SCHEME AND SYLLABUS

FOR

Learning Outcomes based Curriculum Framework

(LOCF)

For

B. Sc. THIRD YEAR (Chemistry Honours)

DEPARTMENT OF CHEMISTRY

SCHOOL OF PHYSICAL SCIENCES

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

To be implemented from 2021-22

Semester wise Theory Papers and Practical

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

Department of Chemistry, School of Physical Sciences

Course Opted	CourseCode	Name of the course	Credit	Hour/ week	Internal Assess	End Sem Exam
Semester V						
CC-XI Theory	**CYUETT1**	Inorganic Chemistry-III	3	3	30	70
CC-XI Practical	**CYUELT1**	Inorganic Chemistry Practical-III	2	4	30	70
CC-XII Theory	**CYUETT2**	Analytical Chemistry	3	3	30	70
CC-XII Practical	**CYUELT2**	Analytical Chemistry Practical	2	4	30	70
AEC-V Theory	**CYUETA1**	Select one from the Pool of AEC Courses offered	2	2	30	70
DSE-I Theory	**CYUETD1**	Select one from the Pool of DSE Courses offered	3	3	30	70
DSE-I Practical	**CYUELD1**	Select one from the Pool of DSE Courses offered	2	4	30	70
DSE-II Theory	**CYUETD2**	Select one from the Pool of DSE Courses offered	3	3	30	70
DSE-II Practical	**CYUELD2**	Select one from the Pool of DSE Courses offered	2	4	30	70
Additional Credit Course V	**CYUETC1**	Select one from the Pool of Value added Courses offered				
		TOTAL	**22**	**30**	**270**	**630**
Semester VI						
CC-XIII Theory	**CYUFTT1**	Green Chemistry	3	3	30	70
CC-XIII Practical	**CYUFLT1**	Green Chemistry Practical	2	4	30	70
CC-XIV Theory	**CYUFTT2**	Materials Chemistry	3	3	30	70
CC-XIV Practical	**CYUFLT2**	Materials Chemistry Practical	2	4	30	70
DSE-III Theory	**CYUFTD1**	Select one from the Pool of DSE Courses offered	3	3	30	70
DSE-III Practical	**CYUFLD1**	Select one from the Pool of DSE Courses offered	2	4	30	70
Seminar	**CYUFSS1**	Followed by report submission and seminar	2	4	30	70
Dissertation/Project	**CYUFL**	Followed by report submission, presentation and Viva-Voce.	7	14	30	70
Additional Credit Course VI	**CYUFTC1**	Select one from the Pool of Value added Courses offered				
MOOC's**						
				2-5	2-5	
			TOTAL	**24**	**34**	**240**	**560**

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

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

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

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

Abbreviations:

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

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

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

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

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

VALUE ADDED COURSES (Optional,CREDIT: 03 EACH)

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

SCHOOL OF PHYSICAL SCIENCES

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR (C.G.)

(A CENTRAL UNIVERSITY)

LOCF, SYLLABUS

PROPOSED (W.E.F. SESSION 2021-22)
B. Sc. THIRD 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 coordination compounds, chemistry of transition metals, lanthanides, and actinides and metals in biological systems. Graduate also able to do qualitative analysis of cations and anions with preparation of metal complexes.

PSO2: Understand fundamentals of analytical chemistry and analytical techniques.

PSO3: Understanding the use of green chemistry principle and processes in laboratory reactions.

PSO4: Understanding the chemistry of materials: synthesis, characterizations, and applications.

PSO5: Understand the chemistry of medicine, polymers, environment, nuclear, and nanomaterials.

B. Sc. III YEAR/ V - SEMESTER SCHEME

Semester	Course	Name of the course	Credits
V	CC 11	Inorganic Chemistry-III	Theory:3
			Practical: 2

Learning objective:

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

1. Coordination compounds – its nomenclature, theories, d-orbital splitting in complexes,

chelate.

2. Transition metals, its stability, color, oxidation states andcomplexes.
3. Lanthanides, Actinides – separation, color, spectra and magneticbehavior
4. Bioinorganic chemistry – metal ions in biological system, its toxicity;hemoglobin.
5. Understanding the nomenclature of coordination compounds/complexes, Molecular orbital theory, d-orbital splitting in tetrahedral, octahedral, square planar complexes, chelate effects.
6. Understanding the transition metals stability in reactions, origin of colour and magnetic properties.
7. Understanding the separation of Lanthanoids and Actinoids, its color, spectra and magneticbehavior.
8. Understanding the bioinorganic chemistry of metals in biologicalsystems.
9. Hemoglobin and its importance in biologicalsystems.

Inorganic Chemistry-III (Theory)

UNIT-I: Coordination Chemistry **10 Lectures**

Werner's theory, EAN rule, piano-stool compounds, valence bond theory (inner and outer orbital complexes), Crystal field theory, d-orbital splitting, , weak and strong fields, pairing energies, factors affecting the magnitude of (Δ). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar complexes, d orbitalsplitting in trigonal bipyramidal, square pyramidal and cubic ligand field environments, CFSE, Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series, Qualitative aspect of Ligand field theory, MO diagrams of representative coronation complexes, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelateeffect,

UNIT-II: Transition Elements ***10 Lectures***

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams).Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

UNIT-III: Lanthanoids and Actinides ***10 Lectures***

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide

contraction, separation of lanthanides (ion-exchange method only).

UNIT-IV: Bioinorganic Chemistry **10 Lectures**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on distribution of metals.Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), toxicity, chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

Recommended text books/References:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
2. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
3. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
4. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
5. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

Inorganic Chemistry-III (Practical)

1. Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given on understanding of the chemistry of different reactions. Following radicals may be analyzed:

   Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions

   e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-,Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot analysis/tests should be done whenever possible.
2. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
3. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. (Also find the λ_{max} of the prepared complex usinginstrument).
4. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitutionmethod.

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

Recommended text books/references:

1. Vogel's *Qualitative Inorganic Analysis*, Revised by G. Svehla. Pearson Education,2002.
2. Marr & Rockett *Practical Inorganic Chemistry*. John Wiley & Sons1972.

