SCHEME AND SYLLABUS

FOR

Learning Outcomes based Curriculum Framework

(LOCF)

For

B. Sc. SECOND 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 PracticalB.Sc. Hon's (Chemistry): LOCF 2021-22

Department of Chemistry, School of Physical Sciences

Course Opted	CourseCode	Name of the course	Credit	Hour/ week	Internal Assess	End Sem Exam
Semester III						
CC-V Theory	**CYUCTT1**	Physical Chemistry-II	3	3	30	70
CC-V Practical	**CYUCLT1**	Physical Chemistry Practical-II	2	4	30	70
CC-VI Theory	**CYUCTT2**	Organic Chemistry-III	3	3	30	70
CC-VI Practical	**CYUCLT2**	Organic Chemistry Practical-III	2	4	30	70
CC-VII Theory	**CYUCTT3**	Molecular Spectroscopy & Photochemistry	3	3	30	70
CC-VII Practical	**CYUCLT3**	Spectroscopy Practical	2	4	30	70
AEC-III Theory	**CYUCTA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
GEC-III Theory	**CYUCTG1**	3A Physics-I, 3B Mathematics-I, 3C Zoology-I 3D Botany-1, 3EAnthropology-1, 3F Biotechnology-1,3G Forensic Science-1	3	3	30	70
GEC-III Practical	**CYUCLG1**	Generic Elective- Practical-III	2	4	30	70
Additional Credit Course III	**CYUCTC1**	Select one from the Pool of Value added Courses offered				
		Total	**22**	**30**	**270**	**630**
Semester IV						
CC-VIII Theory	**CYUDTT1**	Physical Chemistry-III	3	3	30	70
CC-VIII Practical	**CYUDLT1**	Physical Chemistry practical-III	2	4	30	70
CC-IX Theory	**CYUDTT2**	Inorganic Chemistry-II	3	3	30	70
CC-IX Practical	**CYUDLT2**	Inorganic Chemistry practical-II	2	4	30	70
CC-X Theory	**CYUDTT3**	Introduction to Quantum Chemistry	3	3	30	70
CC-X Practical	**CYUDLT3**	QuantumChemistry Practical	2	4	30	70
AEC-IV Theory	**CYUDTA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
GEC-IV Theory	**CYUDTG1**	4A Physics-I, 4B Mathematics-I, 4C Zoology-I 4D Botany-1, 4EAnthropology-1, 4F Biotechnology-1, 4G Forensic Science-1	3	3	30	70
GEC-IV Practical	**CYUDLG1**	Generic Elective- Practical-IV	2	4	30	70
Additional Credit Course IV	**CYUDTC1**	Select one from the Pool of Value added Courses offered				
		Total	**22**	**30**	**270**	**630**
Summer Internship*	**CYUDLF1**		6*	90	30	70

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-III

GE Theory-III: Solid, Solutions, Phase Equilibrium & Chemical kinetics, Conductance, PeriodicProperties and Chemistry of s-, p-, and d- block elements

GE PRACTICAL – III

SEMESTER-IV

GE Theory-IV: Analytical Chemistry, Co-ordination compounds, Organometallics andMolecules of life

GE PRACTICAL - IV

SCHOOL OF PHYSICAL SCIENCES

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (C.G.)

(A CENTRAL UNIVERSITY)

LOCF, SYLLABUS

PROPOSED (W.E.F. SESSION 2021-22)

B. Sc. SECOND 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 the laws, concepts, and application of thermodynamics along with theories/thermodynamics of dilute solutions. Graduate will have knowledge of practical approach of phases, distribution and kinetics.

PSO2: Familiarize with nitrogen containing functional groups, polynuclear hydrocarbons, heterocyclic compounds, alkaloids, and terpenes and their reactions. Graduate will be also able to do qualitative analysis, organic synthesis and characterizations (by IR and NMR).

PSO3: Understand basic principle of spectroscopic techniques and their applications.

PSO4: Understand mechanism of catalytic action, enzyme catalysis along with Langmuir, Freundlich – adsorption isotherms. Determine the cell constant and quantitative analysis by conductometric and potentiometric titrations.

PSO5: Understand the metallurgical science, chemistry of s and p-block elements, and noble gases along with inorganic polymers. Graduates will also be able to do Iodo / Iodimetric titrations and preparation of some Inorganic complexes.

PSO6: Understand basics of Quantum Chemistry.

B. Sc. II YEAR/ III - SEMESTER SCHEME

Semester	Course	Name of the course	Credits
III	CC 5	Physical Chemistry-II	Theory:3
			Practical: 2

Learning objective:

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

1. Laws of thermodynamics andconcepts.
2. Partial molar quantities and itsattributes.
3. Understanding the concept of system, variables, heat, work, and laws ofthermodynamics.
4. Understanding the concept of heat of reactions and use of equations in calculations of bond energy, enthalpy,etc.
5. Understanding the concept of entropy; reversible, irreversible processes. Calculation of entropy using 3nd law of thermodynamics.
6. Understanding the application of thermodynamics: Joule Thompson effects, partial molar quantities.
7. Understanding theories/thermodynamics of dilute solutions.

