SCHEME AND SYLLABUS

FOR

Learning Outcomes based Curriculum Framework

(LOCF)

For

B. Sc. FIRST YEAR (Chemistry Honours)

DEPARTMENT OF CHEMISTRY

SCHOOL OF PHYSICAL SCIENCES

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (CG)
(A CENTRAL UNIVERSITY)

To be implemented from 2021-22

Semester wise Theory Papers and Practical

B.Sc. Hon's (Chemistry): LOCF 2021-2022

Department of Chemistry, School of Physical Sciences

Course Opted	Course Code	Name of the course	Credit	Hour/ week	Internal Assess	End Sem Exam
Semester I						
CC-I Theory	**CYUATT1**	Inorganic Chemistry-I	3	3	30	70
CC-I Practical	**CYUALT1**	Inorganic Chemistry Practical-I	2	4	30	70
CC-II Theory	**CYUATT2**	Organic Chemistry-I	3	3	30	70
CC-II Practical	**CYUALT2**	Organic Chemistry Practical-I	2	4	30	70
AEC-I Theory	**CYUATA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
SEC-I Theory	**CYUATL1**	Select one from the Pool of SEC Courses offered	2	2	30	70
GEC-I Theory	**CYUATG1**	1A Physics-I, 1B Mathematics-I, 1C Zoology-I 1D Botany-1, 1EAnthropology-1, 1F Biotechnology-1, 1G Forensic Science-1	3	3	30	70
GEC-I Practical	**CYUALG1**	Generic Elective- Practical-I	2	4	30	70
Additional Credit Course I	**CYUATC1**	Select one from the Pool of Value added Courses offered				
		TOTAL	**19**	**25**	**240**	**560**
Semester II						
CC-III Theory	**CYUBTT1**	Physical Chemistry-I	3	3	30	70
CC-III Practical	**CYUBLT1**	Physical Chemistry Practical-I	2	4	30	70
CC-IV Theory	**CYUBTT2**	Organic Chemistry-II	3	3	30	70
CC-IV Practical	**CYUBLT2**	Organic Chemistry Practical-II	2	4	30	70
AEC-II Theory	**CYUBTA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
SEC-II Theory	**CYUBTL1**	Select one from the Pool of SEC Courses offered	2	2	30	70
GEC-II Theory	**CYUBTG1**	2A Physics-I, 2B Mathematics-I, 2C Zoology-I 2D Botany-1, 2EAnthropology-1, 2F Biotechnology-1, 2G Forensic Science-1	3	3	30	70
GEC-II Practical	**CYUBLG1**	Generic Elective- Practical-II	2	4	30	70
Additional Credit Course II	**CYUBTC1**	Select one from the Pool of Value added Courses offered				
		Total	**19**	**25**	**240**	**560**

As per UGC LOCF guidelines, University / departments have liberty to offer GEC and SEC courses offered by any department to students of other departments.

The No. of GE course is four. One GEC course is compulsory in first 4 semesters each. In present scheme it is proposed to have minimum two GEC courses (from one subject) in first twosemester after which student shallchange twoGEC for another subject in IIIrd and IVth semester, so that all the student can have exposure of one additional subject.

* May be offered during summer. Summer Internship: duration will be 2-4 weeks (minimum 90 working hours).

** MOOC's courses may be offered at least one time during entire PG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to your subject is not available on MOOC's platform, department may continue with regular courses.

Abbreviations:
CC= Course code; AEC= Ability Enhancement Course;GEC= Generic Elective Course; SEC= Skill Enhancement Course; DSE= Discipline Specific Elective Course.

SKILL ENHANCEMENT COURSE (ANY FOUR) (CREDIT: 02 EACH)

1. Science Communication andPopularization
2. Biofertilizer
3. Personality Development
4. Computer Applications in Chemistry
5. Herbal Science & Technology
6. Fermentation Science & Technology
7. Environment Impact Analysis
8. IT Skill for Chemist
9. IPR and business skill for chemist
10. Analytical Clinical Biochemistry
11. Mushroom Culture Technology

ABILITY ENHANCEMENT COURSE (AEC) offered by Department of Chemistry (CREDIT:02 EACH)

1. Chemistry in Everyday life
2. History of Indian Science
3. English for communication
4. Intellectual Property Rights
5. Good Laboratory Practices
6. Introduction to Forensic Science &
7. Technology
8. Renewable Energies (Solar & Biogas)
9. Cheminformatics
10. Water remediation and conservation studies
11. Research methodology
12. Chemistry of food, nutrition and preservation

VALUE ADDED COURSES (Optional,CREDIT: 03 EACH)

1. Fuel Chemistry (Course Coordinator- Dr. S. S. Thakur and Prof. G. K. Patra)
2. Cosmetic Formulation (Course Coordinator- Dr. S. Banerjee)
3. Polymer Chemistry (Course Coordinator- Dr. A. Srivastava)
4. Eco-Friendly Lubricants – Chemistry And Application (Course Coordinator- Dr. B. L. Sahuand Dr. B. Mondal)
5. Efficient Technologies for Food Processing and Shelf Life Extension (Course Coordinator-Dr. Niraj Kumari and Dr. A. Srivastva)

NAME OF THE GENERIC ELECTIVE OFFERED BY DEPARTMENT OF CHEMISTRY (CREDIT: 05)

SEMESTER-I

GE Theory-I: Atomic Structure, Bonding, General Organic Chemistry & AliphaticHydrocarbons

GE PRACTICAL – I

SEMESTER-II

GE Theory-II: Kinetic Theory of Gases, Chemical Energetics, Equilibria & Functional GroupOrganic Chemistry

GE PRACTICAL – II

SCHOOL OF PHYSICAL SCIENCES

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (C.G.)

(A CENTRAL UNIVERSITY)

LOCF, SYLLABUS

PROPOSED (W.E.F. SESSION 2021-22)
B. Sc. FIRST YEAR
CHEMISTRY HONOURS

Programme Outcomes: Graduates will be able to:

PO1: Core competency: The chemistry graduates are expected to know the fundamental concepts of chemistry and applied chemistry.

PO2: Critical thinking: Chemistry graduates are expected to know basics of cognitive biases, mental models, logical fallacies, scientific methodology and constructing cogent scientific arguments.

PO3: Psychological skills: Graduates are expected to possess basic psychological skills required to face the world at large, as well as the skills to deal with individuals and students of various sociocultural, economic and educational levels.

PO4: Problem-solving: Graduates are expected to be equipped with problem-solving philosophical approaches that are pertinent across the disciplines.

PO5: Analytical reasoning: Graduates are expected to acquire formulate cogent arguments and spot logical flaws, inconsistencies, circular reasoning *etc*.

PO6: Research-skills: Graduates are expected to design a scientific experiment through statistical hypothesis testing and other a *priori* reasoning including logical deduction.

PO7: Teamwork: Graduates are expected to be team players, with productive co- operations involving members from diverse socio-cultural backgrounds.

PO8: Digital Literacy: Graduates are expected to be digitally literate for them to enroll and increase their core competency *via* e-learning resources such as MOOC and other digital tools for lifelong learning.

PO9: **Moral and ethical awareness**: Graduates are expected to be responsible citizens of India and be aware of moral and ethical baseline of the country and the world.

PO10: **Leadership readiness:** Graduates are expected to be familiar with decision-making process and basic managerial skills to become better leader.

PO11: **Communication:** Communicate effectively by presentations and writing reports.

PO12: **Management:** Manage projects in multidisciplinary environments as member or a team leader.

Programme Specific Outcomes: Graduates will be able to:

PSO1: Understand atomic structure and theory, elements in periodic table; physical and chemical characteristics, periodicity, to predict the molecular geometry, chemical bonding, and weak interactions. Graduate also able to do quantitative analysis of inorganic.

PSO2: Understand basic of organic molecules, structure, bonding, reactivity, and reaction mechanisms. Students can draw Stereochemistry of organic molecules, 3-D structure of organic molecules, and mechanism of organic reactions along with qualitative analysis of organic compounds.

PSO3: Familiarize with various states of matter and physical properties of each state of matter and laws related to describe the states. They will understand ionic equilibria and salt hydrolysis (acid-base hydrolysis) and its application in chemistry.

PSO4: Familiarize about classes of organic compounds, their methods of preparation, and reaction mechanism. And also understand organometallic compounds and their uses.

B. Sc. I YEAR/ I - SEMESTER SCHEME

Semester	Course	Name of the course	Credits
I	CC 1	Inorganic Chemistry-I	Theory 3
			Practical: 2

Learning objective:

After completing this course, the students will be able to:

- Develop an understanding on atomic theory, concept of wavefunction.
- Elements in periodic table; physical and chemical characteristics,periodicity.
- To predict the atomic structure, chemical bonding, and molecular geometry based on acceptedmodels.
- To understand atomic theory of matter, composition ofatom.
- Identity of given element, relative size, charges of proton, neutron and electrons, and their assembly to form differentatoms.
- Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodictable.
- Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
- Valence bond theory incorporating concepts of hybridization predicting geometry of molecules.
- Importance of hydrogen bonding, metallicbonding.

Inorganic Chemistry-I (Theory)

Unit I: Atomic Structure ***10 Lectures***

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and $\psi 2$. Quantum numbers and their significance.Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Unit II: Periodicity of Elements ***10 Lectures***

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and*p*-block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van'derWaals)

(c) Ionic and crystalradii.

(d) Covalent radii (octahedral andtetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionizationenthalpy.

(f) Electron gain enthalpy, trends of electron gainenthalpy.

(g) Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, partial charge, hybridization, group electronegativity. Sanderson electron densityratio.

Unit III: Chemical Bonding *14 Lectures*

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation, expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvationenergy.

(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given). Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Ionic character from dipole moment andelectronegativities.

UNIT IV: Metallic bonding and Weak chemical forces *6 Lectures*

(iii) *Metallic Bond:* Qualitative idea of free electron model, Semiconductors,Insulators.

(iv) *Weak Chemical Forces:* vander Waals, ion-dipole, dipole-dipole, induced dipole dipole-induced dipole interactions, Lenard-Jones 6-12 formula, hydrogen bond, effects of hydrogen bonding on melting and boiling points, solubility,dissolution.

Recommended Books/References:

1. Lee, J. D. *Concise Inorganic Chemistry*, Wiley, 5^{th}Ed^{n}.
2. Douglas, B.E., McDaniel, D.H., Alexander J.J., *Concepts & Models of Inorganic Chemistry, (Third Edition)* John Wiley &Sons,1999.
3. Atkins, P. W. and DePaula, J. *Physical Chemistry*, Tenth Edition, Oxford University Press, 2014.
4. Rodger, G. E. *Inorganic and Solid State Chemistry*, Cengage Learning,2002.

Inorganic Chemistry-I (Practical)

(A) TitrimetricAnalysis

(i) Calibration and use of apparatus.

(ii) Preparation of solutions of different Molarity/Normality oftitrants.

(iii) Use of primary and secondary standardsolutions.

(B) Acid-BaseTitrations

(i) Estimation of carbonate and hydroxide present together inmixture.

(ii) Estimation of carbonate and bicarbonate present together in amixture.

(iii) Estimation of free alkali present in differentsoaps/detergents

(C) Oxidation-ReductionTitrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$solution.

(ii) Estimation of oxalic acid and sodium oxalate in a givenmixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and externalindicator.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis* Sixth Edition, Pearson,2009.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Course Outcome:

Graduate will have understanding of:

1. Atomic theory and concept of wave function.
2. Elements in periodic table; physical and chemical characteristics, periodicity.
3. Atomic structure, chemical bonding, and molecular geometry based on accepted models.
4. Atomic theory of matter, composition of atom.
5. Bonding between atoms, molecules, interaction and energetics, hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
6. Importance of hydrogen bonding, metallic bonding.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO2	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO3	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO4	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO5	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO6	3	2	1	2	1	1	1	1	1	1	1	1	3			

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I	CC 2	Organic Chemistry-I	Theory:3
			Practical: 2

Learning objectives:

On completion of this course, the students will be able to understand:

1. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
4. Understanding hybridization and geometry of atoms, 3-D structure of organic molecules, identifying chiral centers.
5. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
6. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*. elimination.

OrganicChemistry-I (Theory)

UNIT I: Basics of Organic Chemistry **10 Lectures**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules,

Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric,resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples.Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes).Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT II: Stereochemistry ***6 Lectures***

Concept of asymmetry, Fischer Projection, Newmann and Sawhorse projection formulae and their interconversions; Geometrical isomerism: cis–trans andsyn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, racemic mixtures, Relative and absolute configuration: D/L and R/S designations.

UNIT III: Chemistry of Aliphatic Hydrocarbons ***18 Lectures***

A. Carbon-Carbon sigmabonds

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

B. Carbon-Carbonpi-bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions.Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2- and 1,4- addition reactions in

conjugated dienes and, Diels- Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilicadditions.

C. Cycloalkanes and ConformationalAnalysis

Cycloalkanes and stability, Baeyer strain theory, Conformation analysis, Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms.

UNIT IV: Aromatic Hydrocarbons **6 Lectures**

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

Recommended Books/References:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
2. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill,(2007)
3. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill(2008).
4. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford UniversityPress.
5. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher,(2000).