Course Outcome:

Graduate will have understanding of:

1. Coordination compounds – its nomenclature, theories, d-orbital splitting in complexes, chelate.
2. Transition metals, its stability, color, oxidation states and complexes.
3. Lanthanides, Actinides – separation, color, spectra and magneticbehavior
4. Bioinorganic chemistry – metal ions in biological system, its toxicity; hemoglobin.

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
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				

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

Semester	Course	Name of the course	Credits
V	CC 12	Analytical Chemistry	Theory:3
			Practical: 2

Learning objective:

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

1. Familiarization with fundamentals of analyticalchemistry.
2. Basics of spectroscopic, thermal, electrochemicaltechniques
3. Learning basics of separation techniques and itsapplications.
4. Understanding analytical tools, statistical methods applied to analyticalchemistry.
5. Understanding principle of UV-Vis spectroscopy and itsapplications.
6. Understandingprinciplesofthermo-gravimetric analysis and study of thermaldecomposition of materials/characterization ofmaterials.
7. Understanding basics of electro-analytical techniques and itsapplications.
8. Understandingprinciplesofseparationtechnology andits use in advanced instrumentations.

Analytical Chemistry (Theory)

UNIT-I: Qualitative and quantitative aspects of analysis **4 Lectures**

Tools in analytical chemistry and their applications, Sampling, evaluation of analytical data, errors, accuracy and precision, statistical test of data; F, Q and t-test, rejection of data, and confidence intervals.

UNIT-II: Spectroscopy ***8Lectures***

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

Vibration spectroscopy: Basic principles of instrumentation, sampling techniques. Application of IR spectroscopy for characterization through interpretation of data, Effect and importance of isotope substitution. Introduction to Raman spectra

UV-Visible Spectrometry: Basic principles of instrumentation, principles of quantitative analysis using estimation of metal ions from aqueous solution, Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

UNIT-III: Thermal analysis ***6 Lectures***

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg fromtheirmixture.

UNIT-IV: Electroanalytical methods **6 Lectures**

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points.

determination of pKa values.

UNIT-V: Separation techniques ***16 Lectures***

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction

of metal ions from aqueous solution, extraction of organic species from the aqueous and non- aqueous media.

Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC andHPLC.

Recommended Books/Reference Books:

1 Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson,2009.

2 Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. WardsworthPublishing California, USA,1988.

3 Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

4 Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.

5 Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis, Saunder College Publications,(1998).*

6 Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood John Wiley1979.

7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand,1974.

8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

9 Skoog D.A., Holler F.J., Nieman T.A., Principles of instrumental analysis, 5thEdn., Brooks & Cole(1997).

Analytical Chemistry (Practical)

At least two experiments from each section

I. Chromatography:

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, andCr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the $R_f$values.

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

(iv) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

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

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

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

III. Analysis of soil:

(i) Determination of pH ofsoil.

(ii) Total solublesalt

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

IV. Ionexchange:

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

(ii) Separation of metal ions from their binarymixture.

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

V. Spectrophotometry

(i) Determination of pKa values of indicator using spectrophotometry.

(ii) Structural characterization of compounds by infraredspectroscopy.

(iii) Determination of dissolved oxygen inwater.

(iv) Determination of chemical oxygen demand(COD).

(v) Determination of Biological oxygen demand(BOD).

(vi) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

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

Recommended text books/references:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson,2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA,1988.
3. Christian, G.D. *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York,2004.
4. Harris, D.C. *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman,2016.
5. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New AgeInternational Publisher,2009.
6. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning IndiaEdition.
7. Mikes, O. & Chalmes, R.A. *Laboratory Handbook of Chromatographic & Allied Methods*, Elles Harwood Ltd.London.
8. Ditts, R.V. *Analytical Chemistry: Methods of separation.* Van Nostrand, NewYork, 1974.

Course Outcome:

Graduate will have understanding of:

1. Fundamentals of analytical chemistry.
2. Basics of spectroscopic, thermal, electrochemical techniques
3. Learning basics of separation techniques and its applications.
4. Principle of UV-Vis spectroscopy and its applications.
5. Principles of thermo-gravimetric analysis and study of thermal decomposition of materials/characterization of materials.
6. Basics of electro-analytical techniques and its applications.
7. Principles of separation technology and its use in advanced instrumentations.

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
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			
CO6	3	2	1	2	1	1	2	1	1	1	1	1		3			
CO7	3	2	1	2	1	1	2	1	1	1	1	1		3			

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

B. Sc. III YEAR/ VI - SEMESTER SCHEME

Semester	Course	Name of the course	Credits
VI	CC 13	Green Chemistry	Theory:3
			Practical: 2

Learning objective:

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

1. Green chemistry and its principles.
2. Green synthesis and reactions.
3. Green chemistry for sustainable solutions.
4. Understanding principles of green chemistry.
5. Understanding design of chemical reactions/chemical synthesis using green chemistry principles.
6. Atom economy and design of chemical reactions using the principle.
7. Understanding the use of green chemistry principle and processes in laboratory reactions.

Green Chemistry (Theory)

UNIT-I: Introduction to Green Chemistry ***4 Lectures***

Basic introduction and explaining goals of Green Chemistry. Limitations/Obstacles in the pursuitof the goals of Green Chemistry

UNIT-II: Principles of Green Chemistry and Designing a Chemical synthesis 12 Lectures

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts;maximumincorporationofthematerialsusedintheprocessintothefinalproducts,Atom Economy, calculation of atom economy of the rearrangement, addition, substitution andelimination reactions).

UNIT-III: Green Synthesis / Reactions ***16 Lectures***

1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylationreaction).
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative toIodine)
4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning ofgarments.
5. Designing of Environmentally safe marineantifoulant.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made fromcorn.
7. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of no Trans-Fats andOils

UNIT-IV: Future Trends in Green Chemistry ***8 Lectures***

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C_2S_3); Green chemistry in sustainabledevelopment.

Recommended Books/References:

1. Ahluwalia, V.K., Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers(2005).
2. Anastas, P.T. & Warner, J.K, *Green Chemistry- Theory and Practical*, Oxford University Press(1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker(2001).
4. Cann, M.C.and Connely, M.E. *Real-World cases in Green Chemistry*, ACS(2000).
5. Ryan, M.A. and Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010.

