lattice energy–definition, factors affecting lattice energy.

Formation of covalent bond (examples: O_2, H_2, N_2) and coordinate bond (dative bond) (examples: NH_4^+, H_3O^+).

Valence Bond Theory (VBT) –assumptions, σ and π bonds (using H_2, HF, O_2 and N_2 molecules as examples), limitations.

Shapes of molecules on the basis of VSEPR Theory–calculation of total number of electron pairs, number of bond pairs, number of lone pairs and predicting the shapes of the molecules (examples: $BeCl_2$, BCl_3, H_2O, NH_3, PCl_5, SF_6, SF_4, XeF_4).

Metallic bond–definition, free electron model, semiconductors and insulators.

General principles of metallurgy 4h

Modes of occurrence of elements in nature, minerals, ores; steps involved in the extraction of metals–concentration, reduction (chemical and electrolytic methods), Ellingham diagrams–definition and application in metallurgy for reduction of metal oxides using C, CO and Al as reducing agents.

Electrolytic or oxidative refining, parting process (separating Ag from Au), vapour phase refining– Mond's process (Ni), zone refining (ultrapure metals for semiconductor technology).

PHYSICAL CHEMISTRY 15h

Second Law of thermodynamics

Review of I law of thermodynamics

Statement and limitations of I law (need for II law of thermodynamics). Different ways of stating II law of thermodynamics with respect to its spontaneity. Spontaneous and non-spontaneous processes. Concept of entropy and its significance.

Change in entropy of universe in reversible and irreversible processes. Entropy as a measure of spontaneity. Calculation of entropy changes in reversible-isothermal and reversible-adiabatic processes (including phase changes and phase transitions).

Gibbs free energy

Definition of Work function, chemical potential, and relationship between free energy and work function. Criteria for equilibrium and spontaneous processes – problems. Gibb's-Helmholtz equation (derivation-differential form). Rate of change of free energy with respect to temperature and pressure. Derivation of van't Hoff isotherm, $\Delta G^o = -RT\ln(K_p)$, van't Hoff reaction isochore (derivation), Clausius-Clapeyron equation (derivation) and its applications in the determination of ΔT_b and ΔT_f (derivation not required). Numerical problems on the above equations.

Third law of thermodynamics

Qualitative treatment of Nernst heat theorem and III law of thermodynamics (statement only). Elementary concept of residual entropy.

Recommended Books/References:

1. Concise Inorganic Chemistry, J.D. Lee, Wiley, 5th edition (2016).
2. Concepts and Models of Inorganic Chemistry, B. E. Douglas, D. H. McDaniel, J. J. Alexander, John Wiley and Sons, 3rd edition (1999).
3. Physical Chemistry P.W. Atkins, J. DePaula, , Oxford University Press, 10th edition (2014).
4. Inorganic and Solid State Chemistry, G. E. Rodger, Cengage Learning (2002).
5. College Chemistry-Vol-III, L. Indira, G. R. Chatwal, Himalya Publishing House, New Delhi (2013).
6. Selected topics in Inorganic Chemistry, Wahid U Malik, G.D. Tuli, R. D. Madan, S Chand Publisher (2010).
7. Principles of Inorganic Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal publishing co., 47th edition (2020).
8. A text book of physical chemistry (Vol. 2) –Thermodynamics and Chemical Equilibrium, K. L. Kapoor, McGraw Hill Education (India) Pvt. Ltd., 6th edition (2019).
9. Advanced Physical Chemistry, Gurdeep, Chatwal, Krishna's publication, 4th edition (2016).
10. Physical Chemistry, G. M. Barrow, Tata McGraw-Hill, 6th edition (2007).
11. Chemistry for Degree students: B. Sc., Second year, R. L. Madan, S. Chand publication (2019).
12. Physical Chemistry A Molecular Approach, Donald A McQuarrie, John D. Simon, Viva Books Private Limited (2019).

CHEOEC02P: GENERAL CHEMISTRY PRACTICALS-II 2h/week

Equal weightage to be given to both inorganic and physical practicals.

INORGANIC CHEMISTRY PRACTICALS

1. Determination of the amount of manganese in pyrolusite ore.
2. Determination of the amount of calcium in limestone.
3. Determination of the amount of iron in haematite.
4. Determination of the amount of nickel as nickel dimethyl glyoximate by gravimetric method.
5. Determination of the amount of magnesium as magnesium oxinate by gravimetric method.
6. Determination of the amount of calcium present in the given solution by complexometric titration using EDTA.
7. Determination of the amount of magnesium present in the given solution by complexometric titration using EDTA.
8. Determination of the amount of zinc present in the given solution by complexometric titration using EDTA.

PHYSICAL CHEMISTRY PRACTICALS

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of HCl with NaOH.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of enthalpy of solution of KNO_3
5. Determination of enthalpy of solution of NH_4Cl.
6. Determination of enthalpy of hydration of copper(II) sulphate.
7. Determination of enthalpy of reaction for the decomposition of hydrogen peroxide.
8. Determination of enthalpy of interaction between acetone and chloroform.

Recommended Books/References:

1. Vogel's Quantitative Chemical Analysis J. A. I. Mendham, Pearson, 6th edition (2009).
2. Chemistry for Degree Students B.Sc. First Year, R. L. Madan, S Chand Publishing Company, New Delhi (2010).
3. Experimental Physical Chemistry, V. D. Athawale, P. Mathur, New Age International Publishers, 1st edition (2001).
4. Advanced Practical Physical Chemistry, J. B. Yadav, Krishna's Education publishers, Krishna Prakashan Media (2015).

OEC (NPR) PATTERN:

L	T	P	Cr
3	-	-	3

CHEOEC03: CHEMISTRY OF WATER 45h

Introduction **15h**

Formation, structure, reaction with metals and nonmetals. Anomalous properties of water.

Water resources and properties

Water resources (oceans, rivers, lakes and wet lands), the hydrologic cycle and types of water. Unpolluted vs polluted water, complexation in natural water and waste water, Aquatic biochemical processes. Over exploitation of surface and ground water resources, water quality parameters-standards in India. Physical properties of domestic water-color, odour, pH, turbidity, hardness.