Physical Chemistry-II (Theory)

UNIT-I: Introduction to thermodynamics ***6 Lectures***

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.*First law:* Concept of heat, *q*, work, *w*, internal energy, *U*, and statement of first law; enthalpy, *H*, relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabaticconditions.

UNIT II: Thermochemistry ***6 Lectures***

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

UNIT III: Second Law ***6 Lectures***

Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy.Calculation of entropychange for reversible and irreversible processes.

UNIT IV: Third law of thermodynamics **4 Lectures**

Third Law of thermodynamics, residual entropy, calculation of absolute entropy of molecules.

UNIT V: Free Energy Functions **6 Lectures**

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

UNIT VI: Partial molar quantities ***6 Lectures***

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

UNIT VII: Dilute solutions *6 Lectures*

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

Recommended Books/References

1 Atkins P. and De Paula, J. *Physical Chemistry* Tenth Ed., OUP, 2014.

2 Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa, 2004.

3 Engel, T. and Reid, P. *Physical Chemistry 3rd Ed.,* Prentice Hall,2012.

4 McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books, 2004.

5 Roy, B. N. Fundamentals of Classical and Statistical Thermodynamics Wiley, 2001

6 *Commonly Asked Questions in Thermodynamics.* CRC Press,2011.

7 Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill, 2010. 8 Metz, C.R. *2000 solved problems in chemistry,* Schaum Series,2006.

Physical Chemistry-II (Practical)

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities onit.
2. Study the equilibrium of at least one of the following reactions by the distribution method:
   (i) I_2 (aq)+$I^- \rightarrow I_3^-$(aq)
   (ii) Cu^{2+}(aq) + $n$$NH_3 \rightarrow Cu(NH_3)_n$
3. Study the kinetics of the followingreactions.
   a. Acid hydrolysis of methyl acetate with hydrochloricacid.
   b. Saponification of ethylacetate.

Adsorption

Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selectedorganic dye(s) on activated charcoal.

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

Recommended Books/References:

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

Course Outcome:

Graduate will have understanding of:

1. Laws of thermodynamics and concepts.
2. Partial molar quantities and its attributes. Understanding the concept of system, variables, heat, work, and laws of thermodynamics.
3. The concept of heat of reactions and use of equations in calculations ofbond energy, enthalpy, *etc*.
4. The application of thermodynamics: Joule Thompson effects, partialmolar quantities.
5. Theories/thermodynamics of dilute solutions.

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	PSO5	PSO6
CO1	3	2	1	2	1	1	2	1	1	1	1	1	3					
CO2	3	2	1	2	1	1	2	1	1	1	1	1	3					
CO3	3	2	1	2	1	1	2	1	1	1	1	1	3					
CO4	3	2	1	2	1	1	2	1	1	1	1	1	3					
CO5	3	2	1	2	1	1	2	1	1	1	1	1	3					

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

Semester	Course	Name of the course	Credits
III	CC 6	Organic Chemistry-III	Theory:3
			Practical: 2

Learning objective:

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

1. Nitrogen containing functional groups and theirreactions.
2. Familiarization with polynuclear hydrocarbons and theirreactions.
3. Heterocyclic compounds and theirreactions.
4. Alkaloids andTerpenes
5. Understanding reactions and reaction mechanism of nitrogen containing functional groups.
6. Understanding the reactions and mechanisms of diazoniumcompounds.
7. Understanding the structure and their mechanism of reactions of selected polynuclear hydrocarbons.
8. Understanding the structure, mechanism of reactions of selected heterocycliccompounds.
9. Classification, structure, mechanism of reactions of few selected alkaloids andterpenes.

OrganicChemistry-III (Theory)

UNIT I: Nitrogen Containing Functional Groups **8 Lectures**

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

UNIT II: Polynuclear Hydrocarbons ***8 Lectures***

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.**UNIT III:Heterocyclic Compounds** **12**

Lectures

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), Pyrimidine, Structure elucidation of indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction Derivatives of furan: Furfural and furoic acid.

UNIT IV: Alkaloids ***6 Lectures***

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of

Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine,and Reserpine.

UNIT V: Terpenes *6 Lectures*

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

Recommended Text Books/references:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7thEdn., Pearson.
2. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly & Sons (1976).
3. Solomons, T.W., Fryhle Craig, *Organic Chemistry*, John Wiley & Sons, Inc(2009).
4. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
5. Kalsi, P. S. *Organic reacations and their mechanisms*, New Age Science(2010).
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press Inc., New York(2001).
7. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan(2010).
8. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, Third Edition (1999).
9. Clayden J., Greeves N., Warren S., Organic Chemistry, (2nd Ed)., (2012), Oxford University Press.

Organic Chemistry-III (Practical)

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols,etc.
2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy
3. Preparation of methylorange.
4. Extraction of caffeine from tealeaves.
5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple labprocedures.