Green Chemistry (Practical)

Any six experiments may be conducted

1. Preparation and characterization of nanoparticles of gold using tealeaves.
2. Preparation of biodiesel from vegetable/ waste cookingoil.
3. Use of molecular model kit to stimulate the reaction to investigate how the atom economy illustrates GreenChemistry.
4. Reactions like addition, elimination, substitution and rearrangement may also be studied for the calculation of atomeconomy.
5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead ofcyanide).
6. Extraction of D-limonene from orange peel using liquid CO_2 prepared form dryice.
7. Mechanochemical solvent free synthesis ofazomethines
8. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II)complex.
9. Photoreduction of benzophenone to benzopinacol in presence ofsunlight.

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

Recommended Books/References:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC(2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC(2002).
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph, International Publishing ISBN 978-93-81141-55-7(2013).
5. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society(2008).

6. Cann, M. C. and Thomas, P. *Real world cases in Green Chemistry*, American Chemical Society(2008).
7. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition,2010.
8. Pavia, D. L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach*, W.B.Saunders,1995.

Course Outcome:

Graduate will have understanding of:

1. Green chemistry and its principles.
2. Green synthesis and reactions.
3. Green chemistry for sustainable solutions.
4. Principles of green chemistry.
5. Design of chemical reactions/chemical synthesis using green chemistryprinciples.
6. Atom economy and design of chemical reactions using the principle.
7. The use of green chemistry principle and processes in laboratory reactions.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
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		
CO6	3	2	1	2	1	1	2	1	1	1	1	1			3		
CO7	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
VI	CC 14	Chemistry of Materials	Theory:3
			Practical: 2

Learning objective:

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

1. Crystalline solids – parameters,symmetry.
2. Silica based materials inapplications.
3. Technological importance of ionic liquids, preparation of materials– using sol-gel technique.
4. Nano-structured materials, self-assembledstructure.
5. Composites and itsapplications
6. Understanding basic parameters of crystalline solids, symmetry and crystalstructures.
7. Mesoporous/microporous silica based materials, functionalized hybrid materials and its applications.
8. Preparation of inorganic solids, host-guest chemistry, ionic liquids and itssignificance.
9. Understanding self-assembled structures, nano-structured materials, carbon nanotubes, applications.
10. Understanding composites and their industrialapplications.

Chemistry of Materials (Theory)

UNIT-I: Basics of crystalline solids **8 Lectures**

Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding , lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations , translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism,twinning.

UNIT-II: Silica based materials ***8 Lectures***

Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications

UNIT-III: Inorganic solids/ionic liquids of technological importance **8 Lectures**

Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium based ionic liquids. Host-guestchemistry (elementaryideas).

UNIT-IV: Nanomaterials ***8 Lectures***

Overview of nanostructures and nano-materials: classification. Preparation of gold and silver

metallic nanoparticles, self-assembled nanostructures-control of nano-architecture-one dimensional control.Carbon nanotubes and inorganic nanowires.

UNIT-V: Composite materials *8 Lectures*

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

Recommend books/References:

1. Atkins P, Overton T., Rourke J. Weller M. and Armstrong F *Shriver and Atkins. Inorganic Chemistry* Oxford University Press, Fifth Edition,2012.
3. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. JohnWiley,1974.
4. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley2003.
5. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning,2002.

Chemistry of Materials (Practical)

1. Preparation of urea-formaldehyderesin
2. Preparations of novalac resin/resolresin
3. Synthesis of materials/porous materials (Sol-gel, hydrothermal, microwave). (Similarly other materials synthesis can bedesigned).
4. Preparation of silver nano material. (Similarly other nano materials of other metals synthesis can bedesigned).
5. Analysis of XRD pattern ofcrystals.
6. Interpretation of FTIR, NMR and UV-Vis data of givenmaterial.
7. Estimation of particle size from the BET, SEMtechniques.
8. Density measurement of ionicliquids
9. Determining dynamic viscosities of given ionicliquids
10. Determination of hydration number IRspectra.

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

Course Outcome:

Graduate will have understanding of:

1. Crystalline solids – parameters, symmetry.
2. Silica based materials in applications.
3. Technological importance of ionic liquids, preparation of materials– using sol-gel technique.
4. Nano-structured materials, self-assembled structure.
5. Composites and its applications
6. Basic parameters of crystalline solids, symmetry and crystal structures.

7. Mesoporous/microporous silica based materials, functionalized hybrid materials and its applications.
8. Preparation of inorganic solids, host-guest chemistry, ionic liquids and its significance.

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
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	
CO6	3	2	1	2	1	1	2	1	1	1	1	1				3	
CO7	3	2	1	2	1	1	2	1	1	1	1	1				3	
CO8	3	2	1	2	1	1	2	1	1	1	1	1				3	

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

DISCIPLINE SPECIFIC ELECTIVE COURSES

Semester	Course	Name of the course	Credits
V,VI	DSE1	Medicinal Chemistry	Theory: 3
			Practical: 2

Learning objective:

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

1. The basics of medicinal chemistry, biophysicalproperties
2. Biological activityparameters
3. Drugmetabolism
4. Biophysical and chemical properties of enzymes, hormones, vitamins
5. Concept of rational drug design

Unit 1: Bio-physicochemical properties

Acidity/Basicity, Solubility, Ionization, Hydrophobic properties, Hydrophilic properties, Lipinski Rule, Drug-like properties, Understanding of the biological activity parameters such as K_i, K_d, LD_{50}, EC_{50}, IC_{50}, CC_{50}, ADMET properties.

Unit 2: Structural properties

Isosterism, Bioisosterism, Nonclassical isosteres, Understanding of the 3D-structure along withbond length, bond angle and dihydral angle, Concept of Configuration and Conformation with examples, Concept of stereochemistry in terms of biological response with examples,Stereoselective receptors or enzymes such as muscarinic receptor, Stereochemically pure drugand recemates, Examples such as catecholamines, etc.

Unit 3: Drug target understanding

Metabolism, Drug metabolism, Anti-metabolite, Enzyme inhibitor, Agonist, Antagonist,Examples.

