Details of Generic Elective (GE) Courses offered by Department of Chemistry

GE COURSES –21 (4 Credits each-3T+1P/2T+2P)		
COURSE CODE	**NAME OF THE COURSE**	**CREDITS** **T=Theory Credits** **P=Practical Credits**
CHEMISTRY-GE-1	Atomic Structure and Chemical Bonding	T=2 P=2
CHEMISTRY-GE-2	Coordination and Organometallic Compounds	T=2 P=2
CHEMISTRY-GE-3	Bioinorganic Chemistry	T=2 P=2
CHEMISTRY-GE-4	Basic Concepts of Organic Chemistry	T=2 P=2
CHEMISTRY-GE-5	Chemistry of Oxygen containing Functional Groups and their Application to Biology	T=2 P=2
CHEMISTRY-GE-6	Molecules of Life	T=2 P=2
CHEMISTRY-GE-7	States of Matter	T=2 P=2
CHEMISTRY-GE-8	Chemical Kinetics and Photochemistry	T=2 P=2
CHEMISTRY-GE-9	Conductance and Electrochemistry	T=2 P=2
CHEMISTRY-GE-10	Basics of Polymer Chemistry	T=2 P=2
CHEMISTRY-GE-11	Chemistry of Food Nutrients	T=2 P=2
CHEMISTRY-GE-12	Chemistry: Statistical Methods and Data Analysis	T=2 P=2
CHEMISTRY-GE-13	Medicines in Daily Life	T=2 P=2
CHEMISTRY-GE-14	Chemistry: Molecular Modelling, Artificial Intelligence and Machine Learning	T=2 P=2
CHEMISTRY-GE-15	Chemistry and Society	T=2 P=2

CHEMISTRY-GE-16	Role of Metals in Medicines	T=2 P=2
CHEMISTRY-GE-17	Energy and the Environment	T=3 P=1
CHEMISTRY-GE-18	Fragrances and Flavours: An Industry's Perspective	T=3 P=1
CHEMISTRY-GE-19	Radio-chemistry in Energy, Medicine and Environment	T=3 P=1
CHEMISTRY-GE-20	Green Chemistry	T=2 P=2
CHEMISTRY GE-21	Chemistry in Indology and Physical & Mental Well Being	T=3 P=1

GE Pool A: Semester I, III, V (ODD SEMESTERS)

1. GE-1: Atomic Structure and Chemical Bonding
2. GE-3: Bioinorganic Chemistry
3. GE-4: Basic Concepts of Organic Chemistry
4. GE-7: States of Matter
5. GE-9: Conductance and Electrochemistry
6. GE-11: Chemistry of Food Nutrients
7. GE-12: Chemistry: Statistical Methods and Data Analysis
8. GE-13: Medicines in Daily Life
9. GE-15: Chemistry and Society
10. GE-19 Radio-chemistry in Energy, Medicine and Environment
11. GE-21: Chemistry in Indology and Physical & Mental Well Being

GE Pool B: Semester II, IV, VI (EVEN SEMESTERS)

1. GE-2: Coordination and Organometallic Compounds
2. GE-5: Chemistry of Oxygen containing Functional Groups and their Application to Biology
3. GE-8: Chemical Kinetics and Photochemistry
4. GE-10: Basics of Polymer Chemistry
5. GE-14: Chemistry: Molecular Modelling, Artificial Intelligence and Machine Learning
6. GE-6: Molecules of Life
7. GE-16: Role of Metals in Medicines
8. GE-17: Energy and the Environment
9. GE-18: Fragrances and Flavours: An Industry's Perspective
10. GE-20: Green Chemistry

Course Code: CHEMISTRY- GE-1

Course Title: Atomic Structure and Chemical Bonding

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The course reviews the structure of the atom, which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It provides basic knowledge about ionic and covalent bonding. The constitution of the course strongly aids in the paramount learning of the fundamental concepts about atomic structure, chemical bonding and their applications.

Learning Outcomes:

By the end of the course, the students will be able to:

- Solve the conceptual questions using the knowledge gained by studying the quantum mechanical model of the atom, quantum numbers, electronic configuration, radial and angular distribution curves, and shapes of s, p, and d orbitals
- Understand the concept of lattice energy and solvation energy.
- Draw the plausible structures and geometries of molecules using radius ratio rules, VSEPR theory and MO diagrams (homo- & hetero-nuclear diatomic molecules).

Theory:

Unit 1: Atomic Structure **Lectures: 14**

Review of: Bohr's theory and its limitations, Heisenberg uncertainty principle, Dual behaviour of matter and radiation, De-Broglie's relation, Hydrogen atom spectra, need of a new approach to atomic structure. Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ2 , Schrödinger equation for hydrogen atom, radial and angular parts of the hydrogen wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation), radial and angular nodes and their significance, radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes, discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, electronic configurations of the atoms, stability of half-filled and completely filled orbitals, concept of exchange energy, relative energies of atomic orbitals, anomalous electronic configurations.

Unit 2: Chemical Bonding and Molecular Structure Lectures: 16

Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds, statement of Born-Landé equation for calculation of lattice energy (no derivation), Born Haber cycle and its applications, covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules. Ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR (H_2O, NH_3, PCl_5, SF_6, ClF_3, SF_4) and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for ss, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+.

Practicals: Credits: 02

(Laboratory periods: 60)

1. Acid-Base Titrations: Principles of acid-base titrations to be discussed.

(i) Estimation of sodium carbonate using standardized HCl.

(ii) Estimation of carbonate and hydroxide present together in a mixture.

(iii) Estimation of carbonate and bicarbonate present together in a mixture.

(iv) Estimation of free alkali present in different soaps/detergents

2. Redox Titrations: Principles of oxidation-reduction titrations (electrode potentials) to be discussed.

(i) Estimation of oxalic acid by titrating it with $KMnO_4$.

(ii) Estimation of Mohr's salt by titrating it with $KMnO_4$.

(iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iv) Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator (diphenylamine/ N-phenylanthranilic acid).

References:

Theory:

1. Lee, J.D.; (2010), **Concise Inorganic Chemistry**, Wiley India.
2. Huheey, J.E.; Keiter, E.A.; Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
3. Douglas, B.E.; McDaniel, D.H.; Alexander, J.J. (1994), **Concepts and Models of Inorganic Chemistry**, John Wiley & Sons.
4. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, 5th Edition, Oxford University Press.

Practicals:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Additional Resources:

1. Wulfsberg, G (2002), **Inorganic Chemistry**, Viva Books Private Limited.
2. Miessler, G.L.; Fischer P.J.; Tarr, D. A. (2014), **Inorganic Chemistry**, 5th Edition, Pearson.

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

Keywords: Atomic Structure, Wave function, Quantum Numbers, Electronegativity, Ionic Bonding, Dipole Moment, VSEPR Theory, Covalent Bonding, Multiple Bonding, Molecular Orbitals, Bonding MO, Antibonding MO, Homonuclear, Heteronuclear.

Course Code: CHEMISTRY- GE-2

Course Title: Coordination and Organometallic Compounds

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The purpose of the course is to introduce students to some important d-block metals and their compounds which they are likely to come across. Students learn about organometallic compounds, a frontier area of chemistry providing an interface between organic and inorganic chemistry. It familiarizes them with coordination compounds which find manifold applications in diverse fields.

Learning Outcomes:

By the end of the course, the students will be able to:

- Familiarize with different types of organometallic compounds, their structures and bonding involved.
- Understand the nature of Zeise's salt and compare its synergic effect with that of carbonyls.
- Identify important structural features of tetrameric methyl lithium and understand the concept of multicenter bonding in these compounds
- Apply 18-electron rule to rationalize the stability of metal carbonyls and related species
- Use IR data to explain the extent of back bonding in carbonyl complexes
- Understand the terms, ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds
- Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes
- Understand the properties of coordination compounds and VBT and CFT for bonding in coordination compounds
- Explain the meaning of the terms Δ_o, Δt, pairing energy, CFSE, high spin and low spin and how
- CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy

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Theory:

Unit 1: Coordination Chemistry **Lectures: 4**

Brief discussion with examples of types of ligands, denticity and concept of chelate. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear) involving simple monodentate and bidentate ligands.

Unit 2:Bonding in coordination compounds **Lectures: 14**

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes of Cr, Fe, Co and Ni. Drawbacks of VBT.

Crystal Field Theory: Splitting of d orbitals in octahedral symmetry. Crystal field effects for weak and strong fields. Crystal field stabilization energy (CFSE), concept of pairing energy. Factors affecting the magnitude of Δ_o.

Spectrochemical series. Splitting of d orbitals in tetrahedral symmetry. Comparison of CFSE for octahedral and tetrahedral fields, tetragonal distortion of octahedral geometry. Jahn-Teller distortion, square planar coordination.

Unit 3: Organometallic Compounds **Lectures: 12**

Definition and classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structure and bonding of methyl lithium and Zeise's salt. Structure and physical properties of ferrocene. 18-electron rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. π-acceptor behaviour of carbon monoxide (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

Practicals: **Credits: 02**
(Laboratory periods: 60)

1. Gravimetry

Discuss basic principles of gravimetry (precipitation, co- precipitation and post precipitation, digestion, washing etc)

(i) Estimation of Ni(II) using dimethylglyoxime (DMG).

(ii) Estimation of copper as CuSCN.

(iii) Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)3 (aluminium oxinate).

2. Inorganic Preparations

(i) Schiff's base involving ethylenediamine and salicylaldehyde (or any other amine and aldehyde/ketone) and to check its purity using TLC.
(ii) Nickel/ Copper complex of the above prepared Schiff's base and its characterisation using UV/Vis spectrophotometer. The IR spectra also to be interpreted
(iii) tetraamminecopper (II) sulphate
(iv) potassium trioxalatoferrate (III) trihydrate.
(v) tetraamminecarbonatocobalt(III) nitrate

References:

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkins Inorganic Chemistry**, W. H. Freeman and Company.
2. Miessler, G. L.; Fischer P.J.; Tarr, D.A. (2014), **Inorganic Chemistry**, Pearson.
3. Huheey, J.E.; Keiter, E.A., Keiter; R.L., Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
4. Pfennig, B. W. (2015), **Principles of Inorganic Chemistry.** John Wiley & Sons.
5. Cotton, F.A.; Wilkinson, G. (1999), **Advanced Inorganic Chemistry** Wiley-VCH.