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

Recommended Books/References:

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

Course Outcome:

Graduate will have understanding of:

1. Nitrogen containing functional groups and their reactions.
2. Familiarization with polynuclear hydrocarbons and their reactions.
3. Heterocyclic compounds and their reactions. Alkaloids and Terpenes
4. Reactions and reaction mechanism of nitrogen containing functional groups, diazonium compounds, polynuclear hydrocarbon and heterocyclic compounds.
5. Classification, structure, mechanism of reactions of few selected alkaloids and terpenes.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	1	2	1	1	2	1	1	1	1	1		3				
CO2	3	2	1	2	1	1	2	1	1	1	1	1		3				
CO3	3	2	1	2	1	1	2	1	1	1	1	1		3				
CO4	3	2	1	2	1	1	2	1	1	1	1	1		3				
CO5	3	2	1	2	1	1	2	1	1	1	1	1		3				

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

Semester	Course	Name of the course	Credits
III	CC 7	Molecular Spectroscopy & Photochemistry	Theory:3
			Practical: 2

Learning objective:

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

1. Interaction between radiation and molecules at various energy levels.
2. About various type of spectroscopic techniques.
3. Characterization of molecules using various spectroscopic techniques.
4. Law of Photochemistry, quantum yield and Franck-Condon Principle.
5. About photochemical reaction, Fluorescence and Phosphorescence.

Molecular Spectroscopy &Photochemistry (Theory)

Unit-I ***15 Lectures***

Interaction of electromagnetic radiation with molecules and various types of spectra; Born- Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

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

Unit-II ***10 Lectures***

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation.

Unit-III ***15 Lectures***

Photophysical and photochemical processes: laws of photochemistry, quantum yield. Jablonski diagrams: Franck-Condon principle, Law of photochemical equivalence, quantum efficiency, low and high quantum efficiency. kinetics of photochemical reactions (H_2 + Br_2 = HBr, 2HI = H_2 + I_2), energy transfer in photochemical reactions (photosensitization and quenching), fluorescence, phosphorescence, chemiluminescence, Discussion of Electronic spectra and photochemistry (Lambert-Beer law and itsapplications).

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. Levine I. N., *Physical Chemistry*, Fourth Edition), McGraw-Hill (International),1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*,University Science Books,1998
4. Rohatgi-Mukherjee K. K. Fundamentals of Photochemistry, New age (revised second

edition).

5. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi(2006).

Molecular Spectroscopy & Photochemistry (Practical)

(i) Determination of indicator constant-colorimetry.

(ii) Verification of Beer's Law - Determination of concentration of solution by colorimetry.

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

Suggested books/reference books:

1. Practicals in physical chemistry – a modern approach, P.S.Sindhu,Macmillan,
2. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.

Course Outcome:

Graduate will have understanding of:

1. Interaction between radiation and molecules at various energy levels.
2. About various type of spectroscopic techniques.
3. Characterization of molecules using various spectroscopic techniques.
4. Law of Photochemistry, quantum yield and Franck-Condon Principle.
5. About photochemical reaction, Fluorescence and Phosphorescence.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	1	2	1	1	2	1	1	1	1	1			3			
CO2	3	2	1	2	1	1	2	1	1	1	1	1			3			
CO3	3	2	1	2	1	1	2	1	1	1	1	1			3			
CO4	3	2	1	2	1	1	2	1	1	1	1	1			3			
CO5	3	2	1	2	1	1	2	1	1	1	1	1			3			

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

Semester	Course	Name of the course	Credits
III	GE-III	Solid, Solutions, Phase Equilibrium & Chemical Kinetics, Conductance,Periodic Properties and Chemistry of *s*-, *p*-, and *d*-block elements	Theory: 3 Practical: 2

Section – A: Physical Chemistry – 2

Unit – 1: Solids

Forms of solids.Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices.X–Ray diffraction by crystals, Bragg's law.Structures of NaCl, KCl and CsCl (qualitative treatment only).Defects in crystals.Glasses and liquid crystals.

(6Hours)

Unit – 2: Solutions, Phase Equilibrium&Chemical Kinetics

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions.Lever rule.Azeotropes.Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids-Principle of steam distillation.Nernst distribution law and its applications, solvent extraction.

Phases, components and degrees of freedom of a system, criteria of phase equilibrium.Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation andits importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H2O and Na-K only).

The concept of reaction rates.Effect of temperature, pressure, catalyst and other factors on reaction rates.Order and molecularity of a reaction.Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants).Half–life of a reaction.General methods for determination of order of a reaction.Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

(11Hours)

Unit – 3: Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods.Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

(5 Hours)

Section – B: Inorganic Chemistry – 2

Unit – 1: Periodic Properties & Acid-Base Concepts

Periodic Properties***:*** Division of elements into *s*, *p*, *d*, and *f* blocks, covalent radii, van derWaals radii and ionic radii; ionization enthalpy, electron gain enthalpy, and electronegativity (Pauling, Mulliken,

and Alfred-Rochow scales: Definition, methods of determination, trends in periodic table, and applications in predictingand explaining chemical behavior).