Organic Chemistry-I (Practical)

1. Checking the calibration of thethermometer.
2. Purification of organic compounds by crystallization using the followingsolvents:

   a.Water b. Alcohol c. Alcohol-Water
3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting pointapparatus).
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillarymethod)
6. Chromatography
   a. Separation of a mixture of two amino acids by ascending and horizontal paper Separation of a mixture of two sugars by ascending paperchromatography
   b. Separation of a mixture of *o*-and *p*-nitrophenol or o-and p-aminophenol by thin layer chromatography(TLC).
   c. chromatography

Recommended Books/Reference:

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

Note: Experiments may be added/deleted subject to availability of time and facilities

Course Outcome:

Graduate will have understanding of:

1. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
2. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
3. Aromatic compounds and aromaticity, mechanism of aromatic reactions.
4. Hybridization and geometry of atoms, 3-D structure of organic molecules,identifying chiral centers.
5. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.
6. Mechanism of organic reactions (effect of nucleophile/leaving group, solvent), substitution *vs*. elimination.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO2	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO3	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO4	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO5	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO6	3	2	1	2	1	1	1	1	1	1	1	1		3		

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I	GE-I	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	Theory: 3
			Practical: 2

Theory: 45Hours

Section – A: Inorganic Chemistry – 1

Unit – 1: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matterand radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it.Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom.Radial and angular parts of the hydogenicwavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3pand 3d orbitals (Only graphical representation).Radial and angular nodes and their significance.Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).

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

(9Hours)

Unit – 2: Chemical Bonding

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionicbonding, lattice energy and solvation energy and their importance in the context of stability and solubilityof ionic compounds.Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. *Covalent bonding:* VB Approach: Shapes of some inorganic molecules and ions on the basisofVSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonalbipyramidal and octahedral arrangements, such as $BeCl_2$, BF_3, SiF_4, PCl_5,SF_6, NH_3, H_2O, OF_2, ClF_3, SF_4, XeF_4, XeF_6, H_3O^+, I_3^-, I_3^+, ICl_2^-, XeF_5^+.

Concept of resonance and resonating structures in various inorganic and organic compounds.

(7Hours)

Unit – 3: Molecular Orbital Theory

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

(7Hours)

Section – B: Organic Chemistry – 1

Unit – 1: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

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

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK

values. Aromaticity: Benzenoids and Hückel's rule.

(6Hours)

Unit – 2: Stereochemistry

Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations.Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis - trans* nomenclature; CIP Rules: R/ S(for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

(7Hours)

Unit – 3: Aliphatic Hydrocarbons

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

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

Alkenes: (Upto 5 Carbons)*Preparation:*Elimination reactions: Dehydration of alkenes anddehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:*cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons)*Preparation:*Acetylene from $CaC_2$and conversion into higheralkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysisand oxidation with hot alk. $KMnO_4$.

(9Hours)

Reference Books:

- J. D. Lee: *A new Concise Inorganic Chemistry*, E L. B. S.
- F. A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- Douglas, McDaniel and Alexader: *Concepts and Models in Inorganic Chemistry*, John Wiley.
- James E. Huheey, *Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principlesof Structure and Reactivity*, Pearson Publication.
- T. W. Graham Solomon: *Organic Chemistry, John Wiley and Sons.*
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
- E. L. Eliel: *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
- I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand

GE PRACTICAL – I (Atomic Structure, Bonding, General OrganicChemistry & Aliphatic Hydrocarbons)

Section – A: Inorganic Chemistry - Volumetric Analysis

(30Hours)

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

Section – B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)

2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)

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

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

Reference Books:

- Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
- Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.
- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
- Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

Course Outcome:

Graduate will have understanding of:

1. Atomic theory and concept of wave function.
2. Atomic structure, chemical bonding, and molecular geometry based on accepted models.
3. Bonding between atoms, molecules, interaction and energetics, hybridization and shapes of atomic, molecular orbitals, bond parameters, bond- distances and energies.
4. Basic of organic molecules, structure, bonding, reactivity and reaction mechanisms.
5. Stereochemistry of organic molecules – conformation and configuration, asymmetric molecules and nomenclature.
6. Hybridization and geometry of atoms, 3-D structure of organic molecules,identifying chiral centers.
7. Electrophile, nucleophiles, free radicals, electronegativity, resonance, and intermediates along the reaction pathways.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO2	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO3	3	2	1	2	1	1	1	1	1	1	1	1	3			
CO4	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO5	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO6	3	2	1	2	1	1	1	1	1	1	1	1		3		
CO7	3	2	1	2	1	1	1	1	1	1	1	1		3		

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

B. Sc. I YEAR/ II - SEMESTER SCHEME

Semester	Course	Name of the course	Credits
II	CC 3	Physical Chemistry-I	Theory:3
			Practical: 2

Learning objective:

On completion of this course, the students will be able to understand:

1. Familiarization with various states ofmatter.
2. Physical properties of each state of matter and laws related to describe thestates.
3. Calculation of latticeparameters.
4. Electrolytes and electrolytic dissociation, salt hydrolysis and acid-baseequilibria.
5. Understanding Kinetic model of gas and itsproperties.
6. Maxwell distribution, mean-free path, kineticenergies.
7. Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of correspondingstates.
8. Liquid state and its physical properties related to temperature and pressurevariation.
9. Properties of liquid as solvent for various household and commercialuse.
10. Solids, lattice parameters – its calculation, application of symmetry, solid characteristics of simplesalts.
11. Ionic equilibria – electrolyte, ionization,dissociation.
12. Salt hydrolysis (acid-base hydrolysis) and its application inchemistry.

Physical Chemistry-I (Theory)

UNIT I: Gaseous state ***12 Lectures***

Behavior of real gases: Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behavior.van derWaals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and theircomparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

UNIT II: Liquid state ***5 Lectures***

Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, and their dependence on temperature, Effect of addition of various solutes on surface tension, cleansing action of detergents. Structure of water.

UNIT III: Ionic equilibria ***13 Lectures***

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of

ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-proticacids.

Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts.Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubilityproduct.

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

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations.Multistage equilibria in polyelectrolytes.

UNIT IV: Solid state *10 Lectures*

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitativeidea of point and space groups, seven crystal systems and fourteen Bravais lattices; X- ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Various types of defects in crystals, Glasses and liquid crystals.

Recommended Text books/references:

1. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
2. Ball, D. W. *Physical Chemistry* Thomson Press, India(2007).
3. Castellan, G. W. *Physical Chemistry* 4th Ed. Narosa(2004).
4. Mortimer, R. G. *Physical Chemistry* 3rd Ed. Elsevier: NOIDA, UP (2009). 5 G. M. Barrow, Tata McGraw Hill (Fifth Edition)(2007)

Physical Chemistry-I (Practical)

1. Surface tensionmeasurements.

a. Determine the surface tension by (i) drop number (ii) drop weightmethod.

b. Study the variation of surface tension of detergent solutions withconcentration.

2. Viscosity measurements using Ostwald'sviscometer.

a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at roomtemperature.

b. Viscosity of sucrose solution with the concentration ofsolute.

3. pH metry

a. Effect on pH of addition of HCl/NaOH to solutions of aceticacid,sodium acetate and their mixtures.

b. Preparation of buffer solutions of differentpH

   i. Sodium acetate-aceticacid

   ii. Ammonium chloride-ammoniumhydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strongbase.

d. Determination of dissociation constant of a weakacid.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended text books/references:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi(2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York(2003).
3 Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).
4 Athawale V. D. amd Mathur P. Experimental Physical Chemistry,, New Age Intenational (2001)

Course Outcome:

Graduate will have understanding of:

1. Familiarization with various states of matter. Physical properties of each state of matter and laws related to describe the states. Calculation of lattice parameters.
2. Electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria.
3. Kinetic model of gas and its properties. Maxwell distribution, mean-free path, kinetic energies. Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, andlaw of corresponding states.
4. Liquid state and its physical properties related to temperature and pressure variation. Properties of liquid as solvent for various household and commercial uses.
5. Solids, lattice parameters – its calculation, application of symmetry, solid characteristicsof simple salts.
6. Ionic equilibria – electrolyte, ionization, dissociation. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	1	1	1	1	1	1	1	1			3	
CO2	3	2	1	2	1	1	1	1	1	1	1	1			3	
CO3	3	2	1	2	1	1	1	1	1	1	1	1			3	
CO4	3	2	1	2	1	1	1	1	1	1	1	1			3	
CO5	3	2	1	2	1	1	1	1	1	1	1	1			3	
CO6	3	2	1	2	1	1	1	1	1	1	1	1			3	

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
II	CC 4	Organic Chemistry-II	Theory:3
			Practical: 2

Learning objective:

After completion of the course, the learner shall be able to understand:

- Familiarization about classes of organic compounds and their methods of preparation.
- Basic uses of reaction mechanisms.
- Name reactions, uses of various reagents and the mechanism of the reaction.
- Preparation and uses of various classes of organic compounds.
- Organometallic compounds and their uses.
- Organic chemistry reactions and reaction mechanisms.
- Use of reagents in various organic transformation reactions.

Organic Chemistry-II (Theory)

UNIT I: Chemistry of Halogenated Hydrocarbons *8 Lectures*

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

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

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

Organometallic compounds of Mg and Li and their use in synthesis.

UNIT II: Alcohols, Phenols, Ethers and Epoxides 6Lectures

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

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

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

UNIT III: Carbonyl Compounds *10 Lectures*

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff- Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);

Addition reactions of unsaturated carbonyl compounds: Michael addition.

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

UNIT IV: Carboxylic Acids and their Derivatives **10 Lectures**

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

UNIT V: Sulphur containing compounds ***6 Lectures***

Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Books/references:

1 Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc(2009).

2 McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013. 3 P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, NewDelhi.

4 Morrison R. T. and Boyd R. N. Organic Chemistry, Sixth Edition Prentice Hall India,2003.

Organic Chemistry-II (Practical)

1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols, carbonyl, carboxylic acid and amine group of compounds.
2. Organic preparations:
   - i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method.and Using green chemistryapproach)
   - ii. Benzolyation of one of the amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the phenols (*β*-naphthol, resorcinol, *p*-cresol) by Schotten-Baumannreaction.
   - iii. Oxidation of ethanol/ isopropanol (Iodoformreaction).
   - iv. Bromination (anyone)
     - a. Acetanilide by conventionalmethods
     - b. Acetanilide using green approach (Bromate-bromidemethod)
   - v. Nitration: (anyone)
     - a. Acetanilide/nitrobenzene by conventionalmethod
     - b. Salicylic acid by green approach (using ceric ammoniumnitrate).
   - vi. Selective reduction of *meta*dinitrobenzene to*m*-nitroaniline.
   - vii. Reduction of *p*-nitrobenzaldehyde by sodiumborohydride.
   - viii. Hydrolysis of amides andesters.
   - ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
   - x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid,

oxalic acid, phenyl acetic acid and phthalic acid).

xi. Aldol condensation with either conventional or green method.

xii. Benzil-Benzilic acid rearrangement.

Collected solid samples may be used for recrystallization, melting point and TLC.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1 Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)

2 Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson(2012)

3 Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press(2000)

4 Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press(2000).

Course Outcome:

Graduate will have understanding of:

1. Organic compounds and their methods of preparation. Basic uses of reaction mechanisms.
2. Name reactions, uses of various reagents and the mechanism of the reaction.
3. Preparation and uses of various classes of organic compounds.
4. Organometallic compounds and their uses.
5. Organic chemistry reactions and reaction mechanisms.
6. Use of reagents in various organic transformation reactions.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	1	1	1	1	1	1	1	1		2		3
CO2	3	2	1	2	1	1	1	1	1	1	1	1		2		3
CO3	3	2	1	2	1	1	1	1	1	1	1	1		2		3
CO4	3	2	1	2	1	1	1	1	1	1	1	1		2		3
CO5	3	2	1	2	1	1	1	1	1	1	1	1		2		3
CO6	3	2	1	2	1	1	1	1	1	1	1	1		2		3

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
II	GE-II	Kinetic Theory of Gases, Chemical Energetics, Equilibria& Functional Group Organic Chemistry	Theory: 3
			Practical: 2

Theory: 45Hours

Section – A: Physical Chemistry – 1

Unit – 1: Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation.Andrews isotherms of CO_2.

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance.

Temperature dependence of these distributions.Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(8 Hours)

Unit – 2: Chemical Energetics

Chemical Energetics: Introduction of different terms and processes in thermodynamics: [systems (isolated, closed, open) and surrounding, macroscopic properties, state and path functions and their differentials.

First Law: concept of heat, q, work, w, internal energy, U, sign convention for heat and work, nature of work, path dependence of work and heat; statement of first law; enthalpy, H, heat changes at constant volume and constant pressure; heat capacities (C_v, C_p) and relation between them for ideal gases. Reversible and irreversible processes, maximum work, thermodynamic quantities (w, q, ΔU, ΔH) and its calculation for isothermal and adiabatic reversible expansion of ideal gases. Ideal gas law for adiabatic reversible expansion, comparison of adiabatic and isothermal reversible expansion. Joule-Thomson effect, JouleThomson coefficient in ideal and real (van der Waal) gases, inversion temperature. ***Thermo-chemistry***: Standard state, standard enthalpy of formation, Hess's Laws of constant heat summation and its application. Change in internal energy (ΔU) and enthalpy (ΔH) of chemical reactions, relation between ΔU and ΔH, variation of heat of reaction with temperature (Kirchhoff's equation). Enthalpy of neutralization. Bond Energy – Bond dissociation energy and its calculation from thermo-chemical data.– Kirchhoff's equation.