Water Harvesting and Conservation

Water Harvesting Techniques– Micro-catchments -Design of small water harvesting structures – Farm ponds–percolation tanks–yield from a catchment, rain water harvesting-various techniques related to rural and urban area.

Water Pollution **15h**

Origin of waste water, types of water pollutants of their sources and effects. Major pollutants such as pathogens, organic wastes and chemical pollutants; their harmful effects and prevention. Sample collection and preservation. Environmental and public health significance and measurement of colour, turbidity, total solids, acidity, alkalinity, hardness chloride, residual chlorine, chlorine demand, DO, BOD and COD. Heavy metal pollution-public health significance of Pb, Cd, Hg, As.

Waste water treatment **15h**

Waste water characteristics, effluent standards, terminology in waste water treatment. Treatment of domestic waste water–preliminary treatment.

Primary treatment: sedimentation, equalization, neutralization.

Secondary treatment: Aerated lagoons, trickling filters, activated sludge process, oxidation ditch, oxidation pond and anaerobic digestion. Sludge treatment and disposal.

Tertiary treatment: evaporation, ion-exchange, adsorption, electrodialysis, electrolytic recovery and reverse osmosis. Advanced waste water treatment: nutrient removal–nitrogen and phosphorus removal, solids removal. Waste water disposal and reuse: industrial waste water and its treatment.

Recommended Books/References:

1. Concise Inorganic Chemistry, J. D. Lee, Blackwell Science, London, 5th edition (2010).
2. Principles of Inorganic Chemistry, B. R. Puri, L. R. Sharma, K. C. Kalia, Vishal Publishers, 33rd edition (2020).
3. Environmental Chemistry, A. K. De, New Age International Ltd, 1st edition (2016).
4. Environmental Science, T. G. Miller Jr., Brooks/Cole Publisher, Meerut, 13th edition (2009).
5. Fundamentals of Ecology, E. P. Odum, W.B. Saunders Co., Philadelphia, 3rd edition (1971).
6. Environmental chemistry, S. E. Manahan, CRC Press, 10th edition (2017).
7. Environmental chemistry, Sharma and Kaur, Pragathi Praksahan (2010).
8. Environmental Pollution: Monitoring and control, S.M. Khopker, New Age International (2007).
9. Environmental chemistry, C. Baird, M. Cann, W. H. Freeman publication, 5th edition (2012).
10. Fundamental Concepts of Environmental Chemistry, G. S. Sodhi, Narosa Publishers, 3rd edition, (2009).
11. Principles of instrumental analysis, D. A. Skoog, Sauns College Publishing (London), 6th edition (2007).
12. Basic concepts of analytical chemistry, S. M. Khopkar, New Age International Pvt. Ltd, 2nd edition (2004).

CHEOEC04: CHEMISTRY OF ELEMENTS 45h

Periodic Table **7h**

Modern periodic law, classification of elements into *s,p,d* and *f* blocks. Review of periodic properties-size of atoms and ions, variation of atomic radius, variation of ionic radii in isoelectronic ions, periodic trend in ionic radii, electron affinity, electronegativity, differences in the behaviour of the periodic elements, comparative study of groups.

General study of *s* block elements **8h**

Elements of group-I alkali metals, general properties-size of atoms and ions, density, melting point, boiling point, ionization energy, compounds of alkali metal oxides, oxides of alkali metals, carbonates of alkali metals, halides of alkali metals, differences between Li and other groups.

Alkaline earth metals: general properties

Size of atoms and ions, density, melting point, boiling point, ionization energy, compounds of alkaline earth metals, oxides of alkaline earth metals, carbonates of alkaline earth metals, halides of alkaline earth metals, differences between beryllium and other elements of group 2.

General study of *p* block elements **8h**

Elements of group-16-oxygen family

General properties: ionisation energy, electron affinity, electronegativity, chemical properties; hydrides of group 16 elements, difference between oxygen and the other elements of group 16.

Elements of group 17 (halogens)

General properties: size of atoms, ions, ionisation energy, electron affinity, electronegativity, oxidation state, oxidising nature, compounds of halogens. Hydrogen halides, differences between fluorine and other halogens.

General study of *d* -block elements **7h**

Transition elements: General properties of transition elements-electronic configuration, atomic and ionic radii, ionisation energies, redox potentials, variable oxidations states, formation of complexes, colour of transition metal compounds, magnetic properties, catalytic properties, formation of interstitial compounds-comparison of *3d* series with *4d* and *5d* series.

General study of *f* - block elements **8h**

General properties of f-block elements-electronic configuration, atomic and ionic sizes (Lanthanide contraction), oxidation states, magnetic properties, colour (spectral properties),

formation of complexes.

Comparison of d-block and f-block elements (oxidation states, complex formation, magnetic properties. Ionic exchange method of separation of lanthanides (ion exchange method).

Noble gases (Elements of group 18) 7h

Occurrence, discovery of noble gases (Ar, He, Ne, Kr, Xe, Rn), isolation of noble gases from liquid air and natural gases; applications of noble gases, compounds of noble gases; fluorides of Xe (XeF_2, XeF_4, XeF_6), oxides of xenon (XeO_3, XeO_4) (properties).

Recommended Books/References:

1. College chemistry, Vol. I, L. Indira, G. R. Chatwal, Himalaya Publishing House, New Delhi, 1st edition (2013).
2. Essential Chemistry III, for BSc III Semester, Vinod kumar B, M Ashwathanarayanappa, Surabhi Books, 1st edition.
3. Concise Inorganic Chemistry, J. D. Lee, Blackwell Science, London, 5th edition (2010).
4. Principles of Inorganic Chemistry, B. R. Puri, L. R. Sharma, K. C. Kalia, Shoban Lal Nagin Chand and Co., New Delhi (2005).
5. Advanced Inorganic Chemistry, Satyaprakash, G. D. Tuli, S. K. Basu, R. D. Madan, Vol. II, 5th edition, S. Chand & company, New Delhi (2000).