Acids and Bases: Arrhenius, Brønsted-Lowry, Lux-Flood and Lewis concepts of acids and bases. Factors affecting strengths of Lewis acids and bases, Classification of acids and basesas hard and soft, Pearsons HSAB concept, acid-base strength and hardness and softness,symbiosis, application of HSAB theory.

(7Hours)

Unit – 2: Oxidation-Reduction

Redox equations, Standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon as reducing agent, Nernst equation, redox potentials to explore the feasibility of reaction and calculation of values of equilibrium constant. Reversible and irreversible cells.Concept of EMF of a cell.Measurement of EMF of a cell.

(5Hours)

Unit – 3: *Chemistry*of *s*-,*p*-and *d*- Block Elements

s-Block Elements: General characteristic properties, complexes of alkali metals, comparative study of hydrides, oxides, hydroxides, halides, carbonates and bicarbonates of group I and II, Diagonal relationship, Biological role of alkali and alkaline earth metals.

p-Block Elements: General characteristic properties, comparative study (including diagonal relationship and inert pair effect) of groups 13-17 (B, C, N, O, F) elements and group trends of compoundslike hydrides, oxides, halides, and oxy acids; preparation properties and structure, of diborane, borazine, alkalimetalborohydrides,fullerenes, silicates and silicones, inter-halogensand polyhalides.

Chemistry of Noble Gases: Isolation and separation of noble gases from air, chemical properties of noble gases, chemistry of xenon, structure and bonding in xenon compounds. d-Block Elements: Characteristic properties of *d*-block elements. Properties of the elements of the first transition series, their binary compounds and complexes illustrating relative stability of their oxidation states, coordination number and geometry.Comparative treatment with their 3d-analogues in respect of ionic radii, oxidation states and stereochemistry.

(11Hours)

Reference Books:

- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Ed. Narosa (2004).
- J. C. Kotz, P. M. Treichel, J. R. Townsend, *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- B. H. Mahan: *University Chemistry*, 3rd Edn. Narosa (1998).
- R. H. Petrucci, *General Chemistry*, 5th Edn., Macmillan Publishing Co.: New York (1985).
- E. S. Gilreath, Fundamental Concepts of Inorganic Chemistry, McGraw Hill Edu. Pvt. Ltd.
- R. Sarkar (Part-I & II), General & Inorganic Chemistry, Central.
- R. L. Dutta (Part-I & II), Inorganic Chemistry, The New Book Stall.
- J. D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
- Gary Wulfsberg: *Inorganic Chemistry*, Viva Books Pvt. Ltd.

GE PRACTICAL – III (Solid, Solutions, Phase Equilibrium,Chemical Kinetics, Conductance & Periodic Properties and Chemistry of s-, p-, and d- block elements)

(30 Hours)

Section – A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$

$Cu^{2+}(aq) + xNH_3(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$

Phase equilibria

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

(I) Surface tension measurement (use of organic solvents excluded).

a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

b) Study of the variation of surface tension of a detergent solution with concentration.

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

a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

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

(III) Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
   c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Conductance

a) Determination of cell constant

b) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

c) Perform the following conductometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

a) Strong acid vs. strong base

b) Weak acid vs. strong base

c) Potassium dichromate vs. Mohr's salt

Section – B: Inorganic Chemistry

Semi-micro qualitative analysis using H_2S of mixtures- not more than four ionic species (twoanions and two cations and excluding insoluble salts) out of the following:

Cations : NH^{4+}, Pb^{2+}, Ag^{+}, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^{+}, Anions : CO_3^{2-}, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_2^{-}, NO_3^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^{-} *(Spot tests should be carried out wherever feasible)*

Reference Books:

- B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra& A. Gulati, College Practical Chemistry, University Press, Delhi.

Course Outcome:

Graduate will have understanding of:

1. Structure of solids and characterizations.
2. Conductance theory.
3. Periodic properties.
4. Chemistry of s, p and d block elements.
5. Chemistry of noble gases.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	1	2	1	1	2	1	1	1	1	1	1	1			1	
CO2	3	2	1	2	1	1	2	1	1	1	1	1	1	1			1	
CO3	3	2	1	2	1	1	2	1	1	1	1	1	1	1			1	
CO4	3	2	1	2	1	1	2	1	1	1	1	1	1	1			1	
CO5	3	2	1	2	1	1	2	1	1	1	1	1	1	1			1	

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

B. Sc. II YEAR/ IV - SEMESTER SCHEME

Semester	Course	Name of the course	Credits
IV	CC 8	Physical Chemistry-III	Theory:3
			Practical: 2

Learning objective:

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

1. Phases, components, Gibbs phase rule, Phase diagrams andapplications.
2. Chemical kinetics: type of reactions, determination of rate, theories of reaction rate, steady stateapproximation.
3. Catalyst – mechanism, acid base catalysis, enzymecatalysis.
4. Adsorptionisotherms.
5. Understanding phases, components, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phasediagram.
6. Understanding the basics of chemical kinetics: determination of order, molecularity, and understanding theories of reaction rates, determination of rate of opposing/parallel/chain reactions with suitable examples, application of steady state kinetics, Steady-state approximation.
7. Catalyst – mechanism of catalytic action, enzymecatalysis.
8. Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory andsignificance.