Second law of thermodynamics, concept of entropy, free energy work functions, Gibbs Helmholtz equation and its applications

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

(9 Hours)

Unit – 3: Chemical and Ionic Equilibrium

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

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

applications of solubility product principle.

(6 Hours)

Section – B: Organic Chemistry – 2

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

Unit – 1: Aromatic Hydrocarbons & Alkyl and Aryl Halides

Aromatic Hydrocarbons**:** *Preparation* (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation andacylation) (upto 4 carbons on benzene).Side chain oxidation of alkyl benzenes (upto 4carbons on benzene); aromatic hydrocarbon side chain reactions.

Alkyl Halides (upto 5 Carbons): Types of Nucleophilic Substitution (S_N2, S_N1, S_Ni)reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite & nitroformation, nitrile &isonitrile formation. Williamson's ether synthesis: Elimination vssubstitution.

Aryl Halides**:** *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer &Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilicsubstitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 or $NaNH_2/NH_3$ reagent system. Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(7 Lectures)

Unit – 2: Alcohols, Phenols, Ethers, Aldehydes and Ketones (Upto 5 Carbons)

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

Phenols**:** (Phenol case) *Preparation:* Cumenehydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten–Baumann Reaction.

Ethers (Aliphatic and Aromatic)**:** Cleavage of ethers with HI.

Aldehydes and Ketones (Aliphatic and Aromatic): (Formaldehye, acetaldehyde, acetone andbenzaldehyde); *Preparation:* from acid chlorides and from nitriles. *Reactions* -Reaction withHCN, ROH, $NaHSO_3$, NH-G derivatives. Iodoform test.Aldol Condensation, Cannizzaro'sreaction, Wittig reaction, Benzoin condensation.Clemensen reduction and Wolff Kishnerreduction.Meerwein-PondorffVerley reduction.

(9 Hours)

Unit – 3: Carboxylic acids and their derivatives& Amines salt

Carboxylic acids (aliphatic and aromatic):*Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell – Vohlard - Zelinsky Reaction. *Preparation:* Acid chlorides, Anhydrides, Esters and Amides from acids and theirinterconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction,Perkin condensation.

Amines and Diazonium Salts: Amines (Aliphatic and Aromatic): (Upto 5 carbons), *Preparation*: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamidereaction. *Reactions:* Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2,Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts:*Preparation:*from aromatic amines. *Reactions:* conversion to benzene, phenol, dyes.

(6Hours)

Reference Books:

- T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons*.
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- J. C. Kotz, P. M. Treichel& J. R. Townsend: *General Chemistry*CengageLening India Pvt. Ltd., New Delhi (2009).
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).

GE PRACTICAL – II(Kinetic Theory of Gases, Chemical Energetics, Equilibria&Functional Group Organic Chemistry)

(30Hours)

Section – A: Physical Chemistry

Thermochemistry

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

Ionic Equilibria

pH measurements

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

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

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

Section – B: Organic Chemistry

I Systematic Qualitative Organic Analysis of Organic Compounds possessingmonofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Criteria of Purity: Determination of melting and boiling points.
2. Purification of organic compounds by crystallization (from water and alcohol) and distillation.

3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline
(b) Benzoylation of amines/phenols
(c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

Reference Books

- A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
- F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry*, UniversitiesPress
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

Course Outcome:

Graduate will have understanding of:

1. Kinetic model of gas and its properties. Maxwell distribution, mean-free path, kinetic energies. Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, andlaw of corresponding states.
2. Liquid state and its physical properties related to temperature and pressure variation. Properties of liquid as solvent for various household and commercial uses.
3. Solids, lattice parameters – its calculation, application of symmetry, solid characteristicsof simple salts.
4. Ionic equilibria – electrolyte, ionization, dissociation. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.
5. Organic compounds and their methods of preparation. Basic uses of reaction mechanisms.Name reactions, uses of various reagents and the mechanism of the reaction.
6. Preparation and uses of various classes of organic compounds.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	2	1	1	1	1	1	1	1	1		2	2	2
CO2	3	2	1	2	1	1	1	1	1	1	1	1		2	2	2
CO3	3	2	1	2	1	1	1	1	1	1	1	1		2	2	2
CO4	3	2	1	2	1	1	1	1	1	1	1	1		2	2	2
CO5	3	2	1	2	1	1	1	1	1	1	1	1		2	2	2
CO6	3	2	1	2	1	1	1	1	1	1	1	1		2	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Ability Enhancement Courses

Semester	Course	Name of the course	Credits
I,II	AEC 1	English for communication	Theory:2

Learning Objective:

On completion of this course, the students will be able to understand about:

- The features of communication
- The various writing skills
- The scientific and technical writings

Unit I: Communication ***3 Lectures***

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

Unit II: Writing Skills ***5 lectures***

Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

Unit III: Technical Writing ***4 lectures***

Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided.

Course Outcome:

Graduate will have understanding of:

1. The features of communication
2. The various writing skills
3. The scientific and technical writings

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1		2	1	2	1	1	1	1	1	1	3	1				
CO2		2	1	2	1	1	1	1	1	1	3	1				
CO3		2	1	2	1	1	1	1	1	1	3	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 2	Intellectual Property Rights	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

1. Understand the concept of IPR
2. Differentiate between various agreements ofIPR
3. Compare copyrights, patents and GeographicalIndicators
4. Examine various legal issues related toIPR
5. Relate to various cyber issues concerning IPR

Keywords:

Copyright act, IPR and WTO, Patents, Bioprospecting, Biopiracy, Database

Unit I: Introduction to Intellectual PropertyRight(IPR) (7 lectures)

Copyright Act and IPR, Economic importance. IPR in India and world: Genesis and scope, some important examples. IPR and WTO (TRIPS, WIPO).Objectives, Rights, Patent Act 1970 and itsamendments.

Unit II: Patents, CopyrightsandTrademarks (7lectures)

Procedure of obtaining patents, working of patents. Infringement of patents, Copyrights: work protected under copyright laws, Rights, Transfer of Copyright, Infringement. Trademarks: Objectives of trademarks, Types, Rights, Protection of goodwill, Infringement, Passing off, Defenses, Domain name.

Unit III: Protection of Traditional Knowledge, Industrial Designs and Plant Varieties

(7 lectures)

Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bioprospecting andBio-piracy, Alternative ways, Protectability, need for a Sui-Generis regime, Traditional Knowledge on the International Arena, at WTO, at National level, Plant varieties protection in India. Rights of farmers, National gene bank, Benefit sharing. Protection of Plant Varieties and Farmers' Rights Act, 2001.

Unit IV: Information Technology Related IPR (7 lectures)

Computer Software and Intellectual Property, Database and Data Protection, Protection of Semiconductor chips, Domain Name Protection. Patenting Biotech Inventions: Objective, Applications, Concept of Novelty, Concept of inventive step, Microorganisms, and Moral Issues in Patenting Biotechnological inventions.

Practical:

The students are expected to prepare some project report based on the Success stories of Traditional Patents secured by India. Likewise, prepare a database for Indian products wherein is issue is still under consideration of the competent authorities. Prepare the dos and don'ts on Patents for Botanists.

Suggested Readings

1. N.S. Gopalakrishnan and T.G. Agitha, (2009) Principles of Intellectual Property Eastern Book Company,Lucknow.

2. David Kitchin QC , David Llewelyn , James Mellor , Richard Meade , Thomas Moody-Stuart,and D. Keeling, Robin Jacob (2005). Kerly's Law of Trade Marks and Trade Names (14th Edition) Thomson, Sweet &Maxweel.
3. Ajit Parulekar and Sarita D' Souza, (2006) Indian Patents Law – Legal & Business Implications; Macmillan IndiaLtd.
4. B.L.Wadehra (2000) Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal law Publishing Pvt. Ltd.,India.
5. P. Narayanan (2010) Law of Copyright and Industrial Designs; Eastern law House,Delhi.

Course Outcome:

Graduate will have understanding of:

1. The concept of IPR
2. Differentiate between various agreements of IPR
3. Compare copyrights, patents and Geographical Indicators
4. Examine various legal issues related to IPR
5. various cyber issues concerning IPR

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	1	1	1	1	1	1				
CO2	1	2	1	2	1	1	1	1	1	1	1	1				
CO3	1	2	1	2	1	1	1	1	1	1	1	1				
CO4	1	2	1	2	1	1	1	1	1	1	1	1				
CO5	1	2	1	2	1	1	1	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 3	History of Indian Science	Theory:2

Learning outcomes

On completion of this course, the students will be able to:

- Develop understanding of various branches of science during different eras
- Analyze the role played by different Indian organizations in science
- Learn about the science and techniques used in ancient India
- Appraise the contribution of different Indian Scientists in science

Keywords:

Astronomy, Ancient India, Colonial India, Modern India, Agricultural techniques, Greenrevolution

Unit I: Science in Ancient and MedievalIndia **8 Lectures**

History of development in astronomy, mathematics, engineering and medicine subjects in Ancient India, Use of copper, bronze and iron in Ancient India, The geography in literature of Ancient India. Influence of the Islamic world and Europe on developments in the fields of mathematics, chemistry, astronomy and medicine, innovations in the field of agriculture-newcrop introduced new techniques ofirrigation.

Unit II: Indian Science in before and after Independence **7 Lectures**

Introduction of different surveyors, botanists and doctors as early scientist in Colonial India, Indian perception and adoption for new scientific knowledge in Modern India, Establishment of premier research organizations like CSIR, DRDO and ICAR and ICMR, Establishment of Atomic Energy Commission, Launching of the space satellites, Botanical survey ofIndia.

Unit III: Prominent Indian scientists ***8 Lectures***

Eminent scholars in mathematics and astronomy: Baudhayana, Aryabhtatta, Brahmgupta, Bhaskaracharya, Varahamihira, and Nagarjuna, Medical science of Ancient India (Ayurveda and Yoga): Susruta, Charak. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha and Vikram Sarabhai.

Unit IV: Prominent research in Plant Sciences in Republic of India **7 Lectures**

History of plant tissue culture from India, Green revolution in India: causes, details, and outcomes. First gene cloning in plants, First genome sequencing from India.Premier Plant Research institutes and scientists in India, GM Mustard. Allelopathy Plant research in India

Practical:

There is no experimental lab based Practical. However, the students are expected to prepare some term paper reports on the Life and works of some noted Indian Scientists especially the Botanists. Likewise, students need to prepare and organize some discussion on the ancient and medieval science in India and trace the reasons of inadequate visibility in the world. Prepare term papers on GM Crops, the controversies and procedure for approval. Prepare term papers on the significance of Allelopathic research fromIndia.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested Readings

1. Kuppuram G (1990) History of Science and Technology in India, South AsiaBooks.
2. Handa O. C. (2014) Reflections on the history of Indian Science and Technology, PentagonPress.
3. Basu A (2006) Chemical Science in Colonial India: The Science in Social History, K.P. Bagchi &Co.
4. Habib I, (2016.)A people's history of India 20: Technology in Medieval India, 5th Edition, Tulika Books.
5. A. Rahman et al (1982) Science and Technology in Medieval India – A Bibliography of Source Materials in Sanskrit, Arabic and Persian, New Delhi: Indian National Science Academy.
6. B. V. Subbarayappa & K. V. Sarma (1985), Indian Astronomy -– A Source Book, Bombay.
7. Srinivasan S, Ranganathan S (2013) Minerals and Metals heritage of India, National Institute of AdvancedStudies.
8. Srinivasiengar C N, (1967) The History of Ancient Indian Mathematics, World Press Private Ltd.Calcutta.
9. Bhardwaj H C (2000) Metallurgy in Indian Archaeology. Tara BookAgency

Course Outcome:

Graduate will have understanding of:

1. Develop understanding of various branches of science during different eras
2. Analyze the role played by different Indian organizations in science
3. Learn about the science and techniques used in ancient India
4. Appraise the contribution of different Indian Scientists in science

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	1	1	1	1	1	1	1				
CO2	2	2	1	2	1	1	1	1	1	1	1	1				
CO3	2	2	1	2	1	1	1	1	1	1	1	1				
CO4	2	2	1	2	1	1	1	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 4	Good Laboratory Practices	Theory:2

Learning Outcomes

On completion of this course, the students will be able to:

1. Apply practical skills in science courses with the understanding of general laboratorypractices
2. Explore various research issues and their solutions
3. Apply various techniques to study chemical compounds, salts
4. Use various micro techniques used in chemistry

Keywords:

Laboratory calculations, calibration procedures, use of glassware, safety aspects inpreparation

Unit I: General Laboratory Practices 5 lectures

Common calculations in chemistry laboratories.Understanding the details on the label of reagent bottles.Preparation of solutions.Molarity and normality of common acids and bases.Dilutions.Percentage solutions.Molar, molal and normal solutions.Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit II: Instrument-Techniques and laboratory preparation procedure. 5 lectures

Use of micropipette, analytical balances, pH meter, conductivity meter, rotary evaporator, potentiometer.Use of purified water in lab experiments, Cleaning and drying of glassware, Preparation of crystals from given salt.Preparation of Dyes, Demonstration of preparation of material using Sol-gel procedure.