Unit 4: Medicinal Chemistry of Therapeutic Agent

Structure, Chemistry, Mode of action and adverse effect of the representative therapeutic agents such as Anti-infective agent, Antimalarials, Antibacterial, Antiviral, Anticancer, CNS acting drugs, Adrenergic Agents, Cholinergic Drugs, Diuretics, Cardivascular, local anesthetic agent, Analgesic Agents, Histamine and Antihistamine agents.

Unit 5: Steroids, Prostaglandins, Enzyme, Hormone and Vitamins

Biophysico-chemical properties, Steroid Hormone Receptors, Chemical Contraceptive agents, COX-2 inhibitors, Prostaglandins for Ophthalmic use, pharmaceutically important enzyme products such as Pancreatin, Trypsin, Insulin. Classification of vitamins with examples.

Unit 6: Concept of rational drug design

Structure activity relationship, Drug-receptor understanding, Molecular modeling, Structure based drug design. QSAR.

Recommended books/References:

1. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical ...by Charles Owens Wilson, John H. Block, Ole Gisvold, John MarloweBeale
2. Foye's Principles of Medicinal Chemistry by David A. Williams, Thomas L. Lemke, William O. Foye (2008), Kluwerpublication.
3. Remington: The Science and Practice of Pharmacy Vol 1, Ed. 19 by Joseph Price Remington, Alfonso R. Gennaro. (1995), MACKPublishing.
4. Burgers Medicinal Chemistry by Manfred E. Wolff, AlfredBurger
5. Burgers Medicinal Chemistry and Drug Discovery by Abraham D. J., Lewis F. L., Burger A., vol.5, 6th Edn., 2003, HobokenN.J.Wiley,
6. The Organic Chemistry of Drug Design and Drug Action by Silverman R. B., 2nd Edn., Academic Press.2012.
7. Exploring QSAR: Fundamental and applications in Chemistry and Biology by Hansch C. and Leo, A American Chemical Society(1995)
8. Patrick, G. Medicinal Chemistry, Oxford.University Press(2000).

Suggested list of Experiments

1. Purification Techniques of Solvents by Fractional Distillation and Vacuum Distillation.
2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by ColumnChromatography.
3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties.(Benzilic Acid & SodiumBenzoate)
4. Synthesis & Purification of following Compoundsusing:

   (i) Precipitation or Recrystallization. (ii) Synthesis of Benzimidazole. (iii) Synthesis of Anthranilic Acid. (iv) Synthesis of Sulphanilamide. (v) Synthesis of benzoic acid from benzyl alcohol. (vi) Synthesis of 1,4 – dihydropyridine.
5. Computational modeling of drug design/use of softwares may be demonstrated tostudents.

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

Suggested books/references:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J. D.Barnes, M. J. K Thomas, 6th Edition, Pearson's Education Ltd.
2. Advanced Practical Medicinal Chemistry, Ashutosh Kar, New Age International Ltd. (2004).
3. Vogel‟sTextbookofPracticalOrganicChemistry,B.S.Furniss,A.J.Hannaford,P. W. G. Smith, A. R. Tatchell, 5th edition (2008), Pearson's Education Ltd

Course Outcome:

Graduate will have understanding of:

1. The basics of medicinal chemistry, biophysical properties
2. Biological activity parameters
3. Drug metabolism
4. Biophysical and chemical properties of enzymes, hormones, vitamins
5. Concept of rational drug design

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
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
V,VI	DSE2	Electrochemistry	Theory: 3
			Practical: 2

Learning objective:

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

1. Basic principle of laws of electrochemistry.
2. Understanding about chemical cells and their function.
3. Understanding about electrodes, EMF measurement.
4. Understanding about potentiometric titrations and their applications.

Unit-I

Arrhenius theory of electrolytic dissociation.Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes.Molar conductivity at infinite dilution.Kohlrausch law of independent migration of ions.Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules.Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants ofsalts.

Unit-II

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry.Chemical cells, reversible and irreversible cells with examples.Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and withouttransference,liquidjunctionpotential;determinationofactivitycoefficientsand transference numbers.Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

Unit-III: Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKavalues.

Unit-IV: Electrical & Magnetic Properties of Atoms and Molecules: Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecularinterpretation.

Recommended books/reference books

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP

(2009).

4. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
6. Rogers, D. W. Concise Physical Chemistry Wiley(2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc.(2005).

List of suggested laboratory experiments

1. Determination of pH of a given solution using glasselectrode.
2. Determination of cellconstant.
3. Determination of equivalent conductance, degree of dissociation, and dissociation constant of weak acid.
3. Conductometric titration: strong acid *vs*. strong base, weak acid *vs*. strongbase.
4. Potentiometric titration: strong acid *vs*. strong base, weak acid *vs*. strong base,potassium dichromate vs. mohr'ssalt.

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

Recommended books/reference books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi(2011).
2. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.
3. Garland,C.W.;Nibler,J.W.&Shoemaker,D.P.*ExperimentsinPhysicalChemistry8thEd.;* McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York(2003).

Course Outcome:

Graduate will have understanding of:

1. Basic principle of laws of electrochemistry.
2. Understanding about chemical cells and their function.
3. Understanding about electrodes, EMF measurement.
4. Understanding about potentiometric titrations and their applications.

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
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

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

Semester	Course	Name of the course	Credits
V,VI	DSE3	Polymer Chemistry	Theory: 3
			Practical: 2

Learning objective:

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

1. The mechanism of polymer materialformation.
2. Molecular weight and structure propertyrelationship
3. Polymerization procedure and Zigler-Nattacatalysis.
4. Characterization ofpolymers

Unit 1: Introduction

Polymer, monomer, examples of polymers, biopolymers, classification, polymerization process, degree of polymerization, condensation, addition polymers, kinetics of addition polymerization process.

Unit 2: Polymeric Structure and Property Relationship

Structure of polymers - Linear, branched, cross linked, and network polymers, molecular weight (number average, weight average, viscosity average) and distribution of molecular weight, polydispersity index, crystallinity in polymer, melting temperature and glass transition temperature, Volumetric properties - molar volume, density, Van der Waals volume - Coefficient of linear thermal expansion and volumetric thermal expansion - Pressure volume temperature (PVT) relationship.

Unit 3: Polymerization Chemistry

Industrial methods of polymerization such as a bulk, solution, emulsion, suspension.Stereochemistry of polymers and stereo-specific polymerization, Catalysts-their utility in polymers and stereo-specific polymerizations, Catalysts their utility in polymer manufacture, Zieglar-Natta, Metallocene and others.