Practicals:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Schiff Base Complex of Cu (II) with Antibacterial and Electrochemical Study, Arjun C. Bhowmick, Majharul I. Moim, Miththira Balasingam **, American Journal of Chemistry** 2020, 10(2): 33-37, DOI: 10.5923/j.chemistry.20201002.03

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

Keywords: Organometallic compounds, metal carbonyls, synergistic effect, Coordination compounds, VBT, Crystal field theory, Splitting of d levels, Dq

Course Code: CHEMISTRY- GE-3

Course Title: Bioinorganic chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The purpose of the course is to introduce students to bioinorganic chemistry, currently a frontier area of chemistry providing an interface between organic chemistry, inorganic chemistry and biology. The student would learn about the importance of inorganic chemical species, especially metals, in biological systems, through discussions on topics such as the sodium-potassium pump, the applications of iron in physiology, including iron transport and storage system, role of magnesium in energy production and chlorophyll, toxicity of heavy metal ions and their antidotes.

Learning Outcomes:

By the end of the course, the students will be able to:

- Classify metal ions in biological systems as essential, non-essential, trace & toxic.
- Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it
- Understand the role of metal ions such as Mg, Ca and Fe in biological systems.
- Understand the toxicity of heavy metal ions (Hg, Pb, Cd and As) in the physiological system
- Explain the use of chelating agents in medicine

Theory:

Unit 1: Introduction **Lectures: 6**

A brief introduction to bio-inorganic chemistry. Metal ions present in biological systems and their classification on the basis of action (essential, non-essential, trace & toxic). Classification of metallobiomolecules (enzymes, transport and storage proteins and non-proteins). Brief idea about membrane transport, channels, pumps.

Unit 2:Role of s-block Elements in Biological System **Lectures: 8**

Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} and Ca^{2+} ions: Na/K pump; Ca pump, role of Mg^{2+} ions in energy production and chlorophyll. Role of calcium in bone formation.

Unit 3:Role of iron in Biological System **Lectures: 8**

Role of iron in oxygen transport and storage (haemoglobin and myoglobin), Perutz mechanism,

Cooperative effect, Bohr effect, comparison of oxygen saturation curves of haemoglobin and myoglobin, carbon monoxide. Storage and transport of iron in humans (ferritin and transferrin).

Unit 4: Toxicity of Heavy Metal Ions **Lectures: 8**

Toxicity of heavy metal ions (Hg, Pb, Cd and As), reasons for toxicity and their antidotes

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. **Spectrophotometric estimation:**

(i) Verify Lambert-Beer's law and determine the concentration of $CuSO_4/KMnO_4/K_2Cr_2O_7/CoSO_4$ in a solution of unknown concentration

(ii) Spectrophotometric estimation of Fe^{2+} ions by using 1, 10- phenanthroline

(iii) Determination of the composition of the Fe^{3+} - salicylic acid complex in solution by Job's method.

2. **Complexometric titrations using disodium salt of EDTA:**

1. Estimation of Zn^{2+} using EBT / Xylenol orange as indicator
2. Estimation of Mg^{2+}
3. Estimation of Ca^{2+} by substitution method
4. To estimate the concentration of Ca in commercially available medicines.
5. To estimate the Mg present in multivitamins.

References:

Theory:

1. Huheey, J.E.; Keiter, E.A., Keiter; R. L.; Medhi, O.K. (2009), **Inorganic Chemistry-Principles of Structure and Reactivity**, Pearson Education.
2. Shriver, D.D.; Atkins, P.; Langford, C.H. (1994), **Inorganic Chemistry** 2nd Ed., Oxford University Press.
3. Cotton, F.A.; Wilkinson, G.; Gaus, P.L. **Basic Inorganic Chemistry**, 3rd Edition,Wiley India.
4. Crichton, R.R. (2008), **Biological Inorganic Chemistry: An Introduction**. Amsterdam, Elsevier.
5. Kaim, W., B. Schwederski and A. Klein. (2014), **Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life: An Introduction and Guide.** 2nd Edition, Wiley.

Practical:

- Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.

Additional Resources:

1. Lippard, S.J.; Berg, J.M. (1994), **Principles of Bioinorganic Chemistry**, Panima Publishing Company.
2. Greenwood, N.N.; Earnshaw, A. (1997), **Chemistry of the Elements**, 2nd Edition, Elsevier

Teaching Learning Process:

- Conventional chalk and board teaching,
- Class interactions and discussions
- Power point presentation on important topics.

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and Practical Examination

Keywords: Bioinorganic chemistry; Sodium potassium pump; chlorophyll, ATP, Haemoglobin, myoglobin, ferritin, transferrin, toxicity, heavy metal ions, antidotes

Course Code: CHEMISTRY- GE-4

Course Title: Basic Concepts of Organic Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This course is designed to teach the fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three- dimensional space. To establish the applications of these concepts, different types of organic reactions are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand and explain the differential behavior of organic compounds based on fundamental concepts learnt.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.

- Learn and identify many organic reaction mechanisms including free radical substitution, electrophilic addition and electrophilic aromatic substitution.
- Differentiate between various types of organic reactions possible on the basis of reaction conditions

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Theory:

Unit 1: Basic Concepts **Lectures: 6**

Electronic displacements and their applications: Inductive, electromeric, resonance and mesomeric effects and hyperconjugation. Dipole moment, acidity and basicity.

Homolytic and heterolytic fissions with suitable examples. Types, shape and relative stability of carbocations, carbanions and free radicals. Electrophiles and nucleophiles

Concept of Aromaticity: Huckel's rule

Unit 2: Stereochemistry **Lectures: 10**

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. specific rotation; Configuration and projection formulae: Newmann, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres; meso configuration.

CIP rules: Erythro/Threo, D/L and R/S designations.

Geometrical isomerism: *cis-trans, syn-anti* and *E/Z* notations.

Unit 3: Types of organic reactions **Lectures: 14**

Introduction to substitution, addition, elimination, isomerization, rearrangement, oxidation and reduction reactions.

Free radical substitutions (Halogenation), concept of relative reactivity v/s selectivity. Free radical reactions in the biological reactions

Mechanisms of E1, E2, Saytzeff, Hoffmann eliminations and Cope elimination. Biological dehydration reactions

Electrophilic Additions reactions of alkenes and alkynes: mechanism with suitable examples, (Markownikoff/Antimarkownikoff addition), syn and anti-addition; addition of H_2, X_2, hydroboration-oxidation, ozonolysis, hydroxylation.

Nucleophilic substitution reactions – S_N1 and S_N2 mechanisms with stereochemical aspects and effect of solvent; nucleophilic substitution vs. elimination. Biological methylating agents

Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/ acylation with their mechanism. Directing effects of groups in electrophilic substitution.

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Calibration of a thermometer and determination of the melting points of the organic compounds (Kjeldahl method, electrically heated melting point apparatus and BODMEL)
2. Purification of the organic compounds by crystallization using the following solvents:

a. Water b. Alcohol c. Alcohol-Water

3. Determination of boiling point of liquid compounds. (Boiling point lower than and more than 100 °C by distillation, capillary method and BODMEL)
4. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (*β*-naphthol, salicylic acid) either by conventional or green method.
5. Bromination of acetanilide/aniline/phenol either by conventional or green method.
6. Nitration of chlorobenzene/nitrobenzene.

References:

Theory:

1. Sykes, P. (2005), **A Guide Book to Mechanism in Organic Chemistry**, Orient Longman.
2. Eliel, E. L. (2000), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Mehta B.; Mehta M. (2015), **Organic Chemistry**, PHI Learning Private Limited
5. Bahl, A; Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.

Practicals:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.

Teaching Learning Process:

- Lectures in class rooms
- PowerPoint presentations/videos
- Hands-on learning using 3-D models

Assessment Methods:

- Presentation/assignment by students
- Class Test at Periodic Intervals
- Written Assignment
- Continuous evaluation in practicals
- End Semester University Theory and Practical Exams

Keywords: Electronic effects, Huckel rule, Stereochemistry, Free radical substitutions, eliminations reactions, electrophilic additions, ozonolysis, nucleophilic substitution reactions, electrophilic aromatic substitution

Course Code: CHEMISTRY- GE-5

Course Title: Chemistry of Oxygen containing Functional Groups and their Applications to Biology

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This course is designed to teach the fundamental chemistry of oxygen containing functional groups. To establish these concepts typical reactions of alcohols, phenols, aldehydes, ketones, carboxylic acids and their derivatives are discussed. Relevance of oxygen containing functional groups to biology is taken up to help students appreciate the importance of these compounds in real world.

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand and explain the differential behavior of organic compounds based on reaction chemistry.
- Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved.
- Understand the applications of functional group chemistry to biology.

Theory:

Unit 1: Alcohols (upto 5 Carbon) **Lectures: 5**

Structure and classification of alcohols as 1º, 2º & 3º, Reactions: Acidic character of alcohols and reaction with sodium, with HX (Lucas Test), esterification, oxidation (with PCC, alkaline $KMnO_4$, acidic $K_2Cr_2O_7$ and conc. HNO_3), Oppeneauer Oxidation, Biological oxidation Reactions

Unit 2: Phenols **Lectures: 4**

Acidity of phenols and factors affecting their acidity, Reactions: Electrophilic substitution reactions, *viz*. nitration, halogenation, sulphonation, Reimer-Tiemann reaction, Gattermann–Koch reaction, Houben-Hoesch condensation; Reaction due to OH group: Schotten-Baumann reaction

Unit 3: Aldehydes and Ketones (Aliphatic and Aromatic) **Lectures: 12**

Reactions: Nucleophilic addition, nucleophilic addition-elimination reaction including reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol condensation and its biological application, Cannizzaro's reaction, Wittig reaction, Benzoin condensation,

Clemmensen reduction, Wolff Kishner reduction, Meerwein-Pondorff Verley reduction, enzyme-catalyzed additions to α,β-unsaturated carbonyl compounds.