PhysicalChemistry-III (Theory)

UNIT-I: Phase Equilibria ***10 Lectures***

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid- liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water- chloroform- acetic acid system, triangular plots.*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

UNIT-II: Chemical Kinetics ***10 Lectures***

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction,differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions, determination of the order, kinetics of complex reactions (limited to first order): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

UNIT-III: Catalysis ***10 Lectures***

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

UNIT-IV: Surface chemistry *10 Lectures*

Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langumuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution.

Recommended books/References:

1. Atkins P. W. and De Paula J., *Physical Chemistry*, *(*tenth edition) Oxford University Press, 2014.
2 Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa,2004.
3 McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books,2004.
4 Engel, T. & Reid, P. *Physical Chemistry* Third Edition,Prentice-Hall,2012.
5 Zundhal, S.S. *Chemistry concepts and applications* Cengage India, 2011
6 Ball, D. W. *Physical Chemistry* Cengage India, 2012.
7 Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP, 2009.
8 Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill, 2011.
9 Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill,2009.

PhysicalChemistry-III (Practical)

Conductometry

1 Determination of cellconstant

2 Equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

3 Conductometric titrations of: (i) Strong acid Vs. strong base, (ii) Weak acid vs. strong base, (iii) Mixture of strong acid and weak acid vs. strong base.

Potentiometry

Potentiometric titrations of: (i) Strong acid vs. strong base, (ii) Weak acid vs. strong base (iii) Dibasic acid vs. strong base, (iv) Potassium dichromate vs. Mohr'ssalt.

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

Recommend books/References:

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

Course Outcome:

Graduate will have understanding of:

1. Chemical kinetics: type of reactions, determination of rate, theories of reaction rate, steady state approximation.
2. Catalyst – mechanism, acid base catalysis, enzyme catalysis.
3. Adsorption isotherms.
4. Phases, components, Gibb's phase rule and its applications, construction of phase diagram of different systems, the application of phase diagram.
5. The basics of chemical kinetics: determination of order, molecularity, andunderstanding theories of reaction rates, determination of rate of opposing/parallel/chainreactions with suitable examples, application of steady state kinetics, Steady-state approximation.
6. Langmuir, Freundlich – adsorption isotherms, significance, multilayer adsorption – theory and significance.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	1	2	1	1	2	1	1	1	1	1	1			3		
CO2	3	2	1	2	1	1	2	1	1	1	1	1	1			3		
CO3	3	2	1	2	1	1	2	1	1	1	1	1	1			3		
CO4	3	2	1	2	1	1	2	1	1	1	1	1	1			3		
CO5	3	2	1	2	1	1	2	1	1	1	1	1	1			3		
CO5	3	2	1	2	1	1	2	1	1	1	1	1	1			3		

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

Semester	Course	Name of the course	Credits
IV	CC 9	Inorganic Chemistry-II	Theory:3
			Practical: 2

Learning objective:

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

1. Oxidation-Reductions and their use inmetallurgy.
2. Chemistry of s and p-blockelements.
3. Chemistry of noblegases.
4. Inorganic polymers and theiruse.
5. Understanding redox reactions in hydrometallurgyprocesses.
6. Structure, bonding of s and p block materials and theiroxides/compounds.
7. Understanding chemistry of boron compounds and theirstructures.
8. Chemistry of noble gases and their compounds; application of VSEPR theory in explaining structure andbonding.
9. Understanding chemistry of inorganic polymers, their structures anduses.

Inorganic Chemistry-II (Theory)

UNIT-I: Oxidation-Reduction and general principle of metallurgy **8 Lectures**

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon or carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process,van Arkel- de Boer process and Mond's process, Zonerefining.

UNIT-II: Chemistry of *s* and *p* Block Elements **16 Lectures**

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behavior of first member of each group. Allotropy and catenation.Complex formation tendency of *s* and *p* block elements.Hydrides and their classification ionic, covalent and interstitial.Basic beryllium acetate andnitrate.

Structure, bonding, preparation, properties and uses.Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine.Per-oxo acids of Sulphur inter-halogen compounds, poly- halide ions, pseudo-halogens, properties of halogens.

UNIT-III: Noble Gases ***8 Lectures***

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Bonding in noble gas compounds (Valence bond and MO treatment for XeF_2), Shapes of noble gas compounds (VSEPR theory).

UNIT-IV: Inorganic Polymers ***8 Lectures***

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

Recommended books/references:

1 Lee, J.D. *Concise Inorganic Chemistry*, ELBS,1991.

2 Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y.1994.

3 Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.

4 Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH,1999.

5 Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.

6 Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010

7 Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

Inorganic Chemistry-II (Practical)

(A) Iodo / IodimetricTitrations

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution(Iodimetrically).