Unit 4: Characterization of Polymers

Molecular Weight Determination by Light Scattering, Osmometry, End-Group Analysis, Viscosity, Gel Permeation Chromatography; Application, of FTIR, UV-visible, NMR, and Mass Spectroscopy for Identification of polymers.

Recommended books/References:

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties Of Polymer, 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford - Newyork.1990.
2. J.E. Mark Ed.AIP, Physical Properties Of Polymers Hand Book, Williston, Vt,1996.
3. Reaction Engineering of Step Growth Polymerization, S K Gupta and Anil Kumar, Plenum Press,1987
4. Odian; George, Principles of Polymerization, McGraw-Hill Book Co., New York(1970).
5. W. Billmeyer, Text book of polymer science, 3rd Edn., 2007,Wiley.
6. J.R.Fried, Polymer Science and Technology, (2005), PHIpublication.
7. Billmeyer Jr.; Fred W., Textbook of Polymer Science, Wiley- Interscience Publishers,

New York(1962).

List of suggested laboratory practicals

1. Free radical solution polymerization of any one: Styrene, methylmethacrylate, methyl acrylate, methacrylic acid (using free radical initiators). (purification of monomer should betaught)
2. Preparation of phenol-formaldehyderesins.
3. Emulsion polymerization ofpolymethylmethacrylate.
4. Use of viscometer for molecular weight determination – (any known polymer, example: polyvinyl pyrrolidone in water/polyacrylamide in $NaNO_2$ solution) by viscometry. (students should be explained regarding principles and use of ubblohde/ostwaldviscometer).
5. Estimation of amount of HCHO in a given solution by sodium bisulphitemethod.
6. Use of FTIR/TGA/DSC – for polymer characterization (may be demonstrated tostudents)
7. Determination of exchange capacity of cation exchange resins and anion exchangeresins.

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

Recommended Books/Reference books

1. P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. John Wiley & Sons (2002).
2. M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press (2005).
3. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons(2005)

Course Outcome:

Graduate will have understanding of:

1. The mechanism of polymer material formation.
2. Molecular weight and structure property relationship
3. Polymerization procedure and Zigler-Natta catalysis.
4. Characterization of polymers

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
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

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

Semester	Course	Name of the course	Credits
V,VI	DSE4	Environmental Chemistry	Theory: 3
			Practical: 2

Learning Objectives:

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

- Compositon of atmosphere
- Biogeochemical cycles
- Hydrological cycle
- Water qualityparameters
- Atomospheric chemical phenomon and environmentalpollution
- Water pollution, parameters of water pollution, treatment of pollutedwater.

Unit 1: Environment

Composition of atmosphere, temperature variation of earth atmospheric system (temperature vs. altitude curve), biogeochemical cycles of C, N, P, S and O system.

Unit 2:Hydrosphere

Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determination fluoride, chromium and arsenic, residual chlorine and chlorine demand, purification and treatment of municipal water and waste water.

Unit 3: Atmosphere

Chemical composition of atmosphere – particle, ions, and radicals in their formation, chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, and O and their effect, pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control.

Unit 4: Aquatic chemistry

Water and its necessities, various water quality parameters (DO, BOD, COD, conductivity, pH, alkalinity, hardness) and its determination, Industrial, municipal water treatment processes, Waste water treatment procedure (primary, secondary and tertiary), Solid waste treatment. Soil pollution and Noisepollution.

Recommended Books/References:

1. De.A.K.Environmental Chemistry, Wiley Eastern Ltd,1990.
2. Miller T. G. Jr., Environmental Science, Wadsworth publishing House, Meerut Odum. E. P. 1971.
3. Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co., Philadelphia
4. S. E. Manahan, Environmental chemistry, 1993, Boca Raton, Lewispublisher
5. Environmental chemistry, Sharma and Kaur, 2016, Krishnapublishers
6. Environmental Pollution, Monitoring and control, S.M. Khopker, 2007, New Age International.

7. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W.H.Freemanpublication.
9. G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa(2009).
10. Principles of instrumental analysis: D. A. Skoog, Fifth Edition, Sauns College Publishing (London)
11. Basic concepts of analytical chemistry: S. M. Khopkar, Wiley Eastern(1995)

List of suggested laboratory practicals

Determination of water quality parameters in following aspect:

1. Determination of dissolved oxygen in given water (chemical method/instrumentation method).
2. Determination of Biological Oxygen Demand (BOD_5).
3. Determination of Chemical Oxygen Demand(COD).
4. Finding out percentage of available chlorine in bleachingpowder.
5. Measurement of chloride, sulphate and salinity of water samples by titration method ($AgNO_3$ and potassiumchromate).
6. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titrationmethod.
7. Estimation of SPM in airsamples.

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

List of Recommended books/Reference Books:

1. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, John Wiley & Sons, Inc. Publishers, New Delhi.(2005 edition).
2. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, NewDelhi.
3. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
4. A. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, NewDelhi.
5. S. M. Khopkar, *Environmental Pollution Analysis*: New Age Int. Publisher, NewDelhi.

Semester	Course	Name of the course	Credits
V,VI	DSE5	Advanced Materials Chemistry	Theory: 3
			Practical: 2

Learning Objectives

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

1. Structure of molecules in solid state. How the atoms/molecules arranged in solid state and crystals.
2. Characterizations of solid materials.
3. Fundamentals of nanomaterials.
4. Synthesis and characterization of nanomaterials.
5. Different types of polymers.
6. Synthesis and characterization of polymers.

Unit 1: Crystal structure of solids

Fundamental of lattices, unit cell, atomic coordinates, Bravais lattices, crystal direction and planes, types of close packing, packing efficiency, radius ratios; few important crystal structures. Synthesis of Inorganic solids; solid state, solution phase and vapor phase synthesis; precipitation, hydrothermal, sol-gel, surfactant based synthesis. Growth of single crystals.

Crystal structure determination by X-ray diffraction, d-spacing formula, symmetrically absent reflections, Multiplicities, Scattering of X-rays by an atom and a crystal.Single crystal and powder diffraction.Electron and neutron diffraction.Concept of reciprocal lattice.Electron microscopy techniques.