Unit 4: Carboxylic acids and their derivatives (Aliphatic and Aromatic) Lectures: 9

Reactions: Hell-Volhard Zelinsky reaction, acidity of carboxylic acids, effect of substitution on acid strength, Claisen condensation and its biological applications, decarboxylation in biological systems, relative reactivities of acid derivatives towards nucleophiles, activation of carboxylate ions for nucleophilic acyl substitution reactions in biological systems, Reformatsky reaction, Perkin condensation.

Practicals: Credits: 02
(Laboratory periods: 60)

Preparations: (Mechanism of various reactions involved to be discussed) (Recrystallization, determination of melting point and calculation of quantitative yields to be done in all cases)

1. Oxime of aldehydes and ketones

2. 2,4-Dinitrophenylhydrazone of aldehydes and ketones

3. Aldol condensation using green method.

4. Benzoin condensation using Thiamine Hydrochloride as a catalyst.

5. Alkaline hydrolysis of amide/ester.

6. Benzoylation of one of the following amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) or one of the following phenols (β-naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.

7. Identification of functional group for monofunctional organic compounds (Alcohols, phenols, aldehydes, ketones, carboxylic acids).

References:

Theory:

1. Sykes, P. (2005), **A Guide Book to Mechanism in Organic Chemistry**, Orient Longman.
2. Eliel, E. L. (2000), **Stereochemistry of Carbon Compounds**, Tata McGraw Hill.
3. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Mehta B.; Mehta M. (2015), **Organic Chemistry**, PHI Learning Private Limited Bahl,
5. Bahl, A., Bahl, B. S. (2012), **Advanced Organic Chemistry**, S. Chand.
6. Bruice, Paula Y. (2020), **Organic Chemistry**, 8th Edition, Pearson.

Practicals:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. Mann, F.G.; Saunders, B.C. (2009), **Practical Organic Chemistry**, Pearson Education.

Teaching Learning Process:

- Lectures in class rooms
- Power point presentations/videos
- Hands-on learning using 3-D models

Assessment Methods:

- Presentation/assignment by students
- Class Test at Periodic Intervals
- Written Assignment
- Continuous evaluation in practicals
- End Semester University Theory and Practical Exams

Keywords: Alcohols, Lucas Test, Phenol, Aldehydes, Ketones, Nucleophilic addition, nucleophilic addition – elimination, Cannizzaro's reaction, Wittig reaction, Benzoin condensation, Enzyme-catalysed reaction, Carboxylic acid, Claisen condensation

Course Code: CHEMISTRY- GE-6

Course Title: Molecules of Life

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This course is designed to deliver information about the chemistry of carbohydrates, proteins & enzymes and its relevance in the biological system using suitable examples. Key emphasis is placed on understanding the structural principles that govern reactivity/physical /biological properties of biomolecules as opposed to learning structural details.

Learning Outcomes:

By the end of the course, the students will be able to:

- Learn and demonstrate how the structure of biomolecules determines their chemical properties, reactivity and biological uses.
- Gain an insight into the mechanism of enzyme action and inhibition.
- Understand the basic principles of drug-receptor interaction and SAR.

Theory:

Unit 1: Carbohydrates **Lectures: 12**

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and anomers, reactions of monosaccharides, determination of configuration of glucose (Fischer proof), cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharides: structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Unit 2: Amino Acids, Peptides and Proteins **Lectures: 10**

Classification of amino acids and biological uses of amino Acids, peptides and proteins. Zwitterion structure, isoelectric point and correlation to acidity and basicity of amino acids. Determination of primary structure of peptides, determination of N-terminal amino acid (by Edman method) and C–terminal amino acid (with carboxypeptidase enzyme). Synthesis of simple peptides (up to dipeptides) by N-protection (t-butyloxycarbonyl) & C-activating groups (only DCC) and Merrifield solid phase synthesis, Overview of primary, secondary, tertiary and quaternary structure of proteins, denaturation of proteins.

Unit 3: Enzymes and correlation with drug action **Lectures: 8**

Classification of enzymes and their uses (mention Ribozymes). Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (Competitive and non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure – activity relationships of drug molecules, binding role of –OH group, $-NH_2$ group, double bond and aromatic ring.

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Estimation of glucose by Fehling's solution.
2. Determination of total sugar content by ferricyanide method (volumetric/colorimetric method).
3. Study of the titration curve of glycine.
4. Estimation of proteins by Lowry's method.
5. Study of the action of salivary amylase on starch under optimum conditions.
6. Qualitative tests for amino acids, proteins and carbohydrates.
7. Separation and identification of mixture of sugars by paper chromatography.

References:

Theory:

1. Finar, I. L. **Organic Chemistry** (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N., Bhattacharjee, S.K. (2010), **Organic Chemistry**, 7th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2019), **Biochemistry**, 9th Ed., W. H. Freeman Co Ltd.

Practicals:

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. (2012), **Vogel's Textbook of Practical Organic Chemistry**, Pearson.
2. **Manual of Biochemistry Workshop**, 2012, Department of Chemistry, University of Delhi.

Teaching Learning Process:

- Chalk and black board method. Along with pedagogy of flipped classroom
- Certain topics like mechanism of enzyme action and enzyme inhibition can be taught through audio-visual aids.
- Students should be encouraged to participate actively in the classroom through regular presentations on curriculum-based topics, peer assessment, designing games based on specific topics etc.
- As the best way to learn something is to do it yourself, practicals are planned in such a way so as to reinforce the topics covered in theory.

Assessment Methods:

- Graded assignments
- Class tests and Quizzes
- Class seminars by students on course topics with a view to strengthening the content through width and depth
- Continuous evaluation for the practicals
- End semester university theory and practical examination.

Keywords: Carbohydrates, point, Amino acids, Enzymes, SAR, Drug Receptor Theory

Course Code: CHEMISTRY- GE-7

Course Title: States of Matter

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The students will learn about the properties of ideal and real gases deviation from ideal behaviour, properties of liquid, types of solids with details about crystal structure. The student will also learn about the reaction rate, order, activation energy and theories of reaction rates.

Learning Outcomes:

By the end of the course, the students will be able to:

- Derive ideal gas law from kinetic theory of gases and explain why the real gases deviate from ideal
- behaviour.
- Explain Maxwell-Boltzmann distribution, critical constants and viscosity of gases.
- Explain the properties of liquids especially surface tension and viscosity.
- Explain symmetry elements, crystal structure specially NaCl, KCl and CsCl
- Define rate of reactions and the factors that affect the rates of reaction.
- Understand the concept of rate laws e.g., order, molecularity, half-life and their determination
- Learn about various theories of reaction rates and how these account for experimental observations.

Theory:

Unit 1: Kinetic Theory of Gases **Lectures: 13**

Postulates of kinetic theory of gases and derivation of the kinetic gas equation, deviation of real gases from ideal behaviour, compressibility factor, causes of deviation, van der Waals equation of state for real gases. Boyle temperature (derivation not required), critical phenomena, critical constants and their calculation from van der Waals equation, Andrews isotherms of CO_2, Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions, most probable, average and root mean square velocities (no derivation), collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules, viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Unit 2: Liquids State **Lectures: 5**

Surface tension and its determination using stalagmometer, Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer, effect of temperature on surface tension and

coefficient of viscosity of a liquid (qualitative treatment only). Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents.

Unit 3: Solid State **Lectures: 12**

Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of crystallography - law of constancy of interfacial angles. Law of rational indices, Miller indices. X–ray diffraction by crystals, Bragg's law and powder XRD. Powder diffraction patterns of NaCl, CsCl and KCl (qualitative treatment only), defects in crystals. Glasses and liquid crystals.

Practicals: **Credits: 02**
(Laboratory periods: 60)

1. Surface tension measurement (use of organic solvents excluded): Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

2. Viscosity measurement (use of organic solvents excluded):
a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

3. Solis State: Powder XRD
a) Differentiate and classify the given set of the diffraction pattern as crystalline materials or amorphous (Glass) substance.
b) Carry out analysis of a given set of powder XRD and determine the type of the cubic crystal structure
c) Determination of approximate crystal size from a given set of powder XRD

References:

Theory:

1. Atkins, P.W.; Overton, T.L.; Rourke, J.P.; Weller, M.T.; Armstrong, F.A. (2010), **Shriver and Atkin's Inorganic Chemistry**, Oxford.
3. Miessler, G. L.; Tarr, D.A. (2014), **Inorganic Chemistry**, Pearson.
4. Castellan, G. W. (2004), **Physical Chemistry**, Narosa.
5. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol.1, 6th Edition, McGraw Hill Education.
6. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol.5, 3rd Edition, McGraw Hill Education.

Practicals:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015),**Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods: Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Ideal/real gases, Surface tension, Viscosity, Crystal systems, Powder-XRD.

Course Code: CHEMISTRY- GE-8

Course Title: Chemical Kinetics and Photochemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The students will learn about fundamentals of chemical kinetics, rates of chemical reactions, complex reactions, theories of reaction rate and the laws of photochemistry aimed at understanding electronic transitions upon irradiation of electromagnetic radiation in UV-Vis region.

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand the concept of rate of a reaction, order and molecularity of a reaction, various factors affecting the rate and theories of reaction rates.
- Students will be able to apply the learnt concepts in studying the reaction kinetics of various reactions.
- Understand the basic concepts of photochemistry, photochemical and photosensitized reactions and their role in biochemical systems.

Theory:

Unit 1: Chemical Kinetics **Lectures: 20**

The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants), half–life of a reaction, general methods for determination of order of a reaction. kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms). Concept of activation energy and its calculation from Arrhenius equation. Theories of reaction rates: Collision theory and activated complex theory of bi-molecular reactions. Comparison of the two theories (qualitative treatment only)

Unit 2: Photochemistry **Lectures: 10**

Characteristics of electromagnetic radiation, Jablonski Diagram. Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitized reactions, quenching. Role of photochemical reactions in biochemical processes.

Practicals: **Credits: 02**

(Laboratory periods: 60)

Chemical Kinetics

Study the kinetics of the following reactions by integrated rate method:

a) Acid hydrolysis of methyl acetate with hydrochloric acid.

b) Compare the strength of HCl and H2SO4 by studying the kinetics of hydrolysis methyl acetate.

c) Initial rate method: Iodide-persulphate reaction

d) Integrated rate method: Saponification of ethyl acetate.

e) Study the reactiob kinetics of Iodination of acetone.