CHEOEC05: INDUSTRIAL CHEMISTRY 45h

Synthetic dyes **4h**

Introduction –definition, conditions, classification based on application, chromophores, auxochromes- definition, examples. Structure and uses of the following dyes i) methyl orange ii) congo red iii) malachite green iv) phenolphthalein v) alizarin vi) indigo.

Drugs **4h**

Definition, chemotherapy- definition, classification of drugs with examples. i) antipyretics, ii) analgesics, iii) antibacterial drugs, iv) antimalarial drugs, v) antibiotics vi) antiseptics vii) hypnotics [structure and uses of i) paracetamol ii) sulphanilamide iii) aspirin, iv) chloroquine, v) dettol (major component only), vi) pencillin-V, vii) barbituric acid].

Pesticides **3h**

Introduction, classification, structure and uses of i) DDT ii) gammaxene iii) chloranil. Advantages and harmful effects of pesticides.

Cosmetics **3h**

Introduction, classification, ingredients and uses of the following i) talcum powder, ii) perfumes, iii) Deodorants, iv) vanishing creams, v) nail polish vi) lipstick. Harmful effects of cosmetics.

Glass **4h**

Introduction, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: i) soda lime glass, ii) lead glass, iii) safety glass, iv) borosilicate glass, v) coloured glass, vi) photosensitive glass.

Cements **4h**

Introduction, classification of cement, raw materials and their role. Manufacture of cement and the setting process (quick setting cement).

Ceramics **4h**

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

Fertilizers **4h**

Definition, types of fertilizers (N-type, P-type, K-type and mixed fertilizers), examples for NP, PK, KN, NPK fertilizers. Preparation of urea, ammonium nitrate, calcium ammonium nitrate and calcium superphosphate.

Surface coatings **4h**

Objectives of surface coatings, preliminary treatment of surface, classification of surface coatings. Paints and pigments: composition and properties (brief mention of-oil paints, toners, fillers, thinners, enamels, emulsifying agents), eco-friendly paints and plastic paints.

Alloys **4h**

Classification of alloys, ferrous alloy with examples and their uses (ferrosilicon, ferrochrome, ferromanganese) and their uses. Non-ferrous alloys with examples and their uses [Copper alloys (bronze, brass), tin alloys (solder), gold alloy (Karat gold for jewellary)]. Composition and properties of different types of Steels (stainless steel, Nickel steel, invar steel, chrome steel and manganese steel).

Propellants **3h**

Introduction to rocket propellants and their classification (solid, liquid, gaseous and hybrid propellants) with examples.

Food preservation **4h**

Definition, objectives and principles of food preservation. Different methods of food preservation. Preserved Products (jam, jelly, sauces, pickles, squashes: composition, storage, uses and their nutritional aspects).

Recommended Books/References:

1. Introduction to Industrial chemistry, Howard L. White, Wiley Interscience Publisher, 1st edition (1986).
2. Industrial chemistry, Vols I and II, B.K. Sharma, Krishna Prakashan Media Pvt. Ltd., (2016).
3. Engineering chemistry, B. K Sharma, Krishna Prakashan Media Pvt. Ltd., (2014).
4. Engineering chemistry, R. Gopalan, D. Venkapayya, S. Nagarajan. Vikas publications, New Delhi, 4th edition (2018).
5. Engineering chemistry, P.C. Jain, M. Jain. Dhanpath Rai and Sons, Delhi, 17th edition (2015).
6. Riegel's Handbook of Industrial Chemistry, J. A. Kent, Springer, 10th edition (2003).
7. Introduction to ceramics, W. D. Kingery, H. K. Bowen, D. R. Uhlmann, Wiley Publishers, 2nd edition (1976).
8. Industrial Chemistry, E. Stocchi, Vol-I, Ellis Horwood Ltd, UK (1990).

CHEOEC06: CHEMISTRY OF FOOD, NUTRITION AND PRESERVATION 45 Hrs

Unit-I -Basics of human physiological system and food science 15 Hrs

Digestive system: structure and functions of gastro intestinal tract, process of digestion and absorption of food, structure and functions of- liver, gall bladder and pancreas.

Basic concepts on food- Classification, chemical composition and nutritional value of common food stuffs, properties and their importance, calorific value (definition and values of different foods). Balanced diet and its importance.

Unit-II -Nutrition 15 Hrs

Definition, scope of nutrition, health and malnutrition, dietary fibers –definition, source and importance. Nutrients and their classification with examples, Minerals and trace elements-sources and biological importance of Na^+, K^+, Mg^{2+} and Ca^{2+} ions. Vitamins- Definition, classification of vitamins, water soluble vitamins-sources and deficiency manifestations, co-enzyme functions of B-complex vitamins (structure not required). Fat soluble vitamins-sources, deficiency symptoms, hypervitaminosis. Water –Functions, requirement and water balance. Community nutrition –Definition, objectives, importance, and various health programmes.

Unit-III - Food preservation 15Hrs

Definition, objectives and general methods of food preservation. Chemical preservatives used in preserved products like jam, jelly, sauces, pickles, squashes.

Composition and manufacture, selection, cost, storage, uses and nutritional aspects of food preservatives.

Food Standards: Different food standards and brief discussion on the following -ISI, Agmark, FPO, MPO, PFA, FSSAI.

Recommended Books/References:

1. The Chemical Analysis of Foods, H. E. Cox, David Pearson, Chemical Publishing Co Inc., U.S (1962).
2. Nutrition Science, B. Srilakshmi, New Age International Publication, 6th edition (2016).
3. Food Additives: Characteristics, Detection and Estimation. S. N. Mahindru, APH Publishing Corporation, New Delhi (2008).
4. A Handbook of Foods and Nutritional Biochemistry, NandalUrvanshi, Agrobios (India) Publisher (2013).
5. Fennema'sFood Chemistry, S. Damodaran, K. L. Parkin, O. R. Fennema, CRC Press, 4thedition, (2008).
6. Foods: Facts and Principles, N. ShakuntalaManay, M. Shadaksharaswamy, Newage International (P) Ltd. Publishers, New Delhi (2011)

CHEOEC07: CHEMISTRY IN DAILY LIFE 45h

UNIT-I **15h**

Dairy Products

Composition of milk:

Definition of milk: Composition of cow, buffalo, sheep, goat, and human milk. Storage of milk. Definition and objectives of Pasteurization of milk. Toned milk, Double toned milk, Reconstituted milk, Standardized milk, and Full cream milk – Standards, Nutritive value of milk, Tests for detection of adulteration of milk.