Suggested Readings

1. Seiler, J.P. (2005). Good Laboratory Practices: the why and how. Springer-Verlag Berlinand Heidelberg GmbH & Co. K; 2nded.
2. Garner, W.Y., Barge M.S., Ussary. P.J. (1992). Good Laboratory PracticeStandards: Application for field and Laboratory studies. WileyVCH.

Course Outcome:

Graduate will have understanding of:

1. Apply practical skills in science courses with the understanding of general laboratorypractices
2. Explore various research issues and their solutions
3. Apply various techniques to study chemical compounds, salts
4. Use various micro techniques used in chemistry

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	1	1	1	1	1	1	1	2	2	2	2

CO2	2	2	1	2	1	1	1	1	1	1	1	1	2	2	2	2
CO3	2	2	1	2	1	1	1	1	1	1	1	1	2	2	2	2
CO4	2	2	1	2	1	1	1	1	1	1	1	1	2	2	2	2

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 5	Introduction to Forensic Science and technology	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

a. Understand the scope of forensic science
b. Understand about various types of evidences
c. Analyse various evidences
d. Utilize various chemical analytical tools to analyze evidences.

Unit I *20 Lectures*

Scope of forensic science, Evidences in criminal law (act, case studies), Physical evidences(identification, collection and preservation of sample, physical properties of sample material, use of physical evidences in criminal proceedings), biological evidences (drugs, effects, identification, serology of blood, semen, saliva, DNA evidence, use of biological evidence in criminal proceedings), trace evidences (finger print, blood stream, hair, firearms, fibers, paints, etc),

Unit II *10 Lectures*

basic techniques of chemical analysis (FTIR, Mass spectroscopy, HPLC and GC with example of analysis). Admissible and non-admissible scientific evidence in legal system, Principle and limitation of DNA finger printing.

Recommended Books/references:

1. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001).
2. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi(2002).
3. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton(2005)
4. W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton (2013).

Course Outcome:

Graduate will have understanding of:

1. The scope of forensic science
2. About various types of evidences
3. Analyze various evidences
4. Utilize various chemical analytical tools to analyze evidences.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

CO3	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO4	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 6	Renewable Energies (solar and biogas)	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

a. Know about the renewable energy sources
b. Utilize various renewable energy technologies to solve future energy consumptionproblems
c. Identify biomass sources
d. Estimate chemical composition of biomasses

Unit I: ***10 Lectures***

Introduction to renewable energy sources – solar, wind, small hydro, biomass, geothermal and ocean energy, energy flow in ecosystem Solar Energy Resources Solar radiation: Spectrum of EM radiation, sun structure and characteristics, extraterrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectraldistribution

Unit II: ***10 Lectures***

Measurement of solar radiation Instruments: sunshine recorder, Pyranometer, Pyrheliometer, Albedometer. Radiation measurement stations in India (NIWE, IMD etc.), solar radiation data, graphs, Meteonorm and NASA-SSE databases Hands-on measurement of beam, diffuse and total radiation

Unit III: ***15 Lectures***

Solar mapping using satellite data, Typical Meteorological Year, Models and methods for estimating solar radiation, estimation of global radiation, estimation of diffused components

Basics Biomass resources: plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis. Biomass resource assessment Estimation of woody biomass, non woody biomass and wastes, ASTM standards, Bulk chemical properties Moisture content, proximate and ultimate analyses, calorific value, waste water analysis for solids

Unit IV: ***15 Lectures***

Chemical composition of biomass Cellulose, hemicelluloses and lignin content in common agricultural residues and their estimation, protein content in biomass, extractable, COD.Structural properties Physical structure, particle size and size distribution, permeability. Physical properties: Bulk density, angle of repose, thermal analysis (thermogravimetric, differential thermal and differential scanning calorimetry).Properties of microbial biomass: Protein estimation, flocculating ability, relative hydrophobicity of sludge, sludge volume index.

Course Outcome:

Graduate will have understanding of:

1. Know about the renewable energy sources
2. Utilize various renewable energy technologies to solve future energy consumptionproblems
3. Identify biomass sources
4. Estimate chemical composition of biomasses

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO4	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 7	Chemoinformatics	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

i. Know about the history and prospects of chemo-informatics
ii. Represent molecules and chemical reaction using different notations, SMILES andMatrix representaion
iii. Search chemical structure and application of chemo-informatics in various fields

Unit I ***5 Lectures***

Introduction to Chemo-informatics: History, Prospects of chemoinformatics, Molecular Modelling and Structure elucidation.

Unit II ***10 Lectures***

Representation of molecules and chemical reactions: Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Unit III ***10 Lectures***

Searching chemical structures: Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit IV ***15 Lectures***

Applications: Prediction of Properties of Compounds; Linear Free Energy Relations; Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; Modeling.Toxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; Computer Assisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drug design; Target Identification and Validation; Lead Finding and Optimization; Analysis of HTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand and structure based drug design; Applications in Drug Design.

Recommended Books/references:

1. Andrew R. Leach and Valerie, J. Gillet (2007) *An introduction toChemoinformatics.* Springer: The Netherlands.
2. Gasteiger, J. and Engel, T. (2003) *Chemoinformatics: A text-book.*Wiley-VCH.
3. Gupta, S. P. (2011) *QSAR & Molecular Modeling.* Anamaya Pub.: New Delhi.

Course Outcome:

Graduate will have understanding of:

1. The history and prospects of chemo-informatics.
2. Represent molecules and chemical reaction using different notations, SMILES and Matrix representation.
3. Search chemical structure and application of chemo-informatics in various fields.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 8	Water remediation and conservation studies	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Know about the various sources of water pollution
- Know the normal standard of potable water as per WHO recommendation
- Understand water conservation and erosion of soil
- Develop various water remediation and conservation studies

Unit-I *10 Lectures*

Sources of water pollutants, pollutants, Industrial and human contribution, WHO recommendation about potable water, current scenario of drinking water quality, chemistry of toxicants like arsenic, fluoride, chromium, lead and mercury, cause and effects of water pollution, remediation, techniques involved such as adsorption, coagulation-filtration, Nalgonada techniques, reverse osmosis, activated charcoal detoxification, applications of non-toxic oxides and mixed oxides, regeneration and recycling, mechanisms of detoxification, bio-remediation, need of green chemistry, futurescope.

Unit-II *10 Lectures*

Introduction to water conservation and erosion of soil, forms of water erosion, factors affecting water erosion, types of water erosion, mechanics of water erosion control, agronomical measures of water erosion control, Terraces for water erosion control:

Modeling of watershed processes, Case study of water-shed modeling for water conservation and water quality.

Recommended Books/references:

1. Cittenden J. C. , Trussell J. R., Hand D. W., Howe K. J., Tchobanoglous G. , Water treatment: Principles and Design MWHpublication.
2. De A. K. Environmental Chemistry, WileyEastern
3. Clarson D., Dara S. S. A text book of Environmental chemistry and pollution control, S Chand Co. Soil and water analyticalmethod
4. Edzwald J., Water Quality & Treatment: A Handbook on Drinking Water (Water Resources and Environmental EngineeringSeries)

Course Outcome:

Graduate will have understanding of:

1. The various sources of water pollution
2. The normal standard of potable water as per WHO recommendation
3. Water conservation and erosion of soil
4. Develop various water remediation and conservation studies

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO4	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 9	Research Methodology	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

- Understand the concept of research and different types of research in the context of biology
- Develop laboratory experiment relatedskills.
- Develop competence on data collection and process of scientificdocumentation
- Analyze the ethical aspects ofresearch Evaluate the different methods of scientific writing andreporting

Keywords:

Qualitative, Quantitative, Reproducibility, Scientific methodology, Plagiarism, Scientificmisconduct, Ethics in Science

Unit I: Basic ConceptsofResearch **12 lectures**

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs. qualitative; conceptual vs empirical).Research methods vs methodology.Literature-review and its consolidation; Library research; field research; laboratoryresearch.

Unit II: Data Collection and DocumentationofObservations **12lectures**

Maintaininga laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of fieldphotography.

Unit III: Overview of Application to Chemistryrelated problems ***5 lectures***

Key chemistry research areas, chemoinfomatics.

Unit IV: Ethics and Good Practical's and Art of Scientific Writing **11 lectures**

Authors, acknowledgements, reproducibility, plagiarism, Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references.Power-point presentation.Poster presentation.Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

Practical

a. Experiments based on chemicalcalculations.
b. Lab computationalexperiments.
c. Poster presentation on definedtopics.
d. Technical writing on topicsassigned.
e. Identification of different type of research in day by daylife.
f. Curation of relevant scientific literature from GoogleScholar.
g. Demonstration for checking of plagiarism using recommendedsoftware.
h. Technical writing on topicsassigned.

Note: Experiments may be added/deleted subject to availability of time and facilities

Suggested Readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, NewDelhi.

Course Outcome:

Graduate will have understanding of:

1. Understand the concept of research and different types of research in the context ofbiology
2. Develop laboratory experiment related skills.
3. Develop competence on data collection and process of scientific documentation
4. Analyze the ethical aspects of research Evaluate the different methods of scientificwriting and reporting

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO4	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 10	Chemistry in Everyday life	Theory:2

Learning Objective:

On completion of this course, the students will be able to:

1. Understand the chemical processes involved in daily life
2. Know the respiration process in terms of chemistry
3. Understand chemicals hazardous for health
4. Understand chemical structures of various vitamins
5. Understand role of minerals in important biological processes.

Unit I: Respiration and energy production in human body **8 Lectures**

Respiration, Respiratory enzymes, brief outline of hemoglobin and myoglobin, oxygen transport mechanism in body, co-operativity, Respiration in lower animals, hemocyanine, hemerythrine. Energy production in body, ATP; enzyme responsible for food digestion, mechanism of food digestion, active site of cytochrome c-oxidase.

Unit II: Chemical aspects of some common health hazards ***5 Lectures***

Anemia, sickle cell anemia, leukemia, blood pressure irregulation, blood sugar, arthritis, carbonmonoxide poisoning in mines, cyanide poisoning, fluorosis etc.

Unit III: Vitamins and minerals ***5 Lectures***

Need for vitamin in body, types of vitamins, water soluble and fat-soluble vitamins, Vitamin B- 12, vitamin C (Cyanocobalamine), D, Vitamin K. Role of minerals in body, iodine deficiency andremedy.

Unit IV: Significance of Radical chemistry in living system **10 Lectures**

Radical production in environment, superoxide and peroxide, health impact, action of radicals, cell mutation, diseases caused by free radical, cancer, radical quencher, anti-oxidants, natural anti-oxidants like vegetables, beverages like tea and coffee, fruits.Radical destroying enzymes: superoxide dismutase, catalase, peroxidase, mechanism of action.

Unit V: Chemistry of Materials ***10 Lectures***

Soaps and Detergents – their action, Biofuels – production of biofuels and its utility as alternative fuel source, Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, PVA; Examples of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, syntheticbiodegradable polymers. Use of polymeric materials in dailylife.

Suggested Laboratory experiments:

1. Analysis of soaps anddetergents.
2. Analysis of Biofuels - flash point, pour point, cloudpoint
3. Preparation ofNylon6/6,6
4. Testing of adulterant in food, oil andvegetable

5. Vitamin-Cpreparation.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/references:

1. Kaim W, Bioinorganic Chemistry, Vol 4, Brigitte Scwederski, Wiley,1994.
2. Crichton R. H. Biological Inorganic Chemistry – An Introduction, Elsevier,2008.
3. Berg J. M., Tymoczeko J. L., Stryer l. Biochemistry, W. H. Freeman,2008.
4. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) *Bioinorganic Chemistry.* University Science Books(1994)
5. Lippard S., Berg J. M. Principles of Bioinorganic Chemistry; University Science Books 1994.
6. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International.

Course Outcome:

Graduate will have understanding of:

1. The chemical processes involved in daily life
2. Know the respiration process in terms of chemistry
3. Chemicals hazardous for health
4. Chemical structures of various vitamins
5. Role of minerals in important biological processes.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO4	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO5	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II	AEC 11	Chemistry of food, nutrition, and preservation	Theory:2

Learning objective:

On completion of this course, the students will be able

1. To know about the basic of human physiological system
2. To learn about the nutrition and itsimportance
3. To learn about the foodscience
4. To learn about the food preservation and itsutility
5. To learn about the Quantitative estimation and nutritional assessment data

Key words: Food, nutrition, preservation.

Unit-I ***10 Lectures***

Basic of human physiological system and food science:Digestive System: Structure and functions of G.I. tract, Process of digestion and absorption of food, Structure and functions of liver, gallbladder and pancreas.Basic concept on Food, Nutrition and Nutrients (Nutrition, Malnutrition and Health: Scope of Nutrition.), Classification of Food, Classification of Nutrients.