References:

Theory:

1. Castellan, G.W. (2004), **Physical Chemistry**, Narosa.

2. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**, Vol 5, 6th Edition, McGraw Hill Education.

3. Kapoor, K.L. (2013), **A Textbook of Physical Chemistry**, Vol 6, 3rd Edition, McGraw Hill Education.

Practicals:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused

- Transaction through an intelligent mix of conventional and modern methods
- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods: Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Rate Law, Rate constant. Arrhenius Equation, Lambert-Beer's law, Jablonski Diagram

Course Code: CHEMISTRY- GE-9

Course Title: Conductance and Electrochemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The students will learn about conductance, its measurement and applications. Students will also learn principles of electrochemical cells: Electrolytic and Galvanic cell, measurement of, measurement of emf and its applications.

Learning Outcomes:

By the end of the course, the students will be able to:

- Explain the factors that affect conductance, migration of ions and application of conductance measurement.
- Understand different types of galvanic cells, their Nernst equations, measurement of emf, calculations of thermodynamic properties and other parameters from the emf measurements.
- Understand applications of Emf measurements in relation to determination of activity coefficients, pH of a solution and Potentiometric titrations.

Theory:

Unit 1: Conductance **Lectures: 10**

Quantitative aspects of Faraday's laws of electrolysis. Arrhenius theory of electrolytic dissociation. Conductivity: equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, Kohlrausch Law of independent migration of ions. Wein Effect and Debye–Falkanhegan Effect.

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

Unit 2: Electrochemistry **Lectures: 20**

Reversible and irreversible cells with Examples, concept of EMF of a cell, measurement of EMF of a cell, Nernst equation and its importance, types of electrodes, standard electrode potential (reduction Potential) and its application to Gas–ion half-cell. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference, liquid junction potential; determination of activity coefficients and salt bridge, pH determination using hydrogen electrode. Potentiometric titrations-qualitative treatment (acid-base and oxidation-reduction only).

Practicals: **Credits: 02**

(Laboratory periods: 60)

Conductance

1. Determination of cell constant.
2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations:

a) Strong acid vs strong base
b) Weak acid vs strong base.

Potentiometry

Perform the potentiometric titrations of (i) Strong acid vs strong base, (ii) Weak acid vs strong base and (iii) Mohr's salt vs $KMnO_4$.

References:

Theory:

1. Castellan, G.W. (2004), **Physical Chemistry**, Narosa.
2. Kapoor, K.L. (2015), **A Textbook of Physical Chemistry**,Vol 1, 6th Edition, McGraw Hill Education.
3. Kapoor, K.L. (2013), **A Textbook of Physical Chemistry**,Vol 3, 3rd Edition, McGraw Hill Education.

Practicals:

1. Khosla, B.D.; Garg, V.C.;Gulati, A.(2015), **Senior Practical Physical Chemistry**, R. Chand & Co.

Teaching Learning Process:

- Teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.

- Engaging students in cooperative learning.
- Learning through quiz design.
- Problem solving to enhance comprehension.

Assessment Methods: Assessment will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Conductance, Ionic mobility, EMF, Nernst Equation, transference number.

Course Code: CHEMISTRY- GE-10

Course Title: Basics of Polymer Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The objective of this course is to help the student to know about the synthesis, properties and applications of polymers.

Learning Outcomes:

By the end of the course, the students will:

- Know about classification of polymeric material.
- Learn about different mechanisms of polymerization and polymerization techniques
- Evaluate kinetic chain length of polymers based on their mechanism
- Differentiate between polymers and copolymers
- Learn about different methods of finding out average molecular weight of polymer.
- Differentiate between glass transition temperature (Tg) and crystalline melting point (Tm)
- Learn properties and applications of various useful polymers in our daily life

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Theory:

Unit 1: Introduction to polymers **Lectures:10**

Different schemes of classification of polymers, Polymer nomenclature, configuration and conformation of polymers, Molecular forces and chemical bonding in polymers, Texture of Polymers

Functionality and its importance:

Criteria for synthetic polymer formation, basic methods of polymerization processes and their mechanism: addition, condensation, Relationships between functionality, extent of reaction and degree of polymerization.

Unit 2: Properties of Polymers — Lectures: 10

Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).
Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity,
Morphology of crystalline polymers, Factors affecting crystalline melting point.
Molecular weight distribution and determination of molecular weight of polymers (Mn, Mw, etc.) by end group analysis, viscometry and osmotic pressure methods. Molecular weight distribution and its significance.

Unit 3: Preparation, properties and applications — Lectures: 10

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

Practicals: — Credits: 02

(Laboratory periods: 60)

Polymer Synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA)/MethylAcrylate (MA).
2. Preparation of nylon 6,6
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resole resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

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

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method.
2. Determine the melting point of crystalline polymer.
3. Measurement of glass transition temperature, T_g.s

References:

Theory:

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

Practical:

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

Teaching Learning Process:

- Student centred teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes for enhanced understanding of the concepts
- Engaging students in collaborative learning.
- Pre-lab learning of theoretical concept of the experiment.
- Performing the experiment, recording the data, calculating the result.
- Interpreting the result.
- Comparing the results of the class.
- Discussing the sources of error.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Mock practical examination.
- Semester end University examination.

Keywords: Bonding, Texture, Polymerization, Crystallization, Properties, Applications.

Course Code: CHEMISTRY- GE-11

Course Title: Chemistry of Food Nutrients

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: This introductory course on food chemistry is designed in such a manner that the students develop a basic understanding of the components of food, their source, properties and interactions as well as changes that occur during processing, storage, and utilization.

Learning Objectives:

On completion of the course, the student will be able to:

- Build a strong understanding of chemistry of food: composition of food, role of each component.
- Understand some of the reactions and changes in individual food components which occur during processing, handling and storage

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Theory:

Unit 1: Carbohydrates **Lectures: 6**

Introduction, sources, functions, classification: monosaccharide, oligosaccharide and polysaccharide, structure and importance of polysaccharides in food chemistry (pectin, cellulose, starch, gums), chemical reactions of sugar: mutarotation, caramelisation; non enzymic browning and its prevention, role of carbohydrates as sweeteners in food.

Unit 2: Lipids **Lectures:8**

Introduction, sources, classification (fatty acids, phospholipids, fats & oils, waxes), common fatty acids present in oils and fats, Omega- 3&6 fatty acids, trans fats, chemical properties-Reichert Meissel value, Polenski value, iodine value, peroxide value, saponification value, effect of frying on fats, changes in fats and oils- rancidity, lipolysis, flavor reversion, auto-oxidation and its prevention.

Unit 3: Proteins **Lectures:8**

Introduction, sources, classification (simple, conjugated, derived), structure of protein (primary, secondary and tertiary), physico-chemical & functional properties of proteins, protein denaturation.

Unit 4: Vitamins & Minerals **Lectures:8**

Vitamins: Introduction, classification: fat-soluble vitamins & water-soluble vitamins.

Minerals: Introduction, classification: macrominerals (Ca, P, Mg) & microminerals (Se, Fe, I, Co, Zn, Cu, Se, Cr).

Physiological importance of vitamins and minerals, effect of food processing on vitamins and minerals.

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Determination of moisture in food products by hot air oven-drying method.
2. Colorimetric determination of Iron in vitamin / dietary tablets.
3. 2, 6-Dichlorophenol indophenol method for estimation of vitamin C in a given solution/ lemon Juice/chillies.
4. Estimation of total soluble sugar content by ferricyanide method (volumetric analysis).
5. Determination of saponification value of the given fat/oil.
6. Determination of iodine value of the given fat/oil.
7. Qualitative tests for proteins and carbohydrates.
8. Qualitative estimation of cholesterol by Liebermann Burchard method.

References:

Theory:

1. deMan, J.M., Finley, J.W., Hurst, W.J., Lee, C.Y. (2018), **Principles of Food Chemistry**, 4th Edition, Springer.
2. Msagati, T.A.M. (2013), **Chemistry of Food Additives and Preservatives**, Wiley-Blackwell.
3. Fennema, O.R. (2017), **Food Chemistry**, 5th Edition, CRC Press.
4. Attokaran, M. (2017), **Natural Food Flavors and Colorants**, 2nd Ed., Wiley-Blackwell.
5. Potter, N.N., Hotchkiss, J.H, (1995) **Food Science,** 5th Ed., Chapman & Hall.
6. Brannen, D., Davidsin, P.M., Salminen, T. Thorngate III, J.H. (2002), **Food Additives**, 2nd Edition, CRC Press.
7. Coultate, T. (2016), **Food: The Chemistry of its Components**, 6th Edn., Royal Society of Chemistry.
8. Belitz, H. D.; Grosch, W. (2009), **Food Chemistry**, Springer.
9. Course: FOOD CHEMISTRY (iasri.res.in)

Practical:

1. Ranganna, S. (2017). **Handbook of analysis and quality control for fruits and vegetable products**, 2nd Edn., McGraw Hill Education
2. Sawhney, S.K., Singh, R. (2001), **Introductory Practical Biochemistry**, Narosa Publishing House

Teaching Learning Process:

- Student centred teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes for enhanced understanding of the concepts
- Engaging students in collaborative learning.
- Pre-lab learning of theoretical concept of the experiment.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.
- Mock practical examination.
- Semester end University examination.

Keywords: Food nutrients, Carbohydrates, Proteins, Lipids, Vitamins, Minerals, Browning reaction.

Course Code: CHEMISTRY- GE-12

Course Title: Chemistry: Statistical Methods and Data Analysis

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objective: In this course the students will be given insight about the statistical treatment on the chemical analysis data along with illustration about the analysis of collected analytical data to take up a job of technician, scientist and laboratory manager. The presentation of data in different form such as "Table, Graph, Bar Diagram, Pie Chart, Venn diagram" are explained along with their reliability and validity.

Learning outcomes:

At the end of this course student will be:

- Familiar with interpretation and use of analytical data collected by different techniques,

- Significance of different analytical techniques and their applications,
- Reliability and presentation of data for reporting to different forum.