Beverages:

Definition, types of non-alcoholic beverages, Source and general account of Tea and Coffee, caffeine in coffee and tea, detection of chicory in coffee.

Food additives, adulterants, and contaminants

Food additives - Definition and classification, preservatives, antimicrobial & antioxidant preservatives, food color, pH control in food, flavour enhancers, sweeteners, anticaking agents, stabilizers and thickeners, surface active agents (emulsifiers). Flavors [vanillin, alkyl esters (fruit flavors) and monosodium glutamate].

Food Adulteration Definition, common food contaminants and adulterants, harmful effects, and detection. Prevention of food adulteration act. Artificial ripening of fruits - explanation with examples

UNIT-II **15h**

Vitamins

Introduction of vitamins, classification, water-soluble and fat-soluble. function, food sources, deficiency, and toxicity of vitamins.

Oils and fats

Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like argemone oil and mineral oils.

Soaps & Detergents

Definition, classification, preparation of soaps, properties of soaps and detergents, Cleansing action of soap, differences between soaps and detergents, Limitations of soaps as cleansing agents.

Proteins

Introduction, Composition Classification, Functions, Food sources, Essential & non-essential amino acids, Protein deficiency & excess Protein quality.

UNIT-III **15h**

Chemical and Renewable Energy Sources

Batteries- Types- primary and secondary batteries with examples and applications. Fuel cells-Definition, Types, principles and applications. Solar energy: solar cells, types, advantageous and disadvantageous and applications.

Polymers:

Types and classification of polymers. Source and general characteristics of natural and synthetic polymers. Typical examples of polymers used as plastics, in textiles, in electronic and automobile components, and in medical and aerospace materials. Problems of plastic waste management. Strategies for the development of environment-friendly polymers.

Recommended Books/References:

1. Introduction to Industrial Chemistry, B. K. Sharma, Krishna Prakashan Media P. Ltd., (2016).

2. Medicinal Chemistry, Ashtoush Kar, New Age International Publishers, 7th edition (2018).

3. The chemical analysis of Foods, H. E. Cox, David Pearson, Chemical Publishing Co Inc., U.S (1962).

4. Foods: Facts and Principles, N. Shakuntala Many and S. Swamy, New Age International, 4thedition (1998).

5. Physical Chemistry, Paul Atkins, J. de Paula, Oxford University Press, 7th edition (2002).

6. Handbook on Fertilizer Technology, FAI, Swaminathan and Goswamy, 6th edition (2001).

7. Organic Chemistry, I. L. Finar, Vols. 1 & 2, Pearson Education India, 6th edition (2002).

8. Polymer Science and Technology, Joel Fried, Pearson Prentice Hall, 3rd edition (2014).

CHEOEC08: ENVIRONMENTAL CHEMISTRY 45h

UNIT –I **15 Hrs**

Atmospheric chemistry: The structure of the earth's atmosphere-chemistry of the lower and upper atmosphere. The chemistry of air pollution- oxides of nitrogen-hydrogen sulphide and oxides of sulphur-Aerosols –ozone depletion and consequences-dioxins burning plastics-other atmospheric chemicals-smog-Greenhouse effect-Global warming, oxides of carbon.

UNIT –II **15 Hrs**

Water pollution and analysis: Water resources, origin of waste water, types of water pollutants and effects, chemical analysis for water pollution, control -objectives of analysis, parameters of analysis, sample collection and preservation.

Waste water treatment:

Waste water characteristics, effluent standards, terminology in Waste water treatment. Treatment of domestic waste water .

A brief discussion on the following treatment processes:

Primary treatment: Sedimentation, equalization, neutralization.

Secondary treatment: Aerated lagoons, trickling filters, activated sludge process. Sludge treatment and disposal.

Tertiary treatment: Evaporation and reverse osmosis

Advanced waste water treatment: Removal of nitrogen and phosphorus.

UNIT –III **16 Hours**

Radioactive pollution: Radioactive materials, Sources of radioactive pollutants, Effects of radioactive pollutants on living organism, Case study –Chernobyl disaster

Noise and Thermal Pollution: Noise pollution –source, measurement, effects and control; Thermal pollution -causes, effects and control.

REFERENCE:

1. Environmental Science (8th Edition) (2010): Daniel D. Chiras, Jones & Bartlett Ltd
2. A textbook of Environment: K. M. Agarwal, P. K. Sikdar & S. C. Deb
3. Environmental Analysis : M. M. Saxena
4. Environmental Chemistry : A. K. De
5. Environmental Chemistry : B.K. Sharma, and H. Kaur
6. Environmental Chemistry : S. E. Manahan
7. Environmental Science : S. C. Santra,
8. Environmental Science (6th ed) (1997): Jr. G. T. Miller, Wadsworth Pub. Co.
9. Environmental Science: D. D. Chiras

10. Forestry – Segreiya : Champion and Seth.

11. Fundamentals of Ecology : E. P. Odum

12. Hydrology – Principles, Analysis and Design: H. M. Raghunath

13. Instrumental Methods of Analysis: Chatwal and Anand.

14. Instrumental Methods of Analysis : G. W. Ewing

15. Introduction to Environmental Engineering and Science: G. M. Masters

16. Introduction to Weather and Cliamte : Trewartha

SKILL ENHANCEMENT COURSES

SEC PATTERN (PRACTICAL ORIENTED)

L	T	P	Cr
1	-	2	2

SEC PATTERN (NON PRACTICAL ORIENTED)

L	T	P	Cr
2	-	-	2

CHESEC01: GENERAL BIOCHEMISTRY 15h

Structure, properties and functions of carbohydrates, lipids and proteins.