Unit-II ***10 Lectures***

Nutrition: Dietary fibers (composition, properties and Minerals and trace elements(biochemical and physiological role, bioavailability and requirement with examples), Vitamines (examples, biochemical and physiological requirements, deficiency and excesses), Water (requirement, water balance), basic idea about community nutrition (objective, importance of various programmes).

Unit-III ***10 Lectures***

Food preservation: definition, objectives and principles of food preservation. Different methodsof food preservation. Preserved Products: Jam, Jelly, Marmalade, Sauces, Pickles, Squashes, Syrups-types, composition and manufacture, selection, cost, storage, uses and nutritional aspects, Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI.

Practical:

Identification of Mono, Di and polysaccharides, Identification of Proteins, Identification of glycerol., Determination of moisture content in food, ash content and determination of calcium, iron, vitamin-C.

Comparison with norms and interpretation of the nutritional assessment data and its significance. Weight for age, height for age, weight for height, body Mass Index (BMI) Waist - Hip Ratio (WHR). Skin fold thickness.

Quantitative estimation of Sugars (Glucose, lactose, starch), Estimation of acid value, iodine value, Saponification value of fats, Estimation of blood Glucose, Estimation of serum cholesterol.

Note: Experiments may be added/deleted subject to availability of time and facilities

Reference/suggested books

1. Sri Lakshmi B(2017): Nutrition Science,6th Multicolour Ed. New Age International

(P)Ltd.
2. Roday S (2012): Food Science and Nutrition, 2nd Ed. Oxford UniversityPress.
3. Mann J and Truswell S(2017) : Essentials of Human Nutrition, 5th Ed. Oxford University Press.
4. Wilson K and Walker J(2000): Principles and Techniques of Practical Biochemistry, 5th Ed. Oxford UniversityPress.
5. Sadasivan S and Manikam K(2007): Biochemical Methods, 3rd Ed. New Age International (P) Ltd.
6. Oser B. L. (1965). Hawk's Physiological Chemistry, 14th Ed. McGraw-HillBook.
7. Gopalan C, Rama Sastri BV and Balasubramanian S.C. (2016): Nutritive value of Indian Foods, Indian Council of MedicalResearch.
8. Subalakshmi, G and Udipi, SA(2006):Food processing and preservation, 1st Ed. New Age International(P)Ltd.
9. Srilakshmi B(2018): Food Science, 7th Colour Ed. New Age International (P) Ltd.
10. Potter NN and Hotchkiss JH(1999): Food science,5th Ed ,Spinger.

Course Outcome:

Graduate will have understanding of:

1. The basic of human physiological system
2. The nutrition and its importance
3. The food science
4. The food preservation and its utility
5. The Quantitative estimation and nutritional assessment data

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO2	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO3	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO4	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1
CO5	2	2	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

SKILL ENHANCEMENT COURSES

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 1	Personality Development	Theory: 2

Learning outcomes:

After the completion of this course, the learner will be able to:

1. Develop understanding of the concepts and principles of basic psychological skills
2. Apply techniques and methods to enhance productivity and time management
3. Develop critical thinking skills
4. Organize human resources with improved leadership qualities

Keywords:

Mental heuristics, Mental priming, Checklists, Stress management, Cognitive biases, Leadershipqualities

Unit I: Basic Psychology Skills ***8Lectures***

Mental Heuristics and Priming, Cialdini's six psychological principles, Charisma and charismaenhancements, facing interviews

Unit II: Productivity andTimeManagement **7 Lectures**

Eisenhower Matrix, Pomodoro Technique, Dealing with Procrastination, Journaling methods, Checklists, to-do lists and scheduling theevents

Unit III: Dealing Negativity ***7 Lectures***

Work-life balance, stress management, coping with failures anddepression

Unit IV: Critical Thinking andHumanresources **8 Lectures**

Logical fallacies, Cognitive biases, Mental Models, Critical Thinking. Evaluation and improvement; Leadershipqualities.

Suggested Readings

1. Bast, F. (2016). Crux of time management for students. Available at:https://www.ias.ac.in/article/fulltext/reso/021/01/0071-0088

2. Cialdini, R.B. (2001). Influence: The Psychology of Persuasion, Revised Edition. Harper Collius.

3. Green, C.J. (2015). Leadership and soft skills for students: Empowered to succeed in High School, College and beyond. Dog EarPublishing.

4. Velayudhan, A. and Amudhadevi, N. V. (2012). Personality Development for College Students. LAP Lambert AcademicPublishing.

Course Outcome:

Graduate will have understanding of:

1. Develop understanding of the concepts and principles of basic psychological skills
2. Apply techniques and methods to enhance productivity and time management
3. Develop critical thinking skills
4. Organize human resources with improved leadership qualities

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				
CO4	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 2	Computer Applications in Chemistry	Theory: 2

Learning outcomes:

After the completion of this course the learner will be able to:

1. Apply the basic operations of spreadsheetapplications
2. Recognize advanced resources for accessing scholarly literature frominternet
3. Utilize bibliography management software while typing and downloadingcitations
4. Operate various software resources with advanced functions and its open office substitutes

Keywords:

Spreadsheet, Google search, Subscription, Bibliography, MS office, Image processing

Unit I:SpreadsheetApplications ***8 Lectures***

Introduction of spreadsheet (MS Excel), application, formulas and functions, performing basic statistics using spreadsheet applications, creating basic graphs using spreadsheet applications, logical (Boolean) operators.

Unit II:InternetResources ***7Lectures***

Advanced Google search operators and Boolean functions, Introduction to Google Scholar and accessing scholarly literature from Internet, Fake News and spotting the fake news, multimedia resources and podcasts, RSS/XML Feeds and feed subscription using a feed reader.

Unit III:Bibliographymanagement **8 Lectures**

Introducing a bibliography management software (for e.g. Endnote), Styles and Templates,Changing the bibliography style as per journal format, Citing while typing in the office application, downloading citations from Google Scholar.

Unit IV: Othersoftwareresources ***7 Lectures***

Introduction to advanced functions of MS Word and its Open Office substitutes including tracking changes, inserting page numbers and automatic table of contents, Google Docs and Forms, MS Power point, Microphotography and scale calibration with ImageJ, digital image processing (Paint.net or GIMP).

Suggested Readings

1. User manual and online user manual of respective soft wares for the most updated content
2. Published books are not recommended as versions keep on updating very frequently; therefore, it is not easy to follow.

Course Outcome:

Graduate will have understanding of:

1. Apply the basic operations of spread sheet applications
2. Recognize advanced resources for accessing scholarly literature from internet
3. Utilize bibliography management software while typing and downloading citations
4. Operate various software resources with advanced functions and its open office substitutes

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				
CO4	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 3	Science Communication and Popularization	Theory:2

Learning outcomes:

After the completion of this course, the learner will be able to:

1. Identify the need and role of science communication in humandevelopment
2. utilize visual media science communication for creating scripts anddocumentaries
3. Contribute in science popularization through internet communication and public sensitization

Keywords:

Print science, Visual media, Internet communication, Blogs, Outreach talks, Public sensitization

Unit I: PrintScienceCommunication ***9 lectures***

Need for Science Journalism: Science has potential for breaking news, impact on Human life, impact on technology. Role of science and technology in human development.Framing policies at national and international levels. Writing and communicating popular articles effectively, case studies of celebrated works of science communicators including Cosmos by Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and Matt Riddley, importance for communication through regionallanguages.

Unit II: Visual MediaScienceCommunication ***7 lectures***

Science outreach through visual media: Creating science documentaries, creating the outline and expanding, scripts, citing authentic sources, case study: Famous documentaries of Carl Sagan, David Attenborough and Prof. Yashpal

Unit III: InternetScienceCommunication ***7 lectures***

Science outreach through internet: Social media, Websites, Blogs, Youtube, Podcast etc.

Unit IV: Science Outreach Talks and Public Sensitization ***7lectures***

Tactics for providing a charismatic and effective public talk, use of metaphors, speaking incontext, Science outreach for biodiversity conservation sensitization of public

Suggested Readings

1. Selected works of Carl Sagan, works of Bill Bryson, Richard Dawkins, Richard Feynman, Isaac Asimov, Carl Zimmer and MattRiddley.
2. Gigante, E. Marie (2018). Introducing Science Through Images: Cases of Visual Popularization (Studies in Rhetoric/Communication), University of South CarolinaPress.

Course Outcome:

Graduate will have understanding of:

1. Identify the need and role of science communication in human development
2. Utilize visual media science communication for creating scripts and documentaries
3. Contribute in science popularization through internet communication and public sensitization

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,III,IV	SEC 4	Biofertilizers (Practical based course)	Theory: 2

Learning outcomes:

On the completion of this course, the students will be able to;

- Develop their understanding on the concept ofbio-fertilizer
- Identify the different forms of biofertilizers and theiruses
- Compose the Green manuring and organicfertilizers
- Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers

Keywords:

Useful microbes, Cyanobacteria, Mycorrhiza, Organic farming, Recycling, Vermicompost

UnitI ***9 Lectures***

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

Unit II ***7 Lectures***

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

UnitIII ***7 lectures***

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation andinoculum production of VAM, and its influence on growth and yield of crop plants.

Unit IV ***7 lectures***

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

Suggested Readings

1. Dubey, R.C. (2005). A Text book of Biotechnology S.Chand & Co, NewDelhi.
2. John Jothi Prakash, E. (2004). Outlines of PlantBiotechnology.Emka Publication, NewDelhi.
3. Kumaresan, V.(2005). Biotechnology, Saras Publications, NewDelhi.
4. NIIR Board. (2012). The complete Technology Book on Biofertilizer and organic farming. 2nd Edition. NIIR Project ConsultancyServices.
5. Sathe, T.V. (2004) Vermiculture and Organic Farming. Dayapublishers.
6. Subba Rao N.S. (2017). Biofertilizers in Agriculture and Forestry. Fourth Edition. Medtech.
7. Vayas,S.C, Vayas, S. and Modi, H.A. (1998). Bio-fertilizersandorganicFarming Akta Prakashan,Nadiad.

Course Outcome:

Graduate will have understanding of:

1. Develop their understanding on the concept ofbio-fertilizer
2. Identify the different forms of biofertilizers and theiruses
3. Compose the Green manuring and organicfertilizers
4. Develop the integrated management for better crop production by using both nitrogenous and phosphate bio fertilizers

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 5	Herbal Science & Technology	Theory: 2

Learning outcomes:

On completion of this course the students will be able to;

- Develop their understanding on HerbalTechnology
- Define and describe the principle of cultivation of herbalproducts.
- List the major herbs, their botanical name and chemicalconstituents.
- Evaluate the drug adulteration through the biologicaltesting
- Formulate the value added processing / storage / quality control for the better use of herbalmedicine
- Develop the skills for cultivation of plants and their value added processing / storage / quality control

Keywords:

Herbal medicines, Plant products, Biopesticides, Pharmacognosy, Adulteration, Secondarymetabolites

UnitI — 7 lectures

Herbal Technology: Definition and scope; Herbal medicines: history and scope; Traditional systems of medicine, and overview of AYUSH (Traditional Indian Systems of Medicine); Cultivation - harvesting - processing - storage of herbs and herbal products.

UnitII — 7 lectures

Value added plant products: Herbs and herbal products recognized in India; Major herbs used as herbal medicines, nutraceuticals, cosmeticals and biopesticides, their Botanical names, plant parts used, major chemicalconstituents.

UnitIII — 8 lectures

Pharmacognosy - Systematic position, botany of the plant part used and active principles of the following herbs: Tulsi, Ginger, Curcuma, Fenugreek, Indian Gooseberry, *Catharanthus roseus*, *Withania somnifera*, *Centella asiatica*, *Achyranthes aspera*, Kalmegh, Giloe (Tinospora), Saravar. Herbal foods, future of pharmacognosy.

UnitIV — 8 lectures

Analytical pharmacognosy: Morphological and microscopic examination of herbs, Evaluation of drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds). Plant gene banks, Cultivation of Plants and their value added processing / storage / quality control for use in herbal formulations, Introductory knowledge of Tissue culture and Micro propagation. of some medicinal plants (*Withania somnifera*, neem andtulsi),

Suggested Readings

1. Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). Current scenario ofHerbal Technology worldwide: An overview. *Int J Pharm Sci Res*; 4(11):4105-17.
2. Arber, Agnes. (1999). Herbal Plants and Drugs. Mangal Deep Publications,Jaipur.

3. Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). Plant Food Residues as a Source of Nutraceuticals and Functional Foods. Foods 5 :88.
4. Aburjai, T. and Natsheh, F.M. (2003). Plants Used in Cosmetics. Phytotherapy Research 17:987-1000.
5. Patri, F. and Silano, V. (2002). Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1. ISBN 978-92-871-8474-0, pp218.
6. AYUSH (www.indianmedicine.nic.in). *About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy.* New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government ofIndia.
7. Evans, W.C. (2009): Trease and Evans PHARMACOGNOSY. 16th Edition,SAUNDERS/ Elsevier.
8. Sivarajan,V.V.andIndia,B.(1994).AyurvedicDrugsandTheirPlantSources..*Oxford&IBH Publishing Company*, 1994 - Herbs - 570 pages.
9. Miller, L. and Miller, B. (2017). Ayurveda & Aromatherapy: The Earth Essential Guide to Ancient Wisdom and Modern Healing. *Motilal Banarsidass,;Fourth edition.*
10. Kokate, C.K. (2003). Practical Pharmacognosy. Vallabh Prakashan,Pune.