Theory:

Unit 1: Basics of Chemical Analysis **Lectures: 6**

Analytical Chemistry, Qualitative and quantitative analysis, Analytical methodology. Calibration of glass wares, recording laboratory data.

Unit 2: Different Methods of Chemical Analysis **Lectures: 8**

Titrimetric method: volumetric titremetry, standard solution, titrimetric curve, calculation; Gravimetric method: precipitation gravimetry, calculation and applications of gravimetry; and Spectrometric methods: introduction, principle and instrument, working quantitative aspects absorbance, applications in chemical analysis

Unit 3: Statistical Method of Chemical Analysis **Lectures: 8**

Accuracy and Precision, Comparison of precision, Errors, Distribution of random errors, propagation of errors, measurement of errors, significant figure, inter laboratory error, methods of least square analysis of variance, Q test, Z test, T test, statistical treatment of finite sample, recommendations for treating outliers. Minimising errors in analytical procedure.

Unit 4: Data Analysis and Validation **Lectures: 5**

Confidence interval, Testing of hypothesis, plotting of data, least square method, Figures of merit: sensitivity, detection limit, linear dynamic range, control test, upper control limit and lower control limit, Validation, reporting analytical results and significant figures

Unit 5: Sampling, Standardisation, Labelling and Calibration **Lectures: 7**

Analytical samples, sample size, constituent sample, real samples, sample, sample handling, preparing laboratory samples, automated sample handling, lab on chip and General laboratory principles, recording laboratory data, standards, comparison of standards, internal standard, external standards calibration, least square method, and multivariant calibration.

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Calibrate the volume of laboratory glass wares i.e. volumetric flask, beaker, burette and calibration constant.
2. Demonstrate the good laboratory practices like effect of dilution, temperature, taking observation, personal and apparatus safety.
3. Determine the quantitative presence of heavy metals like copper, chromium and iron in natural and laboratory samples using volumetric and gravimetric titration.

4. Determine the presence of magnesium ion in heavy water by EDTA method and prepare calibration curve.
5. Evaluate the absolute and method errors in a set of data collected during determination of nitrogen in an organic compound.
6. Calculate the standard deviation and predict precision of analytical results.
7. Determine the concentration of pollutant in natural sample after using external standards methods.
8. Compare the inter laboratory error of a spectroscopic results.
9. Evaluate the limit of detection for colorimetric analysis of dyes and coloured metals in wastes water samples.
10. Demonstrate the control of interference by masking by complexation.
11. Report the ten analytic results in significant numbers along with standard deviation.
12. Determine the confidence limit and interval for a laboratory instrument like breath alcohol analyser
13. Demonstrate the internal standard method for calibration of metal estimation.
14. Estimate the comparative effectiveness of different types of graphs like line, pi chart and bar graph.
15. Demonstrate the working of lab on chip like glucose sensor.

References:

1. Dey, R. A. and Underwood, A. L., **Quantitative Analysis**, 6th Edition, Pearson.
2. Skoog, D. A., West, D. M., Holler, F. J., Crouch, S. R., **Fundamental analytical chemistry**, Thomson Asia Ltd.
3. Encyclopaedia of analytical chemistry: Applications, Theory, and Instrumentation, R A Meyor (Eds) Wiley and Sons (2000).

Teaching Learning Process:

- Student centred teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes for enhanced understanding of the concepts
- Engaging students in collaborative learning.
- Pre-lab learning of theoretical concept of the experiment.
- Performing the experiment, recording the data, calculating the result.
- Interpreting the result.
- Comparing the results of the class.
- Discussing the sources of error.

Assessment Methods:

- Class Tests at Periodic Intervals.
- Written assignment(s)
- Continuous evaluation of laboratory work and record file.
- Oral assessment, quizzes.

- Mock practical examination.
- Semester end University examination.

Keywords: chemical analysis, Statistical method, Sampling, Standardisation, labelling and calibration.

Course Code: CHEMISTRY- GE-13

Course Title: Medicines in Daily Life

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The course is designed to study the basic details about various medicines of general uses, which are crucial for the various diseases. This course also gives the knowledge of active pharmaceutical ingredient in some medicines, their synthesis; therapeutic effect and side effects on human physiology. Medicines are essential for a healthy day-to-day life and therefore this course will aware the students about its positive and negative effects.

Learning Outcomes:

By the end of the course, the students will be able to:

- Understand the role of different medicines on human physiology.
- Gain the knowledge of active pharmaceutical ingredient and their roles in different disease.
- Learn the proper use of different medicines and their effect and side effects.
- Learn the techniques of administering blood group, pulse rate, blood pressure and may other general diagnostic applications.

Theory:

Unit 1: General Introduction **Lectures: 8**

Introduction-Health, disease, drugs, chemotherapy, approaches in drug designing, classification of drugs and their origin.

Unit 2: Different class of medicines **Lectures: 22**

Structure of active ingredients, uses, dosage, side effects and their natural remedies:

Analgesics and antipyretics- Aspirin, paracetamol, ibuprofen, morphine, codeine

Antibiotics- Amoxicillin, norfloxacin, ciprofloxacin

Antihistamines or antiallergics- Cetrizine and Levocetrizine (role of stereoisomers)

Antiparasitic- Albendazole

Antidiabetics- Insulin, Glipizide and metformin

Antihypertensive – Amlodipine and its natural remedies- Rauwolfia.

Diuretic- Lasix

Antidepressant-Zoloft and its natural treatment

Antifungal – fluconazole, Itraconazole

Antacids- Ideal properties of antacids, combinations of antacids, Sodium 40 Bicarbonate, rantidine, milk of magnesia, aluminium hydroxide gel

Anticoagulants/antiplatelet drugs- Warfarin, heparin and Ecosprin

Anaesthetics- Atracurium, Desflurane

Poison and Antidote: Sodium thiosulphate, Activated charcoal, Sodium nitrite

Astringents: Zinc Sulphate, Potash Alum

Supplements- zinc and calcium, vitamins

Synthesis of small molecule drugs like aspirin and paracetamol

Practicals: **Credits: 02**

(Laboratory periods: 60)

1. Determination of heart rate and pulse rate, blood pressure and discussion on medicines affecting them.
2. Identification test- Magnesium hydroxide, Sodium bicarbonate, Calcium gluconate.
3. Preparation of inorganic pharmaceuticals- Boric acid Potash alum
4. Determination of sugar content in the given solution.
5. Estimation of zinc and calcium in a given solution.
6. Qualitative analysis of carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose).
7. Qualitative tests for Proteins
8. Qualitative analysis of vitamin C.
9. Isolation of paracetamol (API) from a commercial tablet
10. Isolation of aspirin (API) from tablet and recording of melting point (synthesis needs discussion)

References:

Theory:

1. Patrick, G. L. (2001) **Introduction to Medicinal Chemistry**, Oxford University Press.
2. Lemke, T. L. & William, D. A. (2002), **Foye's Principles of Medicinal Chemistry**, 5th Ed., USA,

3. Singh H.; Kapoor V.K. (1996), **Medicinal and Pharmaceutical Chemistry**, Vallabh Prakashan.
4. Chatwal, G.R. (2010), **Pharmaceutical chemistry**, inorganic (vol. 1), Himalayan publishing house
5. https://go.drugbank.com./

Practicals:

1. Jeffery, G.H., Bassett, J., Mendham, J., Denney, R.C. (1989), **Vogel's Textbook of Quantitative Chemical Analysis**, John Wiley and Sons.
2. Ahluwalia, V.K., Dhingra, S. (2004), **Comprehensive Practical Organic Chemistry: Qualitative Analysis**, University Press.
3. Munwar, S., Ammaji, S.(2019), **Comprehensive Practical Manual of Pharmaceutical Chemistry,** Educreation Publishing.
4. Mondal, P., Mondal, S.(2019), **Handbook of Practical Pharmaceutical Organic, Inorganic and Medicinal chemistry**, Educreation Publishing.

Teaching Learning Process:

- Lecture in class rooms
- Peer learning
- Technology driven learning
- Learning through experiment in the practical classes

Assessment Methods:

- Presentations by Individual Student/ Group of Students
- Class Tests at Periodic Intervals.
- Written assignment(s)
- End semester University Theory and practical Examination

Keywords: Medicines, Active pharmaceutical ingredient, drug

Course Code: CHEMISTRY- GE-14

Course Title: Chemistry: Molecular Modelling, Artificial Intelligence and Machine Learning in Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives: The course is aimed at familiarization of students to modern scientific machine (programming) language i.e., Python, artificial intelligence (AI) & machine learning (ML) and their potential applications in chemistry. Further the aim of the course is to provide elementary ideas of the techniques prevailing in the field of artificial intelligence (AI) and machine learning (ML) and their applications to research problems especially related to research and development of new materials and pharmaceutical compounds with desired properties.

Learning Outcomes:

By the end of the course, the students will be:

- Conversant with the Python Programming Language.
- Familiar with Elementary techniques of Artificial intelligence (AI) & Machine learning (ML)
- Able to apply techniques of AI & ML in basic problems of research in some important areas of research in Chemistry.

Theory:

Part A: Molecular Modelling

Introduction to computational chemistry: **Lectures: 7**

Overview of Computational Methods in Chemistry (Ab initio, DFT, Semi- empirical, Molecular Mechanics

Potential Energy Surfaces **Lectures: 4**

The concept of Potential energy surface, Intrinsic Reaction Coordinates, Stationary points, Equilibrium points – Local and Global minima, Geometry optimization and energy minimization.

Molecular Mechanics **Lectures: 4**

Force Fields (A brief idea of a basic force field), Elementary idea of MM1, MM2, MM3, MM4, MM+, AMBER etc. A brief Idea of Molecular Docking

Part B: Artificial Intelligence & Machine learning in Chemistry **Lectures: 15**

An overview of computationally readable and processible representation of molecules, e.g., SMILES, mol files. Chemical space and access to chemical databases. Statistical treatment of data: regression analysis and types of regression. Elementary Idea of Quantitative structure-activity relationship (QSAR).

An insight into Artificial Intelligence & Machine learning and potential areas of applications in chemistry. Dimensional reduction; Principal Component Analysis (PCA) and the importance and necessity of nonlinearity in Artificial Intelligence.