Carbohydrates **3h**

Biological importance of carbohydrates, classification, structure, properties, chemical reactions, isolation and characterization of polysaccharides.

Proteins (Amino acids) **3h**

Structure, classification, properties and functions, peptides and polypeptides biological importance; Isolation and characterization of proteins, denaturation of proteins.

Enzymes **3h**

Classification and nomenclature, prosthetic groups, cofactors, properties of enzymes as catalysts, specific activity, turn over number and catalytic center activity, Isolation of enzymes from different sources.

Lipids **2h**

Classification, biological importance of triglycerides and phosphoglycerides and cholesterol; saponification, saponification number, iodine number. Lipid membrane, lipoproteins, functions and biochemical functions of steroid hormones.

Nucleic acids **2h**

Structure of DNA (Watson-Crick Model) and RNA types-tRNA, rRNA and mRNA, genetic code, biological roles of DNA and RNA.

Blood

Composition and functions of blood. Blood collection and preservation of samples. Estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.

Urine **2h**

Collection and preservation of samples, composition and estimation of constituents of normal and pathologicalurine.

Recommended Books/References:

1. Tool of Biochemistry, T. G. Cooper, Wiley-Interscience, 1st edition (1977).
2. Textbook of Biochemistry with Clinical Correlations, T. M. Devlin, Wiley-Liss, 7th edition (2010)).
3. Biochemistry, J. M. Berg, J. L. Tymoczko, L. Stryer, W. H. Freeman and Co. Ltd, 5th edition (2002).
4. Textbook of Biochemistry and Human Biology, G. P. Talwar, M. Srivastava, PHI Learning publisher, 3rdedition (2002).
5. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, Albert L. Lehninger, W. H. Freeman and Company, 6th edition (2013).

CHESEC01P: GENERAL BIOCHEMISTRY PRACTICALS 2h/week

Identification and estimation of the following:

1. Qualitative analysis of carbohydrates (glucose, fructose, sucrose).
2. Qualitative analysis of lipids.
3. Determination of cholesterol using Liebermann- Burchard reaction.
4. Qualitative analysis of proteins.
5. Isolation of casein from milk.
6. Estimation of protein by the Biuret method.
7. Estimation of DNA by diphenylamine method.
8. Isolation of amylase from different sources.
9. Isolation of starch from potato.
10. Determination of saponification and iodine number of an oil or fat.
11. Preparation of osazone derivatives of carbohydrates (Glucose, fructose, sucrose)

Recommended Books/References:

1. Tool of Biochemistry, T. G. Cooper, Wiley-Interscience, 1st edition (1977).
2. Practical Biochemistry: Principles and Techniques, K. Wilson, J. Walker, Cambridge University Press (2009).
3. Practical Clinical Biochemistry, Vol. 1, H. Varley, A. H. Gowenlock, M. Bell, Heinemann, London, 5th edition (1980).
4. Laboratory Handbook of Chromatographic Methods, O. Mikes, R. A. Chalmers, D. Princeton publishers (1966).
5. An Introduction to Practical Biochemistry, D.T. Plummer, Tata McGraw Hill Education, 3rd edition (2006).
6. Laboratory manual in Biochemistry, J. Jayaraman, New Age International Private Limited (2011).

CHESEC02: SEPARATION AND CHROMATOGRAPHIC TECHNIQUES 15h

Solvent Extraction 3h

Introduction, principle, techniques, factors affecting solvent extraction, batch extraction, continuous extraction and counter current extraction. Synergism, application–determination of iron.

Chromatography 3h

Definitions (chromatography, elution, eluent, mobile phase, stationary phase, retention factor), types of chromatographic methods (explain the principles in brief), the chromatograph (elution time and volume), capacity factor, column efficiency and resolution, sample preparation.

Paper Chromatography 3h

Principle, various modes of development, nature of the paper, detection of spots, retardation factors, factors that affect the reproducibility of R_f values (due to paper, solvent system, sample, development procedure), selection of solvent, quantitative analysis, applications.

Thin layer chromatography 3h

Principle, stationary phase, adsorbents, liquid phase supports, plate preparation, mobile phase, sample application, development, saturation of chamber, detection of spot, R_f values (effect of adsorbent, solvent, solute, development process), quantitative analysis, applications.

Column Chromatography 3h

Principle, columns, matrix materials, stationary phase, column packing, application of sample, column development and sample elution, detectors and fraction collectors, applications.

Recommended Books/References:

1. Principles and Practice of Analytical Chemistry, F.W. Fifield and D. Kealy, Wiley-Blackwell, 5th edition (2000).
2. Exploring Chemical Analysis, Daniel C Harris, WH Freeman publishers, 5th edition (2012).
3. Quantitative Chemical Analysis, Daniel C Harris, WH Freeman publishers, 9th edition (2015).
4. Analytical Chemistry Methods of Separation, R.V. Dilts, Van Nostrand publishers (1974).
5. Laboratory Handbook of Chromatographic and allied Methods, O. Mikes, R.A. Chalmers, Ellis Horwood Ltd. (1979).
6. Modern Analytical Chemistry, Alka L Gupta, Pragathi Praksahan, 3rd edition (2019).
7. Analytical Chemistry, Gary D Christian, John Wiley and Sons Inc, 5th edition (2001).
8. Instrumental Methods of Analysis, Gurdeep and Chatwal, Himalaya Publishing House, New Delhi (2011).

CHESEC02P: SEPARATION AND CHROMATOGRAPHIC TECHNIQUES-PRACTICALS 2h/week

1. Determination of R_f value of amino acids using paper chromatography.
2. Separation and identification of monosaccharide present in a given mixture by paper chromatography.
3. Separation of Cu^{2+} and Cd^{2+} present in the mixture using ascending chromatography.
4. Separation of Co^{2+} and Ni^{2+} by thin layer chromatography.
5. Separation of mixture of ortho-nitroaniline and para-nitroaniline using column chromatography.
6. Separation of spinach leaves pigment using ascending chromatography and determination of R_f value.
7. Separation of binary mixtures (discuss the types: acid-base, acid-neutral, base-neutral, acid-phenol, base-phenol, neutral-phenol); preliminary examinations.
8. Separation of solid-solid, solid –liquid, liquid-liquid mixtures (based on solubility).