Course Outcome:

Graduate will have understanding of:

1. Develop their understanding on Herbal Technology
2. Define and describe the principle of cultivation of herbal products.
3. List the major herbs, their botanical name and chemical constituents.
4. Evaluate the drug adulteration through the biological testing
5. Formulate the value added processing / storage / quality control for the better use of herbal medicine
6. Develop the skills for cultivation of plants and their value added processing / storage / quality control

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1		1		1
CO2	1	2	1	2	1	1	2	1	1	1	1	1		1		1
CO3	1	2	1	2	1	1	2	1	1	1	1	1		1		1
CO4	1	2	1	2	1	1	2	1	1	1	1	1		1		1
CO5	1	2	1	2	1	1	2	1	1	1	1	1		1		1
CO6	1	2	1	2	1	1	2	1	1	1	1	1		1		1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 6	Fermentation Science and Technology	Theory: 2

Learning outcomes:

After completing this course, the learner will be able to:

1. Employ the process for maintenance and preservation of microorganisms
2. Analyze the various aspects of the fermentation technology and apply for Fermentative production
3. Demonstrate proficiency in the experimental techniques for microbial production of enzymes: amylase and protease, bio product recover

UnitI ***8 Lectures***

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

UnitII ***8Lectures***

Maintenance and preservation of microorganisms, Metabolic regulations and overproduction ofmetabolites. Kinetics of microbial growth and product formation.

UnitIII ***8 Lectures***

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).

UnitIV ***6Lectures***

Microbial production of enzymes: Amylase and Protease. Bioproduct recovery.

Suggested readings

1. Waites M.J. (2008). Industrial Microbiology: An Introduction, 7th Edition, Blackwell Science, London,UK.
2. Prescott S.C., Dunn C.G., Reed G. (1982). Prescott & Dunn's Industrial Microbiology, 4th Edition, AVI Pub. Co.,USA.
3. Reed G. (2004). Prescott & Dunn's industrial microbiology, 4th Edition, AVI Pub. Co., USA.
4. JR Casida L.E. (2015). Industrial Microbiology, 3rd Edition, New Age International (P) Limited Publishers, New Delhi,India.
5. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001) Industrial Microbiology: An Introduction. 1st Edition, Blackwell Science, London,UK.
6. Pelczar M.J., Chan E.C.S. and Krieg N.R. (2003) Microbiology. 5th Edition, Tata McGraw-Hill Publishing Company Limited, NewDelhi.

Course Outcome:

Graduate will have understanding of:

1. Employ the process for maintenance and preservation of microorganisms

2. Analyze the various aspects of the fermentation technology and apply for Fermentative production

3. Demonstrate proficiency in the experimental techniques for microbial production of enzymes: amylase and protease, bio products recover

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	2	1	2	1	1	2	1	1	1	1	1		1		1
CO2	1	2	1	2	1	1	2	1	1	1	1	1		1		1
CO3	1	2	1	2	1	1	2	1	1	1	1	1		1		1

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 7	Environmental impact analysis (Practical based)	Theory: 2

Learning outcomes:

After completing this course, the learner will be able to;

- Have critical understanding of environmentalimpact
- Learn important steps of EIAprocess
- Interpret the environmental appraisal and procedures inIndia.

Unit I: OriginandDevelopment ***8 Lectures***

Purpose and aim, core values and principles, History of EIA development, Environmental Management Plan, Environmental Impact Statement, Scope of EIA in Project planning and Implementation.

Unit II:EIAProcess ***8 Lectures***

Components of EIA, EIA Methodology- Screening, Scoping, Baseline data, Impact Identification, Prediction, Evaluation and Mitigation, Appendices and Forms of Application, Techniques of Assessment-Cost-benefit Analysis, Matrices, Checklist, Overlays, Impact on Environmental component: air, noise, water, land, biological, social and environmental factors. EIA Document.

Unit III: Main participants inEIAProcess **7 Lectures**

Role of Project proponent, environmental consultant, PCBs, PCCs, public and IAA.Public participation.

Unit IV: Environmental Appraisal and Procedures in India and EIA ***7 Lectures***

Methodology, indicators and mitigation, Environmental Audit of different environmental resources, Risk Analysis, Strategic environmental assessment, ecological impact assessment: legislation.

Practical

1. Prepare a Matrix of every environmental existing resource of your college or your hostel/mohalla or any defined area and evaluate each component using established methods and make auditanalysis.
2. Prepare a case report of Environmental impact of any area underdevelopment.

Suggested readings:

a. Kulkarni V and Ramachandra TV, (2006). Environmental Management, Capital Pub. Co. NewDelhi.

b. Petts, J. (2005) Handbook of Environmental Impact Assessment- Volume 1 and 2. Blackwell Publishers,UK.

c. Glasson, J. Therivel, R. and Chadwick, (2006) A. Introduction to Environmental Impact Assessment. Routledge,London.

d. Canter, W. L. (1995) Environmental Impact Assessment, McGraw-Hill Science/ Engineering/ Math, NewYork;

e. Morris, P. and Therivel, R. (1995) Methods of Environmental Impact Assessment, UCL

Press,London;

f. Petts, J. (1999) (ed) Handbook of Environmental Impact Assessment, volume 1 and 2, Blackwell Science,Oxford;

g. Therivel, R. and Partidario, M. R. (1996) (eds) The Practice of Strategic Environmental Assessment, Earthscan,London;

h. Vanclay, F. and Bronstein, D. A. (1995) (eds) Environmental and Social Impact Assessment, Wiley & Sons,Chichester.

Course Outcome:

Graduate will have understanding of:

1. Have critical understanding of environmental impact
2. Learn important steps of EIA process
3. Interpret the environmental appraisal and procedures in India.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 8	Skill Enhancement Course: IT skills for chemists	Theory: 2

Learning outcome

On completion of this course, the students will be able to:

- Have understanding of fundamental mathemarical functions
- Understand uncertainty in experimental techniques
- Develop computer programmes using various programs.

UNIT-I: IT Skills for Chemists

Fundamentals, mathematical functions, polynomial expressions, logarithms, the exponential function, units of a measurement, inter-conversion of units, constants and variables, equation of a straight line, plotting graphs.

Uncertainty in experimental techniques: Displaying uncertainties, measurements in chemistry, decimal places, significant figures, combining quantities. Uncertainty in measurement: types of uncertainties, combining uncertainties. Statistical treatment. Mean, standard deviation, relative error. Data reduction and the propagation of errors.Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression). Algebraic operations on real scalar variables (e.g. manipulation of van der Waals equation in different forms).Roots of quadratic equations analytically and iteratively (e.g. pH of a weak acid). Numerical methods of finding roots (Newton-Raphson, binary–bisection, e.g. pH of a weak acid not ignoring the ionization of water, volume of a van der Waals gas, equilibrium constant expressions).

Differential calculus: The tangent line and the derivative of a function, numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations). Numerical integration (Trapezoidal and Simpson's rule, e.g. entropy/enthalpy change from heat capacity data).

UNIT-II: Computer programming:

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions.Elements of the BASIC language.BASIC keywords and commands.Logical and relative operators.Strings and graphics.Compiled versus interpreted languages.Debugging.Simple programs using these concepts.Matrix addition and multiplication.Statisticalanalysis. BASIC/FORTRAN programs for curve fitting, numerical differentiation and integration (Trapezoidal rule, Simpson's rule), finding roots (quadratic formula, iterative, Newton-Raphson method).

Recommended books/References:

1. McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books(2008).
2. Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005). 3.Steiner, E. The Chemical Maths Book Oxford University Press (1996). 4.Yates, P. Chemical calculations. 2nd Ed. CRC Press(2007).
5. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters3-5.
6. Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487pages.

7. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co.(1985).
8. Venit, S.M. Programming in BASIC: Problem solving with structure and style. Jaico Publishing House: Delhi(1996).

Course Outcome:

Graduate will have understanding of:

1. Have understanding of fundamental mathemarical functions
2. Understand uncertainty in experimental techniques
3. Develop computer programmes using various programs.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 9	Intellectual property right (IPR) and business skills forchemists	Theory: 2

Learning outcome

On completion of this course, the students will be able to:

1. Know History, types and important of intellectual property.
2. Have understanding about different types of trademarks.
3. Know about Patent and copyright transfer system
4. Learn about registration, Industial design and trade secrets and different international agreements about IPR

Introduction to Intellectual Property:

Historical Perspective, Different Types of IP, Importance of protecting IP.

Copyrights

Introduction, How to obtain, Differences from Patents.

Trade Marks

Introduction, How to obtain, Different types of marks – Collective marks, certification marks,service marks, Trade names, etc. Differences from Designs.

Patents Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India.

Geographical Indications

Definition, rules for registration, prevention of illegal exploitation, importance to India.

Industrial Designs

Definition, How to obtain, features, International design registration.

Layout design of integrated circuits

Circuit Boards, Integrated Chips, Importance for electronic industry.

Trade Secrets

Introduction, Historical Perspectives, Scope of Protection, Risks involved and legal aspects ofTrade Secret Protection.

Different International agreements

(a) World Trade Organization(WTO):

(i) General Agreement on Tariffs & Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade related Services (GATS) (iii) Madrid Protocol (iv) Berne Convention (v) Budapest Treaty.

(b) ParisConvention

WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity

IP Infringement issue and enforcement – Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assets and theirvaluation, Intellectual Property in the Indian Context – Various laws in India Licensing and

technology transfer.

Business Basics

Key business concepts: Business plans, market need, project management and routes to market.

Chemistry in Industry

Current challenges and opportunities for the chemistry-using industries, role of chemistry inIndia and globaleconomies.

Financial aspects

Financial aspects of business with case studies.

Recommended Books/References:

1. Acharya, N.K. Textbook on intellectual property rights, Asia Law House(2001).
2. Guru, M. & Rao, M.B. Understanding Trips: Managing Knowledge in Developing Countries, Sage Publications(2003).
3. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw- Hill(2001).
4. Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers(2000).
5. Watal, J. Intellectual property rights in the WTO and developing countries, Oxford University Press, NewDelhi.

Course Outcome:

Graduate will have understanding of:

1. History, types and important of intellectual property.
2. About different types of trademarks.
3. Patent and copyright transfer system
4. Registration, Industrial design and trade secrets and different internationalagreements about IPR

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				
CO4	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 10	Analytical Clinical Biochemistry	Theory: 2

Learning outcome

On completion of this course, the students will be able to:

1. Identify among various biological molecules
2. Understand primary, secondary and tertiary structures of proteins.
3. Indentify structures of DNA, RNA, Lipids etc.
4. Know about nomenclature, Classification of Enzymes

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

Carbohydrates:Biological importance of carbohydrates, Metabolism, Cellular currency of energy (ATP), Glycolysis, Alcoholic and Lactic acid fermentations, Krebs cycle. Isolation and characterization of polysachharides.

Proteins:Classification, biological importance; Primary and secondary and tertiary structures of proteins: α-helix and β- pleated sheets, Isolation, characterization, denaturation of proteins.

Enzymes:Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes, Coenzymes and cofactors, Enzyme inhibitors, Introduction to Biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

Lipids:Classification. Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications. Lipoproteins: Properties, functions and biochemical functions of steroid hormones. Biochemistry of peptide hormones.

Structure of DNA(Watson-Crick model) and RNA, Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation, Introduction to Gene therapy.

Enzymes**:** Nomenclature, classification, effect of pH, temperature on enzyme activity, enzyme inhibition.

A diagnostic approach to biochemistry:

Blood:Composition and functions of blood, blood coagulation. Blood collection and preservation of samples.Anaemia, Regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol andbilirubin.

Urine:Collection and preservation of samples. 6. Formation of urine. Composition and estimation of constituents of normal and pathological urine.

Recommended books/references:

1. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell(1977).
2. Wilson, K. & Walker, J. *Practical Biochemistry.* Cambridge University Press(2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry,* Heinemann, London (1980).
4. Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons,2010.

5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman,2002.
6. Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman,2013.
8. O. Mikes, R.A. Chalmers: *Laboratory Handbook of Chromatographic Methods*, D. Van Nostrand & Co.,1961.

Analytical Clinical Biochemistry Practical

Identification and estimation of the following:

1. Carbohydrates – qualitative andquantitative.
2. Lipids –qualitative.
5. Determination of cholesterol using Liebermann- Burchardreaction.
6. Proteins –qualitative.
7. Isolation of protein.
8. Determination of protein by the Biuretreaction.
9. Determination of nucleicacids.