Unit 2: Nanomaterial fundamentals

Synthesis: Bottom-up vs. Top-down Methods. Solution phase synthetic methods. Role ofsurfactant in shape and size control of nanomaterials.Synthesis of nanowires and nanotubes by CVD and MOCVD method.

Nanomaterials Characterization: XRD of nanomaterials, Electron microscopy (SEM, TEM, HRTEM and EDX) of nanomaterials, Scanning probe microscopy.

Nanomaterial properties and applications: Magnetic properties of nanoparticles; superparamagnetism, ferromagnetism in antiferromagnetic nanoparticles and single domainto multidomain transition. magnetic nanoparticles as MRI contrast agents.

Unit 3: Frontier areas of polymer science and technology

Conducting polymers: basic principles of conducting polymers, delocalized electronic states of conjugated polymers, polyanilines, polyacetylenes, polythiophene, applications of conducting polymers.

Biodegradable polymers: Definition classification of natural biodegradable polymers, cellulose, cellulose acetate, cellophane, soy protein, corn, zein protein, wheat gluten protein, synthetic biodegradable polymers, polyhydroxy alkanoates, polycarpolactone, poly(vinyl alcohol), polyacetic acid, application of biodegradable and biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin, and blood cells.

Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid,PVC, PVA.

Rubber: Compounding and elastomeric properties, vulcanization, reinforcement.

Recommended books/References:

1. Zhen Guo and Li Tan, *Fundamentals and Applications of Nanomaterials*.2009, Artech House, LondonPublication.
2. Physical methods for chemistry: R. S. Drago, 1992, Saunders collegepublication.
3. Polymer science, V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, New Age International (P) Ltd., 2015.
4. P. J. Flory, Principle of polymer chemistry, Cornell UniversityPress.
5. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
6. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int.Publication, 2019.

List of suggested Laboratory Experiment

1. Preparation of gold and silvernano-particles.
2. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) andphenolphthalein
3. Determination of composition of dolomite (by complexometrictitration).
4. Analysis of XRD pattern of few selected crystals like $NaNO_3$, $CaCl_2$, etc.; Indexing of a given powder diffraction pattern of a cubic crystallinesystem.
5. Interpretation of FTIR, NMR and UV-Vis data of givenmaterial.
6. Estimation of particle size from the BET, SEMtechniques.

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

Recommended books/Reference Book:

1. Fahlman, B.D. *Materials Chemistry*, Springer, 2004.

Course Outcome:

Graduate will have understanding of:

1. Structure of molecules in solid state. How the atoms/molecules arranged in solid state and crystals. Characterizations of solid materials.
2. Fundamentals of nanomaterials. Synthesis and characterization of nanomaterials.
3. Different types of polymers.
4. Synthesis and characterization of polymers.

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
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

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

Semester	Course	Name of the course	Credits
V,VI	DSE6	Advanced Analytical Chemistry	Theory: 3
			Practical: 2

Learning Objectives:

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

1. Methods in chemical analysis.
2. Polarography: Instrumentation and applications.
3. Theory and application of atomic spectroscopy.
4. Theory and application thermogravimetric analysis.
5. Theory and principle of chromatography.
6. Analysis of fuel and drugs.

Unit 1: Statistical methods in chemical analysis

Theory of error and treatment of quantitative data, accuracy and precision, ways of expressing accuracy and precision, Normal error curve and its equation. Useful statistical tests with equation, test of significance, the F-test, the students t-test, the Chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, regression analysis (least square method).

Unit 2: Polarography

Current-voltage relationship, theory of polarographic waves, instrumentation, qualitative and quantitative applications.

Unit 3: Atomic spectroscopy

Atomic absorption spectroscopy, theory and application (with some examples).

Unit 4: Thermal analysis

Theory, methodology, instruments and applications of theromogravimetric analysis (TGA/DTA),and differential scanning calorimetry (DSC).

Unit 5: Chromatography

Principles of chromatography, paper, column and thin layer chromatography, Gas-liquidchromatography, HPLC.

Unit 6: Analysis of fuel and drugs

Fuel analysis: Solid, liquid and gaseous fuels, ultimate and proximate analysis of solid fuel,Determination of calorific value of solid, liquid and gaseous fuels, Flash point and fire point.

Drug analysis: Classification of drugs, Analysis of some standard drug using various chromatographic techniques.

Recommended books/references:

1 Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson,2009.

2 Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing California, USA,1988.

3 Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

4 Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.

5 Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*

6 Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood John Wiley1979.

7 Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand,1974.

8 Khopkar, S. M., Basic Concepts of Analytical Chemistry, New Age (Second edition)1998

List of suggested laboratory experiments

1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. Preparation of buffer solutions of different pH (i. Sodium acetate-acetic acid, ii. Ammonium chloride-ammoniumhydroxide
2. Principles involved in chromatographic separations. Paper chromatographic separation of following metalions:
    i. Ni (II) and Co(II)
    ii. Fe (III) and Al(III)
3. Chromatographic separation of the active ingredients of plants, flowers and juices byTLC.
4. IR/DSC analysis of known polymer sample (for students demonstrationonly)
5. Determination of flash point & fire point of given fuelsample.
6. Determination of viscosity index, cloud point, pour point of given fuelsample.
7. Determination of calorific value of given fuel sample/coal sample using bombcalorimeter.
8. Proximate analysis of given coalsample.
9. Determination of the iodine number ofoil.
10. Determination of the saponification number ofoil.

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

Recommended books/Reference books:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
3. Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age International Publisher, 2009
4. Skoog, D.A. Holler F.J. and Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning IndiaEdition.

Course Outcome:

Graduate will have understanding of:

1. Methods in chemical analysis.
2. Polarography: Instrumentation and applications.
3. Theory and application of atomic spectroscopy.
4. Theory and application thermogravimetric analysis.

5. Theory and principle of chromatography.
6. Analysis of fuel and drugs.

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
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
CO6	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
V,VI	DSE7	Nuclear & Radiation Chemistry	Theory: 3
			Practical: 2

Learning Objectives

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

1. Nuclear forces, nuclear stability, binding energy.
2. Radioactive elements and general characteristics.
3. Measurement of radioactivity.
4. Radiation chemistry.
5. Nuclear pollution and Radiological safety.