Recommended Books/References:

1. College Practical Chemistry, V K Ahluwalia, Sunita Dhingra, Adarsh Gulati, University Press (India) Limited (2005).
2. Advanced Practical Chemistry, Jagadamba Singh, R K P Singh, Jaya Singh, L.D.S. Yadav, I.R. Siddique-Jaya Shrivastava, Pragathi Prakashan, 9th edition (2019).

CHESEC03: Titrimetric Methods 15h

Overview of titrimetry 2h

Titrant and titrand, equivalence points and end points, titration curves, principles of different methods employed for titrations (volumetric, conductometric, potentiometric, thermometric titrations, pH metric).

Volumetric titrations 3h

Principle of acid-base titrations (strong acid-strong base, weak acid-strong base and weak acid-weak base), double titrations, concept of indicators, properties of acid-base indicators, structures of some simple indicators (phenolphthalein, methyl orange).

Complexation titrations 5h

Principle and applicability of EDTA titrations (direct titration of the analyte with EDTA), structure of EDTA, advantages of EDTA as a complexing titrant, an introduction to back titration and substitution titration, application- determination of water hardness. Redox titrations-general principle of redox titrations, use of reducing agents-ferrous ammonium sulphate, sodium thiosulphate, oxidizing agents-potassium permanganate, potassium dichromate (suitable examples should be considered), iodimetry Titration (direct and indirect method).

Conductometric titrations 5h

Principle of conductometric titrations for acid-base reactions [SA vs SB (HCl vs NaOH), SA+WA vs SB (HCl+Acetic acid vs NaOH), dibasic acid vs base (oxalic acid vs NaOH)] and precipitation reactions [Li_2SO_4 vs $BaCl_2$], applications and advantages. Potentiometric titrations-Principle of potentiometric titrations [acid-base titration (HCl vs NaOH), redox titration (FAS vs $KMnO_4$)], applications and advantages. A brief introduction to pH metric and thermometric titrations, their applications and advantages.

Recommended Books/References:

1. Modern Analytical Chemistry, David Harvey Douglas, McGraw-Hill Companies (1999).
2. Analytical Chemistry: Gary D. Christian, Wiley & Sons, 6th edition (2003).
3. Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, Brooks/Cole publishers, 9th edition (2013).
4. Instrumental Methods of Analysis, H. H. Willard, L. L. Mirrit, J. A. Dean, Wadsworth Publishing Co Inc, 7th edition (1988).
5. Vogel's Textbook of Quantitative Inorganic Analysis, A.I. Vogel, Longman Sci. and Tech, 4th edition (1980).
6. Chemical Instrumentation: A Systematic Approach, H. A. Strobel, Wiley-Interscience; 3rd edition (1989).
7. Principles of Instrumental Analysis, Douglas A. Skoog., F. James Holler, Stanley R. Crouch, Cengage Learning publishers, 6th edition (2014).
8. Quantitative Chemical Analysis, Daniel C. Harris, W. H. Freeman publishers, New York, 10th edition (2020).

CHESEC03P: TITRIMETRIC METHODS: PRACTICALS 2h/week

1. Calibration of glassware
2. Preparation of standard solutions
3. Handling of instruments.

Acid-base titrations

4. Estimation of carbonate and bicarbonate present together in a mixture.
5. Estimation of strength of strong base using weak acid (oxalic acid)
6. Estimation of a given strong acid using strong base.
7. Estimation of carbonate and hydroxide present in a mixture.
8. Estimation of oxalic acid and sodium oxalate in a given mixture using standard $KMnO_4$/NaOH solution.

Redox titrations

9. Estimation of Fe(II) using standardized $KMnO_4$ solution.
10. Estimation of oxalic acid using standardized $KMnO_4$ solution.
11. Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine/anthranilic acid) indicator.

Iodometric titration

12. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Conductometric titrations

13. Determination of strength of strong acid by titrating it against strong base conductometrically.
14. Determination of strength of weak acid by titrating it against strong base conductometrically.

Potentiometric titrations

15. Determination of strength of strong acid by titrating it against strong base potentiometrically.
16. Determination of amount of Fe^{2+} ion present in the given solution by titrating the given Mohr's salt solution against potassium dichromate potentiometrically.

Recommended Books/References:

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis, Pearson, 6th edition (2009).
2. Chemistry for Degree Students B.Sc. First Year, R. L. Madan, S Chand Publishing Company, New Delhi (2013).
3. Chemistry for Degree Students B.Sc. Third Year (Physical chemistry), R. L. Madan, S Chand Publishing Company, New Delhi (2013).
4. Experimental Physical Chemistry, V. D. Athawale, P. Mathur, New Age International Publishers, 1st edition (2001).
5. Advanced Practical Physical Chemistry, J. B. Yadav Krishna's Education publishers, Krishna Prakashan Media (2015).

CHESEC04: BIOFERTILIZERS 30h

Unit I **9h**

General account about the microbes used as biofertilizer: rhizobium-isolation, identification, mass multiplication. *Azospirillum:* isolation and mass multiplication- carrier-based inoculant, associative effect of different microorganisms. *Azotobacter*: classification, characteristics-crop response to *Azotobacter* inoculum, maintenance and mass multiplication.

Unit II **7h**

Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, nitrogen fixation, factors affecting growth, blue green algae and *Azolla* in rice cultivation.

Unit III **7h**

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield.

Unit IV **7h**

Organic farming – Green manuring and organic fertilizers, recycling of bio- degradable municipal, agricultural and Industrial wastes – bio compost making methods, types and method of vermicomposting – field, application.