Note: Experiments may be added/deleted subject to availability of time and facilities

Recommended Books/References:

1. Cooper, T.G. *Tool of Biochemistry*. Wiley-Blackwell(1977).
2. Wilson, K. & Walker, J. *Practical Biochemistry*. Cambridge University Press(2009).
3. Varley, H., Gowenlock, A.H & Bell, M.: *Practical Clinical Biochemistry*, Heinemann, London (1980).
4. Devlin, T.M., *Textbook of Biochemistry with Clinical Correlations*, John Wiley & Sons,2010.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman,2002.
6. Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology*, 3rd Ed. PHI Learning.
7. Nelson, D.L. & Cox, M.M. *Lehninger Principles of Biochemistry*, W.H. Freeman,2013.
8. O. Mikes, R.A. Chalmers: *Laboratory Handbook of Chromatographic Methods*, D. Van Nostrand & Co.,1961.

Course Outcome:

Graduate will have understanding of:

1. Identify among various biological molecules
2. Understand primary, secondary and tertiary structures of proteins.
3. Identify structures of DNA, RNA, Lipids etc.
4. Know about nomenclature, Classification of Enzymes

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	2	2	1	2	1	1	2	1	1	1	1	1				
CO2	2	2	1	2	1	1	2	1	1	1	1	1				
CO3	2	2	1	2	1	1	2	1	1	1	1	1				
CO4	2	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

Semester	Course	Name of the course	Credits
I,II,V,VI	SEC 11	Mushroom Culture Technology	Theory: 2

Learning outcomes:

On completion of this course, the students will be able to:

1. Recall various types and categories ofmushrooms.
2. Demonstrate various types of mushroom cultivatingtechnologies.
3. Examine various types of food technologies associated with mushroomindustry.
4. Value the economic factors associated with mushroomcultivation
5. Device new methods and strategies to contribute to mushroomproduction.

Keywords:

Edible mushrooms, Poisonous mushrooms, Cutivation technology, Mushroom bed, Mushroomunit, Storage and Nutrition

UnitI ***7Lectures***

Introduction, History. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus.*

UnitII ***9 Lectures***

Cultivation Technology: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low-cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparations of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation- Low-cost technology, Composting technology in mushroomproduction.

UnitIII ***7 Lectures***

Storage and nutrition: Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

UnitIV ***7 Lectures***

Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and regional level. Cost benefit ratio - Marketing in India and abroad, ExportValue.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore -560018.
3. Tewari, Pankaj and Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol.II.

Course Outcome:

Graduate will have understanding of:

1. Recall various types and categories of mushrooms.
2. Demonstrate various types of mushroom cultivating technologies.
3. Examine various types of food technologies associated with mushroom industry.
4. Value the economic factors associated with mushroom cultivation
5. Device new methods and strategies to contribute to mushroom production.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	1	2	1	2	1	1	2	1	1	1	1	1				
CO2	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				
CO4	1	2	1	2	1	1	2	1	1	1	1	1				
CO3	1	2	1	2	1	1	2	1	1	1	1	1				

Weightage: **1-Sightly; 2-Moderately; 3-Strongly**

CERTIFICATE COURSEs/VALUE ADDED COURSES

Semester	Course	Name of the course	Credits=02
I-VI	VAC-3	Fuel Chemistry	Theory+ Practical

1. **Department** Chemistry
2. **Name of the Course:** Certificate Course in Fuel Chemistry

   Nature of Course(Certificate/ Value Added): Certificate
3. **Mode of Course:** Hybrid Mode (Online + Offline)

   Online / Offline / Physical
4. **Number of Seats:** 20
5. **Eligibility Criteria for Admission:** 12th Pass, Ongoing B Sc in any discipline with Chemistry as a paper.
6. **Introduction and relevance of Course**:

   In the present scenario energy are first and foremost requirement for the socio-economic development of the society and nation as well which is also recognized by United Nations (UN) as one of the very important and inevitable common goals for the sustainable development goals (SDGs). This course will enable the scientific knowledge, skill and hands-on experience about the most non-renewable energy sources fossil fuels (coal, petroleum, and natural gas) to meet out the energy demand of the country. This will assist them to be industry ready to contribute effectively in the field of coal, petroleum chemistry and technology. In the Bilaspur city the regional research centre of CSIR-Central Institute of Mining and Fuel Research (CIMFR) is located where they recruit the project assistant and project fellow having the knowledge and experience on fuel chemistry, therefore, this course will provide job opportunities too.
7. **Objectives of the course**: The course will have the following objectives
   - To know about the sources of energies.
   - To study the fuel as the main source of energy particularly fossil fuels.
   - To know the chemical compositions of different fuels
   - To study Domestic and industrial applications of coal.
   - To understand about petroleum and petrochemical industry.
   - Various prospects of lubricants
8. **Learning outcome of the course**:
   - Understand both conventional based fuels, and alternative & renewable fuels.

- Understand the chemistry that underpins coal and petroleum fuel science and technology.
- They will understand the refining processes used to produce fuels and lubricants and will know how differences in chemical composition affect properties of fuels and their usage in different applications.
- Understand the fuel product specifications, various test methods used to qualifydifferent types of fuels as well characterization methods.
- They will get experimental experience on fossil fuels like coal, petroleum, and natural gas)
- Students can get job opportunities in various projects of of CSIR-Central Institute of Mining and Fuel Research (CIMFR).

9. Number of lectures: 2 hour per week (02 Credit)

10. Number of practical's (if any): 2 hour per week (01 Credit)

11. List of experiments (If any)-

- Determination of flash point & fire point of given fuel sample.
- Determination of viscosity index, cloud point, pour point of given fuel sample.
- Determination of calorific value of given fuel sample/coal sample using bomb calorimeter. Proximate analysis of given coal sample.
- Determination of the iodine number of oil.
- Determination of the saponification number of oil.

12. Syllabus:

Credits: 02 **30 Lectures**

Unit 1

Review of energy sources (renewable and non-renewable). Energy from natural sources (i.e. solar and renewable forms), from fossil fuels and from nuclear fission.Classification of fuels and their calorific value. Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel

Unit II

Coal as Fuel: Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point. Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit III

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining anddifferent types

of petroleum products and their applications Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

Unit IV

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (flash point, fire point, viscosity index, cloud point, pore point) and their determination.

13. Suggestive Readings:

- Industrial Chemistr by Stocchi, E. Vol-I, Ellis Horwood Ltd. UK (1990).
- Engineering Chemistry by Jain, P.C. & Jain, M. Dhanpat Rai & Sons, Delhi.
- A Text Book of Engineering Chemistry S. S. Dara S Chand & Company
- Industrial Chemistry by Sharma, B.K. & Gaur, H. Goel Publishing House, Meerut (1996).
- Chemistry of Fossil Fuels and Biofuels by Harold Schobert , Cambridge University Press 2013.
- The Chemistry and Technology of Coal by James G. Speight, CRC Press Boca Raton (2012)
- Water for Energy and Fuel Production, Yatish T. Shah, CRC Press Boca Raton (2014)
- Process Chemistry of Coal Utilization: Impacts of Coal Quality and Operating Conditions by Stephen Niksa, Elsevier 2019
- Chemistry of Coal Conversion by Richard H. Schlosberg Springer (1985).
- The Chemistry and Technology of Petroleum by James G. Speight CRC, Boca Raton (2014).
- Lubricants and Lubrication by Wilfried Dresel, Wiley (2017).

14. Course Coordinator (Name & Designation)

Dr S S Thakur, Assistant Professor

Prof G, K Patra, Professor

15. Evaluation Criteria:

Components	Class Test	Hands on Experiment	End Semester	Total
Weightage (%)	**20**	**20**	**60**	**100**

16. Infra Structure requirements (if any): Basic laboratory with small instrument like flash and fire point apparatus, Bomb Calorimeter, viscometer, consumables chemicals etc.

17. Financial Requirement (if any): Rs. 50,000/- for instrument and chemicals

18. Proposed fee for the Course (if any): 5000/- (or as per direction of the university)

19. Budgetary provisions : 50, 000/-

Semester	Course	Name of the course	Credits=02
I-VI	VAC-5	POLYMER CHEMISTRY	Theory+ Practical

1. **Department:** Chemistry
2. **Name of the Course:** Certificate Course in Polymer Chemistry
3. **Nature of Course:** Certificate or Value Added Course: Certificate
4. **Mode of Course:** Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
5. **Number of Seats:** 20
6. **Eligibility Criteria for Admission:** Intermediate/ B Sc in any discipline with Chemistry as a paper
7. **Introduction and relevance of Course**: Polymer is a natural or artificial chemical compound consisting of large molecules which are made up of smaller, joined-together molecules called monomers. Due to their broad spectrum of properties, both synthetic and natural polymers play essential and versatile roles in everyday life.Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Polymers, both natural and synthetic, are created via polymerization of many small molecules, known as monomers. This course will provide the opportunity to the learner to get job in polymer industries. Learner can start own small level work based on polymer Processing that are one of the part of Syllabus
8. **Objectives of the course:**
    - To study the methods for preparation of variety of Polymers
    - To study the utilization of polymer in the preparation of different industrial articles along with other important compounds.
9. **Learning outcome of the course:** This course will educate the students on the subject of polymers that constitute one of the most important materials used presently. The course will include fundamentals of synthesis, characterization, properties and also include discussion on the applications of polymers, as well as challenges pertaining to contemporary polymer research.
10. **Number of lectures (I hour =1 credit per week):**2 (02 hour)
11. **Number of practical's (if any)(2 hours = 1 Credit per week):** 1(2 Hour)
12. **List of experiments (If any)-** attached with annexure I
13. **Syllabus:** See annexure 1
14. **Suggestive Readings:** See annexure 1
15. **Course Coordinator (Name & Designation):** Dr Arti Srivastava, Assistant Professor

16. **Evaluation Criteria** (to be decided by HOD and Course Teacher) by Written examination of theory and practical.
17. **Infra Structure requirements (if any):** Available in the department, 01 instrument required
18. **Financial Requirement (if any):**
19. **Proposed fee for the Course (if any):** 5000/-
20. **Budgetary provisions –** See annexure II

Syllabus on Polymer Chemistry (Certificate Course)

Credits: 02 **30 Lectures**

Unit 1

Introduction: Background, Nomenclature, Classifications, Examples and Applications, Principles of Polymerization

Unit II

Synthesis of Polymers: Step-Growth Polymerization, Radical Chain Polymerization, Controlled Radical Polymerization, Copolymerization Ionic Chain Polymerization, Coordination Polymerization, Ring-Opening Polymerization, Polymerization techniques.

Unit III

Characterization of Polymers: Determination of Molecular Weight, Frictional Properties of Polymers in Solution, Hydrodynamic Size, DSC, TGA and SEM.

Unit IV

Polymer Properties: Crystallinity in polymers, Glass transition temperature, Rheological properties, Mechanical, Optical, Electrical, Surface and Other Industrially Relevant Properties Degradation of polymers.

Unit V

Some industrially important Polymer reactions, Polymer Processing: Polymer additives, compounding and processing techniques

21. **Books recommended**:

1. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.

2. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.

3. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore

4. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences , Narosa Publishing House, New Delhi (2002)

5. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar , Polymer Sciences, Wiley Eastern, New Delhi

(1986).

A Visit to Polymer Industry

Suggested list of Experiments (based on availability of the resources)

1. Purification of monomer
2. Radical polymerization vinyl monomers.
3. Determination of molecular weight of polymer by viscometric method.
4. Determination of molecular weight of polymer by GPC method
5. Synthesis of Nylon.
6. Synthesis of Hydrogel and its application

Annexure II

Amount of Minimum Proposed Budget: Rs 50,000/-

Amount required for Chemical: Rs 40,0000/-

Miscellaneous budget: Rs 10,000/-

Semester	Course	Name of the course	Credits=02
I-VI	VAC-4	COSMETIC FORMULATION	Theory+ Practical

Total Credit: 02 ***Total hours: 30***

Course Objective:

This course is intended to provide a comprehensive survey of ingredients fundamental to the cosmetic industry. The course will emphasize current trends in the selection of cosmeticingredients. The chemistry and technology of cosmetic raw materials will be related to theirbehavioral properties as utilized in the construction of stable functional systems. In this way, it isintended to generate a better understanding of the contributions of ingredients to the performanceof finished product formulations. Emphasis will be placed on recognizing and dealing withproblem areas associated with the use of various ingredients. Safety considerations and otherpertinent matters which can influence ingredient selection will be included in these discussions. **Course Content:**

UNIT - I: Classification of raw materials and raw materials used in the cosmetic industry for the manufacture of finished products. Method of sampling, Indian Standard specification laid down for sampling and testing of various cosmetics in finished form by the bureau of Indian standards. Factors affecting stability of a formulation, ICH guidelines, Methods of stabilizations and Methods of stability testing.Concept of development of stability indicating analytical methods.

UNIT - II: Determination of physical and chemical constants such as extractive values, moisture content, alcohol content, volatile oil content, ash values, bitterness values, foreign matters, and physical constants applicable to the lipid containing drugs.

UNIT III: Brief introduction of the following cosmetic preparation and a detailed study on their quality control: Shampoo, Tooth paste, skin powder, skin creams, hair creams, nail polish, after shave lotion, bath and toiletries, lipstick and hair dyes, perfumes, depilatories.

UNIT- IV: Packaging of cosmetics –Filling of solids, semisolids & liquids. Materials used for cosmetic packaging Rules & regulations and legal provisions for packaging & labeling.