(ii) Estimation of (i) arsenite and (ii) antimonyiodimetrically

(iii) Estimation of available chlorine in bleaching powderiodometrically.

(B) Inorganicpreparations

(i) Cuprous Chloride,Cu_2Cl_2

(ii) Preparation of Aluminium potassium sulphate (Potash alum) or Chromealum.

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

Recommended books/references:

Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis* Sixth Edition Pearson, 2009.

Course Outcome:

Graduate will have understanding of:

1. Oxidation-Reductions and their use in metallurgy.
2. Chemistry of s and p-block elements.
3. Chemistry of noble gases and their compounds; application of VSEPR theory in explaining structure and bonding.
4. Understanding chemistry of inorganic polymers, their structures and uses.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	1	2	1	1	2	1	1	1	1	1	1				3	

CO2	3	2	1	2	1	1	2	1	1	1	1	1	1				3	
CO3	3	2	1	2	1	1	2	1	1	1	1	1	1				3	
CO4	3	2	1	2	1	1	2	1	1	1	1	1	1				3	

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

Semester	Course	Name of the course	Credits
IV	CC 10	Introduction to Quantum Chemistry	Theory:3
			Practical: 2

Learning objective:

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

1. Basics of Quantum Chemistry
2. Basic idea about operators, Schrodinger equation and its applications.
3. Use of Schrodinger equation in simple harmonic oscillator model, hydrogen atom and hydrogen like atoms.
4. Quantum mechanical approach towards valence bond and molecular orbital theory.

Introduction to QuantumChemistry (Theory)

Unit-I ***15 Lectures***

Introduction to black-body radiation and distribution of energy, photo-electic effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, eigen function and values, Schrodinger equation and application to free-particle and particle in a box, boundary conditions, wave functions and energies, degeneracy, hydrogen atom, Schrodinger equation in polar coordinates, radial and angular parts of the hydrogenic orbitals, degeneracies, spherical harmonics, representations of hydrogenic orbitals.

Unit-II ***15 Lectures***

Quantitative treatment of simple harmonic osciallator model, setting up of Schodinger equation and discussion of solution of wave functions.Rigid rotator model and discussion of application of Schrodinger equation.idea about transformation to spherical polar coordinate, discussion on solution.

Unit-III ***10 Lectures***

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Valence bond and molecular orbital approaches, LCAO-MO treatment of H_2, H_2^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations.

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition(International)1999
2. Levine I. N., *Physical Chemistry,* Fourth Edition), McGraw-Hill (International),1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,*UniversityScience Books, 1998.
4. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill(2001).
5. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA(2004).

Introduction to Quantum Chemistry (Practical)

i. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene. Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzene and pyridine π bonds.

ii. (a) Perform a conformational analysis of butane. (b) Determine the enthalpy of isomerization of *cis* and *trans*2-butene.

iii. Visualize the electron density and electrostatic potential maps for LiH, HF, N_2, NO and CO and comment. Relate to the dipole moments. Animate the vibrations of these molecules. (Software: ChemSketch, ArgusLab(www.planaria-software.com),TINKER 6.2 (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similarsoftware.

- Determination of indicator constant -colorimetry.
- Verification of Beer's Law - Determination of concentration of solution bycolorimetry.

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

Suggested books/reference books:

1. Essentials of computational chemistry – Theories and models, C. J. Crammer, Wiley, 2nd Edn., 2.Principle and applications of quantum chemistry, V.K.Gupta, Elsevier, 2016.
3. Practicals in physical chemistry – a modern approach, P.S.Sindhu,Macmillan,
4. Experiments in Physical Chemistry, J.M.Wilson, R.J.Newcomb, A.R.Denaro, 2nd Edn., Elsevier.
5. A.R. Leach, *Molecular Modelling Principles and Application*, Longman,2001.
6. J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley and Sons,1997.
7. Gupta, S.P. *QSAR and Molecular Modeling*, Springer - Anamaya Publishers,2008.

Course Outcome:

Graduate will have understanding of:

1. Basics of Quantum Chemistry
2. Basic idea about operators, Schrodinger equation and its applications.
3. Use of Schrodinger equation in simple harmonic oscillator model, hydrogen atom and hydrogen like atoms.
4. Quantum mechanical approach towards valence bond and molecular orbital theory.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6

CO1	3	2	1	2	1	1	2	1	1	1	1	1	1					3
CO2	3	2	1	2	1	1	2	1	1	1	1	1	1					3
CO3	3	2	1	2	1	1	2	1	1	1	1	1	1					3
CO4	3	2	1	2	1	1	2	1	1	1	1	1	1					3

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

Semester	Course	Name of the course	Credits
IV	GE-IV	**Analytical Chemistry, Co-ordination compounds, Organometallics and Molecules of life**	Theory: 3
			Practical: 2

Theory: 60 Hours

Section – A: Analytical Chemistry – 3

Unit – 1: Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature.Balances, burettes, volumetric flasks, pipettes, calibration of tools, sampling. Errors andStatistics: significant figures, rounding off, accuracy and precision, determinate andindeterminate errors, standard deviation, propagation of errors, confidence limit, test ofsignificance, rejection of a result.