Recommended Books/References:

1. A Text book of Biotechnology, R.C. Dubey, S. Chand and Co, 4th revised edition (2006).
2. Outlines of Plant Biotechnology. John Jothi Prakash, Emkay Publication, 1st edition (2014).
3. Biotechnology, V. Kumaresan, Saras Publications, 6th format (2005).
4. The complete Technology Book on Biofertilizer and organic farming, NIIR Project Consultancy Services: NIIR Board, 2nd edition (2012).
5. T. V. Sathe, Vermiculture and Organic Farming. Daya publishers (2004).
6. Biofertilizers in Agriculture and Forestry, Subba Rao N.S. Medtech, 4th edition (2017).
7. S.C. Vayas, S. Vayas, H. A. Modi, Bio-fertilizers and organic Farming Akta Prakashan, Nadiad (1998).

CHESEC05: FERMENTATION SCIENCE AND TECHNOLOGY 30h

Unit I **8h**

Preparation of microbial culture, preparation and sterilization of fermentation media. Isolation and improvement of industrially important microorganisms.

Unit II **7h**

Maintenance and preservation of microorganisms, metabolic regulations and overproduction of metabolites.

Unit III **8h**

Scope and opportunities of fermentation technology. Principles of fermentation: submerged, solid state, batch, fed-batch and continuous culture. Fermentative production of vinegar, alcohol (ethanol, wine, beer), acids (citric acid and gluconic acid), amino acids (lysine and glutamic acid) and antibiotics (penicillin and streptomycin).

Unit IV **7h**

Microbial production of enzymes: amylase and protease. Bioproduct recovery.

Recommended Books/References:

1 Industrial Microbiology: An Introduction, M. J. Waites, Blackwell Science, London, UK, 7th edition (2008).

2. Prescott & Dunn's Industrial Microbiology, S.C. Prescott, C.G. G. Dunn Reed AVI Pub. Co., USA, 4th edition (1982).

3. Prescott & Dunn's Industrial microbiology, G. Reed. AVI Pub. Co., USA, 4th edition (2004).

4. Industrial Microbiology, L.E. JR Casida New Age International (P) Limited Publishers, 3rd edition (2015).

5. Industrial Microbiology: An Introduction, M. J. Waites, N.L. Morgan, J. S. Rockey, G. Higton Blackwell Science, London, UK, 1st edition (2001).

6. Microbiology, M. J. Pelczar E.C.S. Chan, N.R. Krieg Tata McGraw-Hill Publishing Company Ltd., 5th edition (2003).

Submitted by BoS (UG) in Chemistry, Tumkur University

1. Dr. Aruna Kumar. D. B - Chairperson
2. Dr. Nirmala. B-Member
3. Dr. T. B. Nijalingappa-Member
4. Dr. Aisha Siddekha- Member
5. Sri. Dakshinamurthy K.-Member
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LOCF CHEMISTRY

Question paper pattern
(I to IV Semester)

B.Sc. in Chemistry (Honours)

Undergraduate Programme

2021

BOS(UG) Chemistry
Tumkur University, Tumakuru

GENERAL REQUIREMENTS & OTHER INFORMATION

1. **Title and Commencement**: As per the university guidelines.
2. Undergraduate programme offered with multiple entry and exit options
   Certificate: 2 semesters
   Diploma: 4semesters
   Bachelor of Science (B.Sc. 6 Semesters)
   Bachelor of Science (Honors in Chemistry) (B.Sc. Hons, 8 Semesters)
3. **Faculty of Science and Technology**
4. **Semester and Programme Structure:** The credit pattern for the course is Lecture (L): Practicals (P)
5. **Subject Combinations:** As per the university guidelines.
6. **Eligibility for admission, Scheme of the program, medium of instructions, attendance, examination, valuation and result:** As per the university guidelines.

CHEMISTRY EXAMINATION PATTERN

FOR

1. DISCIPLINE SPECIFIC CORE COURSES (DSC) (I-IV Semester B. Sc)

Theory: 4 Credits: 100 Marks
[Summative assessment (SA)-60 Marks + Internal assessment (IA)-40 Marks]

Practicals: 2 Credits: 50 Marks
[Summative assessment (SA)-25 Marks + Internal assessment (IA)-25 Marks]

CREDITS:	**THEORY**	**PRACTICALS**	**TOTAL**
Lecture (L)+ Practical (P)(4:2)	**Maximum Marks (M)**		
Internal Assessment (IA)	40 2 Tests (10+10=20) 2 Assignments (10+10=20)	25 1 Test+1 Assignment + Record + Viva (10+5+5+5)	**65**
Summative Assessment (SA)	60	25	**85**
Duration of end semester examination	2 hours	4 hours	
Maximum marks	**100**	**50**	**150**

2. OPEN ELECTIVE COURSES (NON-PROGRESSIVE) (WITHOUT PRACTICALS)

(OEC-NPR) (I-IV Semester B. Sc)

Theory: 3 Credits : 100 Marks
[Summative assessment (SA)-60 Marks + Internal assessment (IA)-40 Marks]
Practicals: 0 Credits : 0 Marks

CREDITS:	**THEORY**	**TOTAL**
Lecture (L)+ Practical (P)(3:0)	**Maximum Marks (M)**	
Internal Assessment (IA)	40 2 Tests (10+10=20) 2 Assignments (10+10=20)	**40**
Summative Assessment (SA)	60	**60**
Duration of end semester examination	2 hours	
Maximum marks	**100**	**100**

3. OPEN ELECTIVE COURSES (PROGRESSIVE) (WITH PRACTICALS) (OEC-PR)

(I-II Semester B. Sc)

Theory : 2 Credits : 60 Marks
[Summative assessment (SA)-40 Marks + Internal assessment (IA)-20 Marks]

Practicals: 1 Credit : 40 Marks
[Summative assessment (SA)-20 Marks + Internal assessment (IA)-20 Marks]

CREDITS: Lecture (L)+ Practical (P)(2:1)	THEORY	PRACTICALS	TOTAL
	Maximum Marks (M)		
Internal Assessment (IA)	20 1 Test+1 Assignment (10+10=20)	20 Test + (Record+Viva) (10+10)	**40**
Summative Assessment (SA)	40	20	**60**
Duration of end semester examination	1.5 hours	2 hours	
Maximum marks	**60**	**40**	**100**