Genetic algorithm, basics of random mutation hill climbing (RMHC) and simulated annealing.

Practicals/Hands-on Training: **Credits: 02**

(Laboratory periods: 60)

Molecular Modeling based Exercise

1) Write the Z-Matrix of a given set of molecules.

2) Carry out geometry optimisation on H_2O, H_2S, H_2Se molecules and compare the optimized bond angles and dipole moments from the results obtained. Obtain the ESP-mapped density surfaces and interpret the results obtained with reference to bonding in these molecules.

Suggestive: A comparative analysis of results of the above exercise may be carried out using different quantum mechanical methods.

3) Calculate the energy of the following chemical species and arrange them in order of increasing stability.

1-hexene, 2-methyl-2-pentene, (E)-3-methyl-2-pentene, (Z)-3- methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.

4) Carry out the geometry optimisation on the following chemical species and compare the shapes and dipole moments of the molecules.

1-butanol, 2-butanol, 2-methyl-1-propanol, and 2-methyl-2- propanol.

Correlate the computationally obtained values of the dipole moments with the experimental values of the boiling points: (118ºC, 100 ºC, 108 ºC, 82 ºC, of 1-butanol, 2-butanol, 2-methyl-1- propanol, and 2-methyl-2- propanol respectively).

5) Based on the implicit electronic structure calculations, determine the heat of hydrogenation of Ethene.

6) Based on the calculations of enthalpies of the participating chemical species on optimized geometry of the molecules, calculate the reaction enthalpy at 298 K for the following, industrially important reactions:

$$CH_4 + H_2O \rightarrow CO + 3H_2$$ (steam reforming of methane)

$N_2 + 3\,H_2 \rightarrow 2NH_3$ (Haber-Bosch process)

7) Carry out geometry optimisation and determine the energy of the participating chemical species in the following reactions Using these results calculate the resonance energy of thiophene.

8) Carry out geometry optimization & energy calculations on the following species and obtain Frontier Molecular Orbitals. Visualize the Molecular Orbitals of these species and interpret the results for bonding in these molecules.

   Benzene, Naphthalene, and Anthracene.

9) Compare the gas phase basicities of the methylamines by comparing the enthalpies of the following reactions:

10) On the basis of results of geometry optimization and energy calculations, determine the enthalpy of isomerization of cis and trans 2-butene.

11) QSAR based exercise on problems of interest to chemist.

12) Perform a conformational analysis of butane. Plot the graph between the angle of rotation and the energy of the conformers using spreadsheet software.

13) Compute the resonance energy of benzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.

14) Perform a geometry optimization followed by a frequency assessment (opt+freq keyword) using the B3LYP method and 6-31-G(d) basis set on a given set of small molecules i.e. BH_3, CH_4.

Suggestive: A greater number of molecules may be studied as per instructions received from the concerned teacher.

15) Based on the fundamentals of conceptual DFT calculate the ionization potential (IP), electron affinity (EA), electronegativity and electron chemical potential of a given set of molecules.
16) Perform molecular docking of Sulfonamide-type D-Glu inhibitor into MurD active site using Argus lab.

Artificial Intelligence (AI) and Machine Learning (ML) based exercise on problems of interest to chemist

17. Travelling salesman problem and electrical circuit design (minimization of path-length).
18. Genetic algorithm, in solving matrix form of linear equations
19. Non-linear least-square fitting problem.
20. Particle Swarm Optimization on the sphere function.

Important Instruction Note on working approach:

- A student is required to perform/investigate a minimum of 10 exercises in total.
- The exercises mentioned above will be performed by the studentstrictly in accordance with the instructions received and only under the supervision of the teacher concerned.
- Any other exercise may be carried out with prior permission, input, discussion and instructions received from the teacher concerned.

References:

1. Lewars, E. (2003), **Computational Chemistry**, Kluwer academicPublisher.
2. Cramer, C.J. (2004), **Essentials of Computational Chemistry**, John Wiley & Sons.
3. Cartwright C.; Kharma N., (2008), **Using artificial intelligence in chemistry and biology**, First Edition, CRC Press Taylor & Francis Group
4. Hippe; Z., **Artificial Intelligence in Chemistry: Structure Elucidation and Simulation of Organic Reactions**, (1991) Academic Press, Elsevier
5. Soft Computing in Chemical and Physical Sciences A Shift in Computing Paradigm (Kanchan Sarkar, Sankar Prasad Bhattacharyya) (z-lib.org)
6. Understanding Properties of Atoms, Molecules and Materials (PRANAB. SARKAR, Sankar Prasad Bhattacharyya) (z-lib.org)

Web Resources:

1. https://www.afs.enea.it/software/orca/orca_manual_4_2_1.pdf
2. https://dasher.wustl.edu/chem430/software/avogadro/learning-avogadro.pdf
3. http://www.arguslab.com/arguslab.com/ArgusLab.html
4. https://barrett- group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf
5. https://gaussian.com/techsupport/
6. https://gaussian.com/man/
7. https://gaussian.com/wp-content/uploads/dl/gv6.pdf
8. https://dasher.wustl.edu/chem478/software/spartan-manual.pdf
9. http://www.mdtutorials.com/gmx/
10. https://vina.scripps.edu/manual/

Teaching Learning Process: Hands-on laboratory exercises Conventional teaching learning method. Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file.Oral assessment, quizzes.
- Presentation on lab practices.Semester end examination.

Keywords: Molecular Modeling, Potential Energy Surface (PES), Geometry Optimization, Frequency calculation, Artificial Intelligence, Machine Learning, Nural Networks, Genetic

Algorithm.

Course Code: CHEMISTRY- GE-15

Course Title: Chemistry and Society

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objective: The course is designed to expand the literacy of chemistry among the non-chemistry student even arts as well as commerce with objective increase general awareness, background of chemistry and its importance. This paper will be helpful for a common student to understand the importance and role of chemistry in development of civilization, societal issues related to chemistry and their expected solutions.

Learning Outcomes:

At the end of this course the student will be able to:

- Increase the literacy of chemistry even in non-science students
- Understand the basic concept, principle and importance of chemistry
- Realize the importance of chemistry in daily life and future requirement

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Theory:

Unit 1: Basics of chemistry **Lectures: 4**

Periodic table, Atom and molecules, chemical bonding, properties and chemical reactions with simple examples and illustration.

Unit 2: Chemistry in Heritage **Lectures: 8**

Extraction and uses of metals like iron and stone in ancient times, metals in ornaments, medicines, weapons and chemistry for preservatives, basics of preservation and few examples of preservatives.

Unit 3: Chemistry in Life **Lectures: 8**

Edible and non- edible molecules, biochemistry of foods and medicine with examples: Aspirin, Paracetamol. Ibuprofen and Penicillin, Cephalosporin, Chemistry for industry: Artificial sweeteners, Soaps and detergents and cosmetics, Polymer and Plastics: Uses and environmental issues.

Unit 4: Chemical pollution and Toxicity **Lectures: 4**

Chemical source of water, air and soil pollution, biomagnification and metal toxicity with example and illustrations. monitoring of air pollution.

Unit 5: Testing of chemicals **Lectures: 4**

Flame test, solubility test, qualitative and quantitative identification of ions in natural samples like metal copper, iron and chromium ores and adulterant in foods.

Unit 6: Future of chemistry **Lectures: 2**

Basics of green chemistry, Reuse and recycling of by-products, zero waste chemistry and Alternate fuel and energy providing chemicals: biodiesel, natural gas and hydrogen.

Practicals/Hands-on Training: **Credits: 02**

(Laboratory periods: 60)

1. Determine the calcium and magnesium contents in water samples using EDTA methods.
2. Determine the organic contents and pH of soil sample.
3. Estimate the food adulterants in edible items
4. Quantify the presence metals by flame test method
5. Demonstrate the conversion of PET into bottle into value added products.
6. Determine the quantitative presence of heavy metals like copper and chromium in natural sample like ore.
7. Demonstrate the exothermic and endothermic reaction in laboratory
8. Preparation aspirin and paracetamol as well as identify.
9. Compare the fuel efficiency of biodiesel and petrol.
10. Preparation of representative compound using microwave
11. Demonstrate the biodegradability of natural and synthetic plastics.
12. Demonstrate the protection of rusting of iron after surface spray coating.
13. Estimate the protein contents in edible samples using chemical methods.
14. Small working project on heritage chemistry like bio compatibility of metals and medicinal importance of metals like iron, gold and silver.

References:

1. Lee, J. D., **Concise Inorganic Chemistry**, Wiley India Pvt. Ltd.
2. Sharma, B. K., **Industrial chemistry**, Goel Publishing House, India
3. Christian, Gary D., Dasgupta, Purnendu K., Schug, Kevin A., **Analytical chemistry**, Wiley
4. V. Subramanian, **A text book of Environmental chemistry**, Wiley

Teaching Learning Process:

- Hands-on laboratory exercises

- Conventional teaching learning method. Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file. Oral assessment, quizzes.
- Presentation on lab practices.
- Semester end examination.

Key words: Fundamental of chemistry, Chemistry for advancement in society, Chemistry and industry, Sustainable future of chemistry.

Course Code: CHEMISTRY- GE -16

Course Title: Role of Metals in Medicines

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objective: To make the learners familiar about role of metal ions in some commercially available medicines.

Learning Outcomes:

By the end of this course student will be able to learn:

- Role of metal ions in various biomolecules and their functions.
- Role of metals in commercially available medicines and their functions

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Theory:

Unit 1: Bio role of Metals **Lectures: 4**

Brief introduction of following metals in biological system
Fe, Cu, Zn, Mn, Cr(III), V, Mo, W, Co, Ni, Na, K, Mg and Ca
Chemical structure, Commercial name, Name of the disease it is made for and its brief mechanism of action shall be taught for all the mentioned metals below.

Unit 2: Diagnostic and therapeutic agents **Lectures: 8**

Diagnostic and therapeutic agents with Pt (Cisplatin) and Ga for cancer, Au (auranofin) for arthritis and V for diabetes.