Unit 1: Nucleus and its classification, nuclear forces, nuclear stability, binding energy, nuclear models. Radioactive decay (Radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, half-life, mean life period), units of radioactivity, Transient and secular equilibria, Carbon dating and itsusefulness.

Nuclear reactions: Bethe notation, types of nuclear reactions (n, p, α, d and γ), conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions. Nuclear fission: the process, fragments, mass distribution, and fission energy.

Unit 2: Measurement of radioactivity, idea about accelerator and detectors, Van de Graaaf and linear acceletors, synchrontrons, Geiger-Muller detector, Scintillaton detectors, Type of nuclear reactions, Nuclear fission, Nuclear fusion, Nuclear reactor: classification of reactors, the natural uranium reactor, breeder reactor. Nuclear fusion and stellarenergy.

Unit 3: Radiation chemistry: Elementary ideas of radiation chemistry, radiolysis of water and aqueous solutions, unit of radiation chemical yield (G-value), radiation dosimetry (Fricke's dosimeter), units of radiation energy (Rad, Gray, Rontgen, RBE, Rcm,Sievert)

Unit 4: Nuclear pollution and Radiological safety: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry. Radioactive isotopes and their applications, Isotopic dilution analysis, Neutron activation analysis, disposal of nuclear waste, nuclear.

Recommended Books/references:

1. Friendlander G, Kennedy G and Miller J. M. Nuclear and Radiochemistry, Wiley Interscience
2. Harvey, B. G. Introduction to Nuclear Physics & Chemistry, Prentice –Hall,
3. Overman R. T, Basic concept of Nuclear Chemistry, Chapman &Hall.
4. A. N. Nesmeyanov, Radiochemistry, MIR Publication,Moscow.
5. Spinks J. W. T. and Woods R. J. An Introduction to Radiation Chemistry,Wiley
6. Arnikar H. J., Essentials of Nuclear Chemistry, Wiley Eastern, SecondEdition.

Suggested laboratory practicals:

1. The safe laboratory use of radionuclide andradioisotopes
2. demonstration of activity on Geiger-Muller and scintillation basedcounter.

3. liquid scintillation counting, alpha spectrometry, gamma spectrometry – to identify and quantify radioisotopes.
4. occurrence of radon daughter particles in environmentalsamples.
5. Liquid-liquid separation/extraction of radio nuclide from environmental samples/water samples.
6. Isotopic application in removal process adsorption / ionexchange.

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

Course Outcome:

Graduate will have understanding of:

1. Nuclear forces, nuclear stability, binding energy.
2. Radioactive elements and general characteristics.
3. Measurement of radioactivity.
4. Radiation chemistry.
5. Nuclear pollution and Radiological safety.

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
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
V,VI	DSE8	**Organic Spectroscopy**	Theory: 3
			Practical: 2

Learning Objectives:

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

1. Spectroscopic techniques used for characterization of organic compounds.
2. Basic Principles of UV, IR and NMR Spectroscopy and Mass Spectrometry.
3. Application of various spectroscopy in characterization of chemical compounds.

Unit 1: Basic Principles of UV Spectroscopy

Application of Woodward-Fiser rule in interpretation of Organic compounds: Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturated compounds.

Unit 2: Basic principles of IR Spectroscopy

Identification of Functional groups of various classes of organic compounds: Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Unit 3: NMR (^{1}H and ^{13}C NMR)

Application of Chemical Shifts, Splitting of signals, Spin coupling and Over Houser effect ininterpretation of NMR spectra, Isotopic exchange

Unit 4: Basic principles Mass Spectrometry

Application of fragmentation rule in characterization of organic compounds.Problems onstructure elucidation of organic compounds based on spectral data.

Recommended Books/References:

1. R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of Organic Compounds*, John Wiley &Sons.
2. John R. Dyer, Applications of absorption spectroscopy of organic compounds, Prentice Hall India(2012).

Suggested laboratory experiments

1. Purification method for liquid, solid organic substance (distillation, recrystallization, chromatorgrapy)
2. Analysis of spectra of UV-Vis, FTIR, NMR and Mass of simple organic compounds. (azodyes, acetanilides, benzoic acid, etc.)

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

Course Outcome:

Graduate will have understanding of:

1. Spectroscopic techniques used for characterization of organic compounds.
2. Basic Principles of UV, IR and NMR Spectroscopy and Mass Spectrometry.
3. Application of various spectroscopy in characterization of chemical compounds.

Course Outcomes and their mapping with Programme Outcomes:

CO	PO												PSO				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
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

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

Semester	Course	Name of the course	Credits
V,VI	DSE9	**Heterocyclic Chemistry**	Theory: 3
			Practical: 2

Learning Objectives

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

1. Chemistry of heterocyclic compounds.
2. Synthesis, structures and characterizations of three to five membered rings.
3. Chemistry of Condensed five-membered Heterocycles.

Unit 1

Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines and episulphides - synthetic approaches andreactivities.

Unit 2

Three-membered heterocycles with two heteroatoms: oxaziranes, diaziridines and diazirines - synthetic approaches andreactivities.

Unit 3

Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches andreactivities. natural products:synthesis of Peniciline andcephalosporine.

Unit 4: Five-membered aromatic heterocycles:

1. With one heteroatom: furans, pyrroles and thiophenes - general synthetic approaches, properties and reactivities.
2. With two heteroatoms: oxazoles, isoxazoles, imidazoles, thiazoles, pyrazoles and isothiazoles - general synthetic approaches andreactivities.
3. With three and four heteroatoms: triazoles and tetrazoles - synthetic approaches, properties andreactivity.

Unit 5: Condensed five-memberedHeterocycles:

Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis onthe chemistry ofIndoles.

Recommended Books/references:

1. Heterocyclic Chemistry, J.A. Joule, K. Mills, Wiley,2010.
2. The Essence of heterocyclic Chemistry, A. R. Parikh, H. Parikh, R. Khunt, New Age Int. Publication,
3. Principles of Modern Heterocyclic Chemistry, L. A. Paquette, W. A. Benjamin, New York,1968.
4. Heterocyclic Chemistry, J.A. Joule and G. F. Smith, van Nostrand, London,1978.
5. Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds, (Ed. A.R. Katritzky and C. W. Rees),.Vol 1-8, Pergamon Press,1984.
6. Handbook of Heterocyclic Chemistry, A. R. Katritzky, Pergamon Press,1985.
7. Van der plas, H. C. Ring transformations of Heterocycles, Vols 1 and 2, Academic

Press,1974.