(5Hours)

Unit – 2:Volumetric Titration

Standard solution, primary standard and secondary standard, titration, end point, indicator, concentration of standard solution- moles, Normality, molarity, Molality, parts per million(PPM), volumetric calculation, acid base titration and use of indicators,titration curves for strong acid vs strong base, weak acid with strong base, weak base with strong acid, theory of acid base indicator, Redox titration- titration of Mohr salt against $KMnO_4$, Titration of Oxalic acid against $KMnO_4$, Titration of $FeSO_4$ against $K_2Cr_2O_7$.

(6 Hours)

Unit – 3: Chromatography

Chromatographic Techniques:classification, theory of chromatographic separation, distribution coefficient, retention,sorption, efficiency and resolution. - Column, ion exchange, paper, TLC & HPTLC chromatography etc.

***Solvent Extraction*:** Distribution Coefficient, distribution ratio, percent extracted, solvent extraction of metals ions, extraction of ion association complex, extraction of metal chelates, multiple batch extraction and applications.

***Ion-exchange*:** Column, ion-exchange chromatography etc.Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

Gas Chromatography: retention time or volume, capacity ratio,partition coefficient, theoretical plate and number, separation efficiency and resolution,instrumentation and application.

(8Hours)

Section – B: Inorganic Chemistry – 3

Unit – 1: Coordination Compounds

Werner's coordination theory and its experimental verification,effective atomic number concept,chelats, nomenclature of co-ordination compounds,isomerism in coordination compounds.

Crystal Field Theory: Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry.Factors affecting the magnitude of D. Spectrochemical series.Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry.Jahn-Teller distortion, Square planar coordination.

(7 Hours)

Unit – 2: Organometallics

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of

mononuclear and polynuclear carbonyls of 3d metals. p-acceptorbehaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

(6Hours)

Section – C: Organic Chemistry – 3

Molecules of Life

Unit – 1: Carbohydrates

Classification of carbohydrates, reducing and non reducing sugars, and General Properties, Glucose and Fructose,their open chain structure. Epimers, mutarotation and anomers, Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

(5Hours)

Unit – 2: Amino Acids, Peptides, ProteinsandNucleic Acids

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis.Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$group, complexationwith Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins.Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme).Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

Components of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides **(nomenclature)**, Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA(**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

(8 Hours)

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6thEd.*, Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7thEd.*, Prentice Hall.
- Vogel, A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- 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).
- B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
- R. H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- J. D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- D. F. Shriver and P. W. Atkins: *Inorganic Chemistry*, Oxford University Press.
- R. L. Dutta (Part-I & II), Inorganic Chemistry, The New Book Stall.
- Gary Wulfsberg: *Inorganic Chemistry*, Viva Books Pvt. Ltd.
- S. Chand. 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).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Bioch*emistry *7thEd.*, W. H. Freeman.
- Berg, J. M., Tymoczko, J. L. &Stryer, L. *Biochemistry 7thEd.*, W. H. Freeman

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GEPRACTICAL – IV (Electrochemistry, Chemical Kinetics, Co-ordination compounds, Organometallics and Molecules of life

(30 Hours)

Section – A: AnalyticalChemistry

1. Estimation of the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oxinate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.
4. To draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound and estimate the concentration of the same in a given solution.
5. Determination of the composition of the Fe^{3+} - salicylic acid complex / Fe^{2+} - phenanthroline complex in solution by Job's method.
6. Determination of concentration of Na+ and K+ using Flame Photometry.

Section – B: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given)

Binary mixture of nickel and cobalt, copper and nickel, zinc and magnesium, iron andcopper; aluminium and nickel.

2. Preparation of any two of the following complexes:
   (a) tetraaammine copper (II) sulphate
   (b)tetraamminecarbonatocobalt (III) nitrate
   (c) potassiumtrioxalatochromate (III)
   (d) potassiumtrioxalatoferrate (III)
   (e) sodiumhexanitritocabaltate (III)
   (f) prussin blue

Section – C: Organic Chemistry

1. Determination of the concentration of glycine solution by formylation method.
2. Titration curve of glycine
3. Action of salivary amylase on starch
4. Effect of temperature on the action of salivary amylase on starch.
5. Determination of the saponification value of an oil/fat.
6. Determination of the iodine value of an oil/fat
7. Differentiation between a reducing/nonreducingsugar.
8. Extraction of DNA from onion/ cauliflower

Reference Books:

- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6thEd.*, Saunders College Publishing, Fort Worth (1992).
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7thEd.*, Prentice Hall.
- Vogel, A. I. Vogel's *Quantitative Chemical Analysis 6thEd.*, Prentice Hall.
- G. M. Barrow: *Physical Chemistry* Tata McGraw-Hill (2007).
- G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011
- V. K. Ahluwalia, S. Dhingra& A. Gulati, College Practical Chemistry, University Press, Delhi.