Unit 3: Metals in drugs **Lectures:6**

Li_2CO_3 (Camcolit) for manic-depressive illness, $NaHCO_3$ (Alka-seltzer) for heartburn, $Al(OH)_3$ (Gaviscon) for heartburn, As (melarsoprol) for sleeping sickness, Bi subsalicylate (pepto-Bismol) for heartburn and diarrhea, Bi subcitrate (De-nol) peptic ulcer, Zinc oxide with Fe_2O_3 (Calamine lotion) as antimicrobial agent.

Unit 4: Metals in Multivitamins **Lectures:6**

Cyanocobalamin (Co), Ferrous fumerate (Fe), Magnesium oxide (Mg), Zinc Sulfate (Zn), Manganese sesulphate (Mn), Copper Sulfate (Cu), Sodium selenite (Se) and Chromium trichloride (Cr).

Unit 5: Radiopharmaceuticals and MRI contrast agents **Lectures:6**

^{99m}Tc for heart, brain and bone imaging, ^{123}I radiopharmaceuticals, $BaSO_4$for X-ray contrast agent, Gd (III) for MRI contrast agents.

Practicals: **Credits: 02**

(Laboratory periods: 60)

Volumetric titrations:

1. To estimate the acidity of commercially available antacids.
2. To estimate the concentration of Fe in commercially available medicines.
3. To estimate the concentration of Ca in commercially available medicinces.
4. To estimate the strength of carbonate in tablets containing Li_2CO_3
5. To estimate the sodium bicarbonate in synthetic/commercially available drug.
6. To estimate the zinc and iron present in Calamine lotion.
7. To estimate the Mg present in multivitamins.

References:

1. **Metals in Medicine**, John Wiley & Sons Ltd, Nov 2009
2. Chapter-9, **Metals in Medicine**, Stephen J. Lippard
3. Jones, Chris and Thornback, John, **Medicinal applications of coordination chemistry**, Cambridge, UK: Royal Society of Chemistry, 2007

Teaching Learning Process:

- Hands-on laboratory exercises
- Conventional teaching learning method. Engaging students in collaborative learning

Assessment Methods:

- Continuous evaluation of laboratory work and record file. Oral assessment, quizzes.

- Presentation on lab practices.
- Semester end examination.

Key words: Diagnostic, therapeutic agents, multivitamins, radiopharmaceuticals and MRI contrast agents.

Course Code: CHEMISTRY- GE- 17

Course Title: Energy and the Environment

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objectives: The objective of this paper is to develop basic understanding of energy, issues related to energy, importance of energy in terms of economy, health and the environment. To understand different sources of energies, renewable and non-renewable sources of energy. To understand the importance of green fuels. This course will help the students to understand the adverse effect of pollution, and possible remediations.

Learning Outcomes:

By the end of this course student will be able to learn:

- Describe basic energy concepts
- Account for conventional and renewable energy technologies and their application
- Reflect and evaluate the environmental impact of energy production and the relationship between energy production, consumption and climate change
- Reflect on energy costs, analyse the consequences of today's energy consumption
- Efficient use of energy, water and other resources, Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality, Use of materials that are non-toxic, ethical and sustainable
- Consideration of the environment in design, construction and operation

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Theory:

Unit 1: **Lectures: 13**

Introduction, chemistry and energy, conversion of chemical energy to electrical energy, Carbon cycle, Greenhouse gases, Global warming and climate change, Carbon footprint, zero-carbon or low-carbon energy. Electrical energy and steam energy, Energy Alternatives, Hidden Costs of Energy.

Unit 2: **Lectures: 10**

Production methods for electric power: Non-Renewable (conventional) sources of energy: Fossil fuels: Coal, petroleum and Natural gas. Energy transformation. Renewable energy sources: solar, hydropower, wind, geothermal, wave, ocean thermal, tidal, ocean currents, nuclear energy, biomass.

Unit 3: **Lectures: 12**

Production methods for electric power: Renewable (green) energy, conversion and storage systems. Nuclear fusion, Hydrogen fuels, photovoltaic solar cells, hydroelectric. Sustainable energy, biomass, Biofuels, production of biofuels, advantages, blending of biofuels with conventional fuels, Carbon Capture and Reuse, Waste to Energy Technologies.

Unit 4: Lectures: 10

Air Pollution, Urban and Indoor Air Pollution, Pollution and waste reduction measures, chemical remediation of air pollution. Effect of pollution on health and economy.

Practicals: **Credits: 01**

(Laboratory periods: 30)

Tutorials

1. Conversion of biomass to biofuels (2-3 different biofuels)
2. Working on solar cell model.
3. Working on wind turbine model.
4. Working on geothermal energy model.
5. Working on hydroelectric plant model.
6. Presentations by students

References:

Theory

1. Rao, C S., **Environment pollution control Engineering**, New Age International reprint 2015, 2nd edition
2. Bharucha, E., **Textbook of Environmental Studies**, Universities Press (2005)
3. Wright, R.T., **Environmental Science-Towards a sustainable Future**, Prentice Hall (2008) 9th edition.
4. Ahluwalia, V. K., **Energy and Environment**, The Energy and Resources Institute (TERI) (2019).

References:

Practicals

- Challapalli Narayan Rao, **Practical approach to implementation of Renewable Energy Systems,** Evincepub Publishing, 2022

Teaching Learning Process: To accomplish a goal, it is very important to learn in a strategic manner. There are different components of learning and the capacity of each learner varies. It is expected to have a student centric teaching. Questions and answers, both should come from students. 'How' to teach and 'What' to teach in the defined curriculum not only depends on the content and the knowledge of the teacher but critically more so on designing, i.e. how to introduce the concept to the students in a very effective way. Different ways of teaching include classical board teaching method, visual conceptual method, application based practical demonstration of the concept etc. are required in this course. In fact, the pedagogy is to make a class interesting and thus learning becomes enjoyable.

Assessment Methods: The effectiveness of learning can be judged by assessing the students. Various types of assessment methods can be followed depending on the branch of student opting the course. Assessment can be in form of Graded assignments, conventional class tests, class seminars and presentations by students on course topics with a view to strengthening the content through width and depth, end semester university examination for theory and practical.

Keywords: Energy, Renewable and non-renewable energy resources, Synthetic fuels, Biofuels, Carbon footprint, air pollution, remediation, pollution related health and economy.

Course Code: CHEMISTRY- GE -18

Course Title: Fragrances and Flavours: An Industry's Perspective

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objectives: The use of fragrance is ubiquitous and is a global human phenomenon. Over the course of time, countless numbers of flavors and fragrances have found their way into everyday life, notably into foods, beverages and confectionery items; into personal care products (soaps, toothpastes, mouthwashes, deodorants, bath lotions and shampoos), perfumes, and other cosmetics as well as pharmaceutical formulations. Indeed, flavors and aromas are added to make such products more attractive or to mask the taste or smell of less pleasant ones. There is need to understand the applications of chemistry in the world of flavours and fragrances.

Learning Outcomes:

By the end of this course student will be able to learn:

- Synthesis of various fragrance and flavour ingredients
- Formulation methods, how different factors affects the formulation process in Fragrance and Flavour industry
- Uphold safety regulation and execute quality processes
- Quality control in manufacturing process, legal aspects, classification of odour and odorants.
- Different methods used for separation, purification and isolation of perfumes and flavours like distillation, extraction, crystallization, etc.

Theory:

Unit 1: Fragrances **Lectures: 18**

- Introduction to fragrances, types of fragrances (Fragrance families and classification)
- History of perfumes, Perfumery raw materials, classification of odour, odour type and odorants
- India in the context of Fragrance Industry
- ABCs of perfumery, odour aspects of perfumes, fragrance pyramid, fragrance families
- Some basic chemical knowledge to provide a better understanding of the structure of molecules possessing a sensory power, The volatility and solubility of sensory molecules
- Chemistry of aromatic compounds in perfume making, Composition of fragrances
- Current trends in fragrances, sensory analysis of different products
- Study of the raw materials used in perfumery (origin, extraction method, and olfaction)
- Key chemical reactions for conversion of raw materials to fragrances
- Extraction of essential oils used in perfumery
- Difference between alcohol and oil-based perfumes
- Outline of health, safety and sustainability parameters in perfumer

Unit 2: Sustainable Fragrance by Design **Lectures: 4**

- The challenges of sustainability and how it impacts the industry
- Sustainability charter
- Green chemistry principles
- Commitment to Biodiversity

Unit 3: Flavours **Lectures: 18**

- Introduction to flavours, types of flavours, flavour raw materials
- Understanding of terms like, Flavour and Flavouring agents. Attributes of flavour, taste, odour, odour stimulation, basic tastes and the human olfactory system.
- Stability of flavour in food, sensory evaluation of flavours in foods, Various flavour formulation
- Systematic approach to understanding flavour formation during food processing, food matrix, interaction of added flavours
- Flavour enhancers, modifiers, precursors, suppressors, solvents.
- Key chemical reactions for conversion of raw materials to flavours

- Forms of flavour and the manufacturing processes involving all types of flavours. Aroma recovery during processing.
- Biogenesis of flavours in fruits and vegetables, reaction flavours, off flavours.
- Stability of flavor in food, sensory evaluation of flavours in foods
- Selection and application of flavours in foods and beverages
- Legal aspects (natural flavours and natural flavouring substances, nature identical flavouring substances, artificial flavouring substances), and the FSSA act.

Unit 4: Extraction, Isolation and Purification of Perfumes and Flavour Compounds

Lectures: 5

- Extraction techniques for the separation of volatile oils from natural source- including. Distillation, Evaporation, Crystallization and Adsorption, supercritical fluid extraction methods of isolation of important ingredients

Practicals: **Credits: 01**

(Laboratory periods: 30)

1. Extraction of D-limonene from orange peel using liquid CO_2.
2. Extraction of caffeine from coffee beans using liquid CO_2.
3. Extraction of essential oils from lemon using steam distillation
4. Extraction of essential oils from lemon using liquid CO_2.
5. Extraction of essential oils from fragrant flowers.
6. Determination of esters by Thin Layer Chromatography
7. Memorisation of different raw materials used in perfumery, perfume language, Memorisation of perfumes
8. Testing up of different flavours
9. Analysis of spectra of perfume formulations.