List of suggested laboratory experiments

1. Identification of hetero atoms (S, N, X) in given organic compounds inlab.
2. Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC) inlab.
3. Spectroscopic identification of simple organic compounds
4. Teacher may guide the students for preparation of : Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basiccondition).

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

Course Outcome:

Graduate will have understanding of:

1. Chemistry of heterocyclic compounds.
2. Synthesis, structures and characterizations of three to five membered rings.
3. Chemistry of Condensed five-membered Heterocycles.

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
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

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

Semester	Course	Name of the course	Credits
V,VI	DSE10	**Biochemistry**	Theory: 3
			Practical: 2

Learning Objectives:

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

1. Biological importance of carbohydrates.
2. Classification, biological importance of proteins.
3. Nomenclature, Characteristics, Classification of enzymes.
4. Biological importance of lipids.
5. Structure of DNA/RNA and their role in living organisms.

Unit 1: Carbohydrates: ***8 Lectures***

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

Unit 2: Proteins: ***8 Lectures***

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

Unit 3: Enzymes: ***8 Lectures***

Nomenclature, Characteristics (mention of Ribozymes), Classification; Active site, Mechanism of enzyme action, Stereospecificity of enzymes,Coenzymes and cofactors, Enzyme inhibitors, Biocatalysis in Green Chemistry" and ChemicalIndustry

Unit 4: Lipids: ***8 Lectures***

Biological importance of triglycerides and phosphoglycerides and cholesterol; Lipid membrane, Liposomes and their biological functions and underlying applications.

Unit 5: Structure of DNA/RNA: ***8 Lectures***

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

Recommended Books/References:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VI the Edition. W.H. Freeman andCo.
2. Nelson, D. L., Cox, M. M. and Lehninger, A. L. (2009) principles of Biochemistry.IVEdition.W.H. Freeman and Co.
3. Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. (2009) Harper's Illustrated Biochemistry. XXVIII edition. Lange medical Books/McGraw-Hill

Suggested Practical in Biochemistry

1. Quantitative estimation of protein using Lowry's method. Determine the concentration of the unknownsample.
2. Action of salivary amylase at optimumconditions
3. Effect of pH on the action of salivaryamylase
4. Effect of temperature on salivaryamylase

5. Effect of inhibitor on salivaryamylase
6. Study of the activity of Trypsin using fresh tissueextracts.
7. Effect of temperature, organic solvents, on semi-permeablemembrane.
8. Isolation of Genomic DNA from EColi

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

Course Outcome:

Graduate will have understanding of:

1. Biological importance of carbohydrates.
2. Classification, biological importance of proteins.
3. Nomenclature, Characteristics, Classification of enzymes.
4. Biological importance of lipids.
5. Structure of DNA/RNA and their role in living organisms.

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
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
V,VI	DSE11	**Organometallics and Bioinorganic Chemistry**	Theory: 3 Practical: 2

Learning Objectives:

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

1. Chemistry of coordination compounds.
2. Characteristics of organometallic compounds.
3. Structures and characterizations of organometallic compounds.
4. Applications of organometallic compounds.
5. Role of metals in biological systems.

Unit 1:Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,$Na_3[Co(NO_2)_6]$.

Unit 2: Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type.Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity.Comparison of aromaticity and reactivity with that of benzene.

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-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

Unit 3: Bioinorganic chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy

production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

Recommended books/reference books

1. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH,1999
3. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
4. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann,1997

List of Laboratory experiments

1. Rection of metal with halide – preparation of Grignard reagent.
2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline)
3. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.
4. Preparation of any two of the following complexes and measurement of their conductivity measurement:
    a. tetraamminecarbonatocobalt (III)nitrate
    b. tetraamminecopper (II)sulphate
    c. potassium trioxalatoferrate (III)trihydrate

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

Recommended books/reference books

1. Synthesis of organometallic compounds: A practical guide, S. Komiya,Wiley.
2. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7thEdn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*,Prentice-Hall.

Course Outcome:

Graduate will have understanding of:

1. Chemistry of coordination compounds.
2. Characteristics of organometallic compounds.
3. Structures and characterizations of organometallic compounds.
4. Applications of organometallic compounds.
5. Role of metals in biological systems.

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

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
V,VI	DSE12	**Introduction to Nanochemistry & Applications**	Theory: 3
			Practical: 2

Learning objectives:

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

1. Idea of nanoscience.
2. Chemistry of nanostructures and nano-materials.
3. Properties of nano-materials.
4. Synthesis of nano-materials.
5. Characterizations of nano-materials.

Unit-I: Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures - Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

Unit-II: Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blue shift & Red shift), Magnetic, thermal and catalytic properties.

Unit-III: Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-controlof nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

Unit-IV: Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).

Recommended Books/References books:

1. C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Willey-VCH Verlag, Germany, 2005.
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Appications, Imperial College Press, London, 2004
3. R.W.Kelsall,I.W.Hameley,M.Geoghegan,Nanoscale Science and Technology, John Wiley& Sons, England,2005.
4. Charles P. Poole and Frank J Owens, *Introduction to nano technology*, Wiley Interscience, 2003.
5. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi,2012.

List of Laboratory Experiments suggested:

1. Synthesis of ZnOnanoparticles.
2. Preparation of Silvernanoparticles.
3. Verification of Beer-Lambert law using nano-particles

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

Recommended/Ref. Books:

1. Pradeep T., A text book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012 edition.

Course Outcome:

Graduate will have understanding of:

1. Idea of nanoscience.
2. Chemistry of nanostructures and nano-materials.
3. Properties of nano-materials.
4. Synthesis of nano-materials.
5. Characterizations of nano-materials.

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
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**

Ability Enhancement Courses

Semester	Course	Name of the course	Credits
I - VI	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 - VI	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 - VI	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 - VI	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 - VI	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 - VI	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 - VI	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 - VI	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 - VI	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 - VI	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 - VI	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.

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)