4. SKILL ENHANCEMENT COURSES WITHOUT PRACTICALS (SEC) (I-IV Semester B. Sc)

Theory : 2 Credits : 50 Marks
[Summative assessment (SA)-30 Marks + Internal assessment (IA)-20 Marks]
Practicals: 0 Credits : 00 Marks

CREDITS: Lecture (L)+ Practical (P) (2:0)	THEORY	TOTAL
	Maximum Marks (M)	
Internal Assessment (IA)	20 1 Test+ 1 Assignment (10+10)	**20**
Summative Assessment (SA)	30	**30**
Duration of end semester examination	1 hour	
Maximum marks	**50**	**50**

5. SKILL ENHANCEMENT COURSES WITH PRACTICALS (SEC)

(I-IV Semester B. Sc.)
Theory : 1 Credits : 25 Marks
[Summative assessment (SA)-15 Marks + Internal assessment (IA)-10 Marks]

Practicals: 1 Credit : 25 Marks
[Summative assessment (SA)-15 Marks + Internal assessment (IA)-10 Marks]

CREDITS: Lecture (L)+ Practical (P) (1:1)	**THEORY**	**PRACTICALS**	**TOTAL**
	Maximum Marks (M)		
Internal Assessment (IA)	10 1 Test (10)	10 1 Test+Record(5+5)	20**
Summative Assessment (SA)	15	15* *The questions related to practical should be asked in theory exam. No separate practical exams to be conducted.	30
Duration of end semester examination	**1 hour (30 Marks = 15 T+ 15 P)**		
Maximum marks			**50**

****Colleges should award IA marks to students out of 20 considering both theory and practical components as single unit and submit the same (without splitting theory and practical IA marks) to University (for SEC papers).**

BLUE PRINT OF QUESTION PAPERS FOR EXAMINATION AND EVALUATION

DISCIPLINE SPECIFIC COURSES (I-IV Semester B. Sc)

DURATION: 2 HOURS	THE QUESTION PAPER SHALL CONSIST OF TWO PARTS: PART A AND PART B	MAXIMUM MARKS: 60
Part A	Answer any 6 out of 8 questions [Q1 to Q8] **(two questions from each unit)**	6 ×2 =12
Part B	Answer any 8 out of 10 questions [Q9 to Q18]	8 × 6 =48
i) Equal weightage of marks shall be given to all the units in Part A and Part B. ii) In part B, each main question shall have only two sub-divisions (a) and (b) with (3+3)/(4+2) marks respectively. iii) Q9 to Q16: two main questions should be drawn from each unit. iv) Q17 and Q18: one sub-question from each unit should be drawn.		

OPEN ELECTIVE COURSES (NON-PROGRESSIVE) (WITHOUT PRACTICALS)

(I-III Semester B. Sc)

DURATION: 2 HOURS	THE QUESTION PAPER SHALL CONSIST OF TWO PARTS: PART A AND PART B	MAXIMUM MARKS: 60
Part A	Answer any 6 out of 9 questions [Q1 to Q9] **(three questions from each unit)**	6 × 2 =12
Part B	Answer any 8 out of 12 questions [Q10 to Q21]	8 × 6 =48
i) Equal weightage of marks shall be given to all the units in Part A and Part B. ii) In part B, each main question shall have only two sub-divisions (a) and (b) with (3+3)/(4+2) marks respectively. iii) Q10 to Q21: four main questions should be drawn from each unit.		

OPEN ELECTIVE COURSES (PROGRESSIVE) (WITH PRACTICALS) (OEC-PR)

(I-II Semester B. Sc)

DURATION: 1.5 HOURS	THE QUESTION PAPER SHALL CONSIST OF TWO PARTS: PART A AND PART B	MAXIMUM MARKS: 40
Part A	Answer any 5 out of 8 questions (Q1 to Q8) **(four questions from each section)**	5 × 2 =10
Part B	Answer any 5 out of 8 questions (Q9 to Q16) **(four questions from each unit)**	5 × 6 =30
i) Equal weightage of marks shall be given to all the sections in Part A and Part B. ii) In part B, each main question shall have only two sub-divisions (a) and (b) with (3+3)/(4+2) marks respectively.		

SKILL ENHANCEMENT COURSES WITHOUT PRACTICALS (SEC) (I-IV Semester B. Sc.)

DURATION: 1 HOUR	THE QUESTION PAPER SHALL CONSIST OF TWO PARTS: PART A AND PART B	MAXIMUM MARKS: 30
Part A	Answer any 3 out of 4 questions (Q1 to Q4) **(two questions from each unit)**	3 × 2 = 06
Part B	Answer any 4 out of 5 questions (Q5 to Q9)	4 × 6 = 24
i) Equal weightage of marks shall be given to all the units in Part A and Part B. ii) In part B, each main question shall have only two sub-divisions (a) and (b) with (3+3)/(4+2) marks respectively. iii) Q5-Q8-two main questions from each unit and Q9 one sub question shall be drawn from each unit.		

SKILL ENHANCEMENT COURSES WITH PRACTICALS (SEC) (I-IV Semester B. Sc.)

DURATION: 1 HOUR	THE QUESTION PAPER SHALL CONSIST OF TWO PARTS: PART A AND PART B	MAXIMUM MARKS: 30
Part A (Theory)	Answer any 3 out of 4 questions (Q1 to Q4)	3 × 2 = 06
	Answer any 3 out of 5 questions (Q5 to Q9)	3 × 3 = 09
Part B (Practicals)	Answer any 3 out of 4 questions (Q10 to Q13)	3 × 2 = 06
	Answer any 1 out of 2 questions (Q14 to Q15)*	1 × 9 = 09
*Q14 and Q15 question shall have only two sub-divisions (a) and (b) with (4+5)/(3+6) marks respectively. In part B, questions from the experiments related to practical (principle, reactions, reaction mechanisms, structures, formulas, calculations and procedure shall be given).		