UNIT-V: Experiments: Nano-Formulation of Gels, Shampoos, Hair-conditioners; Color cosmetics

Examination Scheme:

Components	**Class Test**	**Hands on Experiment**	**End Semester**	**Total**
Weightage (%)	**20**	**20**	**60**	**100**

Text & References:

1. Comprehensive Pharmacy Review 5th Edition by Leon Shargel, Alan H. Mutnick, Paul F. Souney, Larry N. Sawnson – 2004.
2. Applied Biopharmaceutics and Pharmacokinetics, 4th Edition by Leon Shargel / Andrew B.C., Yu – 1999.
3. A. H. Beckett and J. B. Stenlake Practical Pharmaceutical Chemistry, Part I and Part II, 4th Edition.
4. G. H. Jeffery, J. Basset, J. Mendham, R. C. Denny (Rev. by) Vogels Text Book of Quantitative Chemical Analysis, 5th Edition 1989, ELBS.
5. The Controller of Publications; New Delhi, Govt. of India, Indian Pharmacopoeia, Vol. I and Vol. II - 1996.
6. J. B. Wilkinson and R. J. Moore: Herry's Cosmeticology; Longman Scientific and Technical Publishers, Singapore.
7. P.D. Sethi; Quantitative Analysis of Drugs in Pharmaceutical Formulations, 3rd Edition - 1997,
8. ICH guideline for impurity determination and stability studies.
9. Practical HPLC method development by Lloyd R. Snyder, Joseph J. Kirkland, Joseph I. Glajch, John Wiley and Sons 2nd Edition – 1997
10. Chang. W.N "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009.
11. Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, Edited by M. S. Dresselhaus,G. Dresselhaus, P. Avouris, Springer-Verlag, 2000.
12. Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).
13. Introduction to Nanotechnology by Charles P. Poole Jr and. Frank J. Owens, Wiley-Inter science, 2003.

14. Nanoscale Materials in Chemistry Edited by Kenneth J. Klabunde, John Wiley & Sons, Inc., ISBNs: 0-471-38395-3 (Hardback); 0-471-22062-0.

How is Cosmetic Formulation Course Beneficial?

- They can also work in hospitals by training patients how to take care of their skin after surgery.
- They can also have jobs related to manicure and pedicure such as to beautify the hands and nails by cleaning and shaping the nails; decorate nails with paintings or designs or even with imitation jewels.

Cosmetic Technology Employment Areas

- Advertisement Industries
- Beauty Clinics
- Beauty parlour
- Food & Cosmetic Industries
- Resorts
- Skin Clinics
- Spa Centers
- Star Hotels

Semester	Course	Name of the course	Credits=02
I-VI	VAC-1	**EFFICIENT TECHNOLOGIES FOR FOOD PROCESSING AND SHELF LIFE EXTENSION**	Theory+ Practical

1. Department: Chemistry
2 Name of the Course: Certificate Course in
3 Nature of Course: Certificate or Value Added Course: Certificate
4 Mode of Course: Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
5 Number of Seats: 20
6 Eligibility Criteria for Admission: 10+2 in any discipline.
7. **Introduction and relevance of Course**: Food processing which includes both fresh and packaged food involves handling of foods, preparation and storage through the subsequent stages so that the pathogens and toxic components present in food are destroyed and deactivated making the food safer and hygienic. Food preservation techniques combines science-based knowledge with technologies, to prevent spoilage and extend shelf-life and ensure consumers free of pathogenic microorganism food. Deterioration of food leads to loss of quality including color, texture, taste as well as nutritive value.By preserving food, food waste can be reduced, which is an important way to decrease production costs and increase the efficiency of food systems, improve food security and nutrition and contribute towards environmental sustainability.For instance, it can reduce the environmental impact of food production

8. Objectives of the course:

- ✓ To impart knowledge in the area of food science and technology
- ✓ To aware with the recent technologies used in food preservation and processing
- ✓ To understand the quality control of different food items
- ✓ To understand the importance of food safety and food management

1. Learning outcome of the course:

After completing this certificate course the learner will be able to:

- ✓ understand the food processing and technology, its history,development and present status
- ✓ explain the significance and basic concepts of the subject
- ✓ aware of the skills required to be a professional food technologist
- ✓ aware of the career opportunities available and educational
- ✓ qualifications required for specific careers in the industry
- ✓ know the scope for self employment as small, medium or large scaleentrepreneurs.

10. Number of lectures (I hour =1 credit per week): 1 (01 hour)
11. Number of practical's (if any) (2 hours = 1 Credit per week) 1(2 Hour)
12. List of experiments (If any)- attached with annexure I

13 Syllabus:

Credits: 02 *30 Lectures*

Unit I

Introduction: Food Constituents & Functions, Quality and Safety Aspects of Food, Factors Affecting Quality during Processing and Storage, Role of Water in Food and its Shelf Life, Browning Reactions

Unit II

Technologies in Food Preservation: Principles of Food Preservation, Traditional Food Preservation Technologies, High Pressure Processing of Food, Membrane Technology, Food Irradiation, Hurdle Technology.

Unit III

Nanotechnology in Food Packing: Nano encapsulation,Nanoemulsions, Nanoparticles/active packagingNanoclays in packaging, Nanocomposites in packaging, Nanosensors at the packaging and processing plant, Nanosensors in plastic film packages/ Electronic tongue/ Intelligent packaging, NanosensorsNanofibresColor changing labels: Nanocochelates/ nanodroplets, Nanofilms/ Nanolaminates

Unit IV

Food Quality enhancement and analysis: Rancidity, Natural Antioxidants,High Energy RTE Food Paste, Ozonation of Food Grains, Food Fortification: Iron Fortified Rice (IFR), Nutri Dal and Fortified Noodles, Hyper Spectral Imaging for Quality Analysis of Food Grains, Non-Destructive Methods for Analysis of Grain Quality, Detection of Spoilage in Grains using Biosensors.

Practical

- To study the effect of enzymatic browning in fruits and vegetables.
- To study different types of blanching of fruits and vegetables.
- Preservation of food by canning.
- To perform cut out analysis of caned product.
- Preservation of food by high concentration of sugar i.e. jam.
- Preservation of food by high concentration of salt/acid i.e. pickle.
- Preservation of food by addition of chemicals i.e. tomato ketchup.
- Preservation of food by drying in a cabinet drier.
- Preservation of fruits & vegetables by freezing.

- Preservation of milk by pasteurization and sterilization.

14. Suggested readings/ Text and Reference Books:

- Food Processing Technology by P.J.Fellows, Woodhead publishing ltd.
- Food Science by N.N. Potter, CBS publishing.
- Physical principles of Food Preservation. Vol. II by M. Karel, O.R. Fenema and D.B. Lurd, Maroel, Dekker Inc. New York.
- The technology of food preservation by N.W. Desrosier and J.N. Desrosier, CBS publishing

15. Course Coordinator:

a. Dr NirajKumari, Assistant Professor in Chemistry, Department of Chemistry, Guru GhasidasVishwavidyalaBilaspur CG, India

b. Dr Arti Srivastava, Assistant Professor in Chemistry, Department of Chemistry, Guru GhasidasVishwavidyalaBilaspur CG, India

16. Evaluation Criteria (to be decided by HOD and Course Teacher):

Components	Class-Test	Experiment	End Semester	Total Marks
Weightage (%)	**20**	**20**	**60**	**100**

17. Infrastructure requirements (if any): Basic laboratory system with pH meter, magnetic stirrer, characterization and small testing equipments.

18. Financial Requirement (if any): Approx. Rs 50,000

19. Proposed fee for the Course (if any): Rs.5000.00 (As per the University's norms).

20. Budgetary provisions: Rs.50,000.00

Semester	Course	Name of the course	Credits=02
I-VI	VAC-6	Eco-Friendly Lubricants – Chemistry And Application	Theory+ Practical

1. **Department:** Chemistry
2. **Nameof the Course:** **Eco-friendly Lubricants – Chemistry and Application**
3. **Natureof the Course:** Certificate
4. **Modeof the Course:** Online/Offline/Physical
5. **NumberofSeats:** 20
6. **EligibilityCriteriaforAdmission:** 10+2 (OngoingUGstudents)

7. IntroductionandRelevanceof the Course: The automotive industry in India is the fifth-largest in the world as per the last year statistics. Lubricants are the soul of the automotive industry. A lubricant is a substance that helps to reduce friction between surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces. The property of reducing friction is known as lubricity.

The certificate course in *Eco-friendly Lubricants - Chemistry and Application* is designed for undergraduate students looking for career in automotive industry as well as lubricants industry. This course emphases on chemistry involves in the formulating process, quality assessment, characterization and disposal techniques of lubricants. Through this course, students must improve their skills concerning theoretical and practical approaches towards all kinds of lubricants.

8. Objectives of the Course:

- The main objective of the course is to deal fundamentals of friction, viscosity and lubrication.
- The course is useful in understanding the nature and characteristic of lubricants raw materials.
- The basic objective of the course is to learn about types of lubricants.
- The course is convenient to understand the various industrial applications of lubricants.
- The basic objective of the course is to get knowledge about role of lubricants in engineering chemistry.
- The course is helpful in comprehension the various properties of lubricants such as iodine number, aniline point, emulsion number, flash and fire point, drop point, cloud and pour point, corrosion stability, saponification number etc.
- The course is fruitful in appreciation the importance of eco-friendly lubricants.

9. LearningOutcomeof the Course:

Upon completing the course, student will be able to:

- Describe the chemistry of lubricants.
- Understand and importance of composition of lubricants.
- Optimize the iodine number, aniline point, emulsion number, flash and fire point, corrosion stability, saponification number etc.
- Understand the lubrication mechanism.
- Determine the application of lubricants.
- Analyze the disposal techniques of lubricants.

10. Number of Lectures: 02hrs perweek(2Credit)

11. NumberofPractical: 02 hrs perweek (1Credit)

12. ListofExperiments:

- Viscosity measurement of various lubricants.
- Determining flash and fire point of lubricants.
- Analyzing drop point and aniline point of lubricants.
- Chemical analysis of corrosion stability in lubricants.
- Laboratory analysis various automotive engine oils.
- On site industrial visit.

13. Syllabus:

UNIT I: Definition of Lubricants and Lubrication: Definition,Brief history and progress of Lubricants. Composition of Lubricants. Additives used in Lubricants. Functions and various characteristic features of Lubricants.Role of Lubricants in Engineering Chemistry.

UNIT II:Classification of Lubricants: Solid, liquid, semi-solid and synthetic Lubricants. Properties of Lubricants: viscosity, iodine number, aniline point, emulsion number, flash and fire point, drop point, cloud and pour point, corrosion stability, saponification number etc.

UNIT III: Various Lubrication Methods: Grease Lubrication, Oil Lubrication, etc. Mechanism of Lubrication: thick film, thin film and extreme pressure lubrication. Essential requirements of a good lubricant. Application of Lubricants: Automotive engine oils, tractor, other motors, industrial, aviation, marine etc.

UNIT IV: Eco-friendly Lubricants and Disposal Techniques: Eco-friendly Lubricants, Lanolin: composition, modern developments, production and applications, Guidelines for the proper disposal, Biodegradability of Lubricants, Stabilization and reuse, Degradation through tillage or composting, Dumping, Storage of waste.

14. SuggestiveReadings:

- Don, M. P.; Webster, M.; Daschner, E. (2016). *Lubrication Fundamentals* (Third Edition, Revised and Expanded ed.). CRC Press.
- Donnet, C.; Erdemir, A. (2004). "Historical developments and new trends in tribological and solid lubricant coatings". *Surface and Coatings Technology*. 76–84.
- Jumat, S.; Nadia, S.; Emad, Y. (2010). "Biolubricants: raw materials, chemical modifications and environmental benefits". *European Journal of Lipid Science and Technology*. 112: 519– 530.
- Khopkar, S. M. (2007). Environmental Pollution, Monitoring and Control. New Age International Publishers.
- Chawla, S.; Rai, D. & Sons (2017). A Text Book of Engineering Chemistry.
- Sahoo, P. (2005). Engineering Tribology. Prentice-Hall of India. New Delhi.
- Lansdown, A. R. (1982). Lubrication, A practical Guide to Lubricant selection. Pergamon Press.
- Majumdar, B. C. (1999). Introduction to Tribology of Bearings. Wheeler Publishing. NewDelhi.

15. CourseCoordinator(Name&Designation):

(a) Dr. Bharat Lal Sahu (Assistant Professor)

(b) Dr. Bijnaneswar Mondal (Assistant Professor)

16. EvaluationCriteria:

Components	**ClassTest**	**Hands on Experiment**	**EndSemester**	**Total**
Weightage (%)	**20**	**20**	**60**	**100**

17. InfraStructureRequirements: Basiclaboratorywithsmallequipment likeheating mantle, magneticstirrer, melting point checker and viscometer for characterization and testingpurpose.

18. Financial Requirement: Approximate Rs. 50,000.

19. ProposedfeefortheCourse: Rs.5000(As per the University's norms).

20. BudgetaryProvisions: Rs.50,000.

(Existing staff will handle all the classes, No separate/additional Faculty will be provided for the conduct of the course, however guest faculty may be called on demand basis, payment of which may be made asper budgetary provisions of the course)