Course Outcome:

Graduate will have understanding of:

1. Basics of Analytical Chemistry
2. Basic idea about chromatography.
3. Coordination Chemistry.
4. Chemistry of molecules in life.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6
CO1	3	2	1	2	1	1	2	1	1	1	1	1	1	1			3	
CO2	3	2	1	2	1	1	2	1	1	1	1	1	1	1			3	
CO3	3	2	1	2	1	1	2	1	1	1	1	1	1	1			3	
CO4	3	2	1	2	1	1	2	1	1	1	1	1	1	1			3	

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.

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:

- Understand the concept of IPR
- Differentiate between various agreements ofIPR
- Compare copyrights, patents and GeographicalIndicators
- Examine various legal issues related toIPR
- 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.

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 differenteras
- Analyze the role played by different Indian organizations inscience
- Learn about the science and techniques used in ancient India
- Appraise the contribution of different Indian Scientists inscience

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

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:

- Apply practical skills in science courses with the understanding of general laboratory practices
- Explore various research issues and theirsolutions
- Apply various techniques to study chemical compounds,salts
- Use various micro techniques used inchemistry

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.

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:

- Understand the scope of forensic science
- Understand about various types of evidences
- Analyse various evidences
- 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).

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:

- Know about the renewable energy sources
- Utilize various renewable energy technologies to solve future energy consumption problems
- Identify biomass sources
- 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.

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:

- Know about the history and prospects of chemo-informatics
- Represent molecules and chemical reaction using different notations, SMILES and Matrix representaion
- 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.: NewDelhi.

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)

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:

1. Understand the concept of research and different types of research in the context of biology
2. Develop laboratory experiment relatedskills.
3. Develop competence on data collection and process of scientificdocumentation
4. 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

1. Experiments based on chemicalcalculations.
2. Lab computationalexperiments.
3. Poster presentation on definedtopics.
4. Technical writing on topicsassigned.
5. Identification of different type of research in day by daylife.
6. Curation of relevant scientific literature from GoogleScholar.
7. Demonstration for checking of plagiarism using recommendedsoftware.
8. 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.

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:

a. Understand the chemical processes involved in daily life
b. Know the respiration process in terms of chemistry
c. Understand chemicals hazardous for health
d. Understand chemical structures of various vitamins
e. 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, synthetic biodegradable 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.

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.

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:

- Develop understanding of the concepts and principles of basic psychologicalskills
- Apply techniques and methods to enhance productivity and timemanagement
- Develop critical thinkingskills
- Organize human resources with improved leadershipqualities

Keywords:

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

Unit I: BasicPsychologySkills ***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:DealingNegativity ***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.

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:

- Apply the basic operations of spreadsheetapplications
- Recognize advanced resources for accessing scholarly literature frominternet
- Utilize bibliography management software while typing and downloadingcitations
- 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 tofollow.

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:

- Identify the need and role of science communication in humandevelopment
- utilize visual media science communication for creating scripts anddocumentaries
- 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.

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.

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.

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:

- Employ the process for maintenance and preservation ofmicroorganisms
- Analyze the various aspects of the fermentation technology and apply for Fermentative production
- Demonstrate proficiency in the experimental techniques for microbial production of enzymes: amylase and protease, bio productrecover

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.

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.

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).

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:

- Know History, types and important of intellectual property.
- Have understanding about different types of trademarks.
- Know about Patent and copyright transfer system
- 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.

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:

- Identify among various biological molecules
- Understand primary, secondary and tertiary structures of proteins.
- Indentify structures of DNA, RNA, Lipids etc.
- 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.

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:

- Recall various types and categories ofmushrooms.
- Demonstrate various types of mushroom cultivatingtechnologies.
- Examine various types of food technologies associated with mushroomindustry.
- Value the economic factors associated with mushroomcultivation
- 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.

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:** 12^{th} 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:

5. Industrial Chemistr by Stocchi, E. Vol-I, Ellis Horwood Ltd. UK (1990).
6. Engineering Chemistry by Jain, P.C. & Jain, M. Dhanpat Rai & Sons, Delhi.
7. A Text Book of Engineering Chemistry S. S. Dara S Chand & Company
8. Industrial Chemistry by Sharma, B.K. & Gaur, H. Goel Publishing House, Meerut (1996).
9. Chemistry of Fossil Fuels and Biofuels by Harold Schobert , Cambridge University Press 2013.
10. The Chemistry and Technology of Coal by James G. Speight, CRC Press Boca Raton (2012)
11. Water for Energy and Fuel Production, Yatish T. Shah, CRC Press Boca Raton (2014)
12. Process Chemistry of Coal Utilization: Impacts of Coal Quality and Operating Conditions by Stephen Niksa, Elsevier 2019
13. Chemistry of Coal Conversion by Richard H. Schlosberg Springer (1985).
14. The Chemistry and Technology of Petroleum by James G. Speight CRC, Boca Raton (2014).
15. 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)