References:

1. Arctander, S. (2008), **Perfume and flavour materials of Natural origin,** Allured Publishing Corporation, USA
2. Arctander, S. (2017), Volume I and II, **Perfume and Flavour Chemicals**, (Aroma Chemicals), Allured Publishing Corporation, USA
3. Curtis,T.; Williams, D. C.(2001) 2nd Edition, **An Introduction to Perfumery**, Micelle Press, USA.
4. Sell,C. (2008), **Understanding Fragrance Chemistry,** Allured Publishing Corporation, USA
5. Calkin,R.R., Jellinek, J.S., **Perfumery: Practice and Principles,** John Wiley & Sons Inc.
6. Gimelli, S.P. (2001), **Aroma Science,** Micelle Press, USA
7. Arctander, S. (2019), **Perfume and Flavour Materials of Natural Origin,** Orchard Innovations
8. https://www.beyondbenign.org/lessons/essential-oil-extraction-using-liquid-co2/

Teaching Learning Process: Blackboard, Power point presentations, Assignments, Field Trips to Flavour and perfumery Industry, Different working models, ICT enabled classes, Interactive sessions, recent literature using internet and research articles.

Assessment Methods: Students' evaluation will be done on the basis of regular class test, presentations and assignments as a part of internal assessment during the course as per the curriculum. End semester university examination will be held for both theory and practical. In practical, assessment will be done based on continuous evaluation, performance in the experiment on the date of examination and viva voce.

Keywords: Fragrances, Flavours, pharmaceutical formulation, distillation, extraction techniques

Course Code: CHEMISTRY- GE-19

Course Title: Radio-chemistry in Energy, Medicine and Environment

Total Credit: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objectives: The objective of this course is to give an introduction to nuclear and radiochemical concepts. It will also help the student to gain fundamental knowledge about the radioisotopes and their real-world applications in medicine, diagnostic techniques, energy, research and environment.

Learning Outcomes:

By the end of the course, the students will:

- Learn about radioisotopes, radioactive decay
- Use of radiochemistry in various fields
- Effect of radiations on health
- Learn about nuclear energy and nuclear pollution

Theory:

Unit 1: Introduction **Lectures: 10**

Atoms, composition of nucleus, mass number, isotopes, nuclear stability, radioactive decay, radioactivity in nature: natural and artificial radioisotopes, elementary particles, radioactive decay (α, β and γ decay), half-life period, types of nuclear reactions: nuclear fission and nuclear fusion.

Unit 2: Nuclear power generation **Lectures: 5**

Nuclear Power generation from uranium ore (energy production and nuclear waste), introduction to nuclear reactors for energy and nuclear weapons

Unit 3: Applications of radiochemistry **Lectures: 15**

C 14 decay and radioactive dating, irradiation of food, radiotracers for studying chemical reactions (photosynthesis, metabolic studies of drugs, metabolism of organisms, fundamental properties of genetic material), medicinal application of radio chemicals in radiotherapy (use in cancer, hyperthyroidism, blood disorders), radio-pharmaceuticals, diagnostic procedures: CT, PET

Unit 4: Environment radioactivity **Lectures: 7**

Natural radioactivity, natural process that release radioactive material in environment, man-made events like Chernobyl disaster, bomb test, use of radiotracers in environmental studies.

Unit 5: Nuclear pollution and safety management **Lecture: 8**

Radiation protection standards, basics of radiation hazards, international guidelines on radiation protection, disposal of nuclear waste, nuclear disaster and it's managements, Effect of radiation on health: Biological effects of radiation, radiation monitors, dose limits for workers and public,

Practicals: **Credits: 01**

(Laboratory periods: 30)

1. Study the background radiation in different places and identify the probable source. (Data to be provided).
2. Survey the diagnostic procedures involving radio-chemistry in different diagnostic laboratories.
3. Write a report on the radio isotopes used in various diagnostic procedures.
4. Write a report on safety measures taken in diagnostic labs.
5. Write a report on any two nuclear and radiation accidents focusing on their impact on human life, environment and economy.

References:

1. Nuclear and radiochemistry, Konya J., Nagy N. 2nd Edition, Elsevier
2. Radiochemistry and Nuclear Chemistry, 4th Edition, Choppin G., Lilijenzin J-O, Rydberg J., Ekberg C. Elsevier.

Teaching Learning Process:

- Student centered teaching Learning process.
- Blend of conventional blackboard teaching and modern teaching learning tools
- Focus on real life applications of concepts
- Problem solving and quizzes
- Engaging students in collaborative learning.

Assessment Methods:

- Class Tests at Periodic Intervals.

- Written assignment(s)
- Oral assessment, quizzes.
- Semester end University examination.

Keywords: Radioisotopes, Radio-analysis, Radiopharmaceuticals, Nuclear reactor, Nuclear pollution.

Course Code: CHEMISTRY- GE-20

Course Title: Green Chemistry

Total Credits: 04 (Credits: Theory-02, Practical-02)

Total Lectures: Theory- 30, Practical-60

Objectives:

Huge rise in environmental pollution, depleting resources, climate change, ozone depletion, heaps and heaps of landfills piling up has forced the society to become more and more environmentally conscious. Future chemists and innovators are compelled to work towards sustainable practices. Green chemistry has arisen from these concerns. It is not a new branch of chemistry but helps to improve the creative and innovative thinking in undergraduate students. Green chemistry is a way to boost profits, increase productivity and ensure sustainability with absolute zero waste. Innovations and applications of green chemistry in education have helped companies to gain environmental benefits as well as to achieve economic and societal goals also. Undergraduate students are the ultimate scientific community of tomorrow. Training them to practice chemistry in the safest way possible is key towards safe working conditions in the laboratories as well as the chemical industry and extends to society in a sustainable future for the planet.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand the twelve principles of green chemistry and also build the basic understanding of toxicity, hazard and risk related to chemical substances.
- Calculate atom economy, E-factor and relate them in all organic synthesis
- Appreciate the use of catalyst over stoichiometric reagents
- Learn to use green solvents, renewable feedstock and renewable energy sources for carrying out safer chemistry
- Appreciate the use of green chemistry in problem solving skills and critical thinking to innovate and find solutions to environmental problems.
- Learn to design safer processes, chemicals and products through understanding of inherently safer design (ISD)

- Appreciate the success stories and real-world cases as motivation for them to practice green chemistry

Unit 1: Introduction — Lectures:08

Definition of green chemistry and how it is different from conventional chemistry and environmental chemistry.

• Need of green chemistry

• Importance of green chemistry in- daily life, Industries and solving human health problems (four examples each).

• A brief study of Green Chemistry Challenge Awards (Introduction, award categories and study about five last recent awards).

Unit 2: Twelve Principles of Green Chemistry — Lectures: 12

The twelve principles of the Green Chemistry with their explanation, Special emphasis on the following:

• Prevention of waste / byproducts, pollution prevention hierarchy.

• Green metrics to assess greenness of a reaction: environmental impact factor, atom economy and calculation of atom economy.

• Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, solvent less reactions, solvents obtained from renewable sources.

• Catalysis and green chemistry- comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.

• Green energy and sustainability.

• Real-time analysis for pollution prevention.

• Prevention of chemical accidents, designing greener processes, inherent safer design, principle of ISD "What you don't have cannot harm you", greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation

Unit 3: — Lectures: 10

The following Real-world Cases in green chemistry should be discussed: Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments. Designing of environmentally safe marine antifoulant. Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments. An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

Practical: **Credits: 02**

(Laboratory periods: 60)

Characterization by melting point, UV-Visible spectroscopy, IR spectroscopy and any other specific method should be done (wherever applicable).

1. Preparation and characterization of nanoparticles of gold using tea leaves/silver nanoparticles using plant extracts.

2. Preparation of biodiesel from waste cooking oil and characterization (TLC, pH, solubility, combustion test, density, viscosity, gel formation at low temperature and IR can be provided).

3. Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.

4. Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.

5. Mechanochemical solvent free, solid-solid synthesis of azomethine using *p*-toluidine and *o*-vanillin/*p*-vanillin.

6 Microwave-assisted Knoevenagel reaction using anisaldehyde, ethylcyanoacetate and ammonium formate.

7. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

8. Photochemical conversion of dimethyl maleate to dimethyl fumarate (*cis-trans* isomerisation)

9. Benzil- Benzilic acid rearrangement: Preparation of benzilic acid in solid state under solvent-free condition.

References:

Theory:

1. Anastas, P.T., Warner, J.C. (2014), **Green Chemistry, Theory and Practice**, Oxford University Press.
2. Lancaster, M. (2016), **Green Chemistry: An Introductory Text**, 3rd Edition, RSC Publishing.
3. Cann, M. C., Connely, M.E. (2000), **Real-World cases in Green Chemistry, American Chemical Society**, Washington.
4. Matlack, A.S. (2010), **Introduction to Green Chemistry**, 2nd Edition, Boca Raton: CRC Press/Taylor & Francis Group publisher.
5. Alhuwalia, V.K., Kidwai, M.R. (2005), **New Trends in Green chemistry**, Anamalaya Publishers.
6. Sidhwani, I.T, Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.

Practical:

1. Kirchoff, M.; Ryan, M.A. (2002), **Greener approaches to undergraduate chemistry experiment**, American Chemical Society, Washington DC.
2. Sharma, R.K.; Sidhwani, I.T.; Chaudhari, M.K. (2013), **Green Chemistry Experiments: A monograph**, I.K. International Publishing House Pvt Ltd. New Delhi.
3. Pavia, D.L.; Lamponam, G.H.; Kriz, G.S.W. B. (2012), **Introduction to organic Laboratory Technique- A Microscale approach**, 4th Edition, Brooks-Cole Laboratory Series for Organic chemistry.
4. Sidhwani I.T. (2015), Wealth from Waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated. **DU Journal of Undergraduate Research and Innovation**, 1(1),131-151. ISSN: 2395-2334.
5. Sidhwani, I.T; Sharma, R.K. (2020), **An Introductory Text on Green Chemistry**, Wiley India Pvt Ltd.
6. **Monograph on Green Chemistry Laboratory Experiments**, Green Chemistry Task Force Committee, Department of Science and Technology, Government of India.

Teaching Learning Process:

- **Conventional chalk and board teaching**
- Power point presentations
- Interactive sessions on recent green chemistry presidential awards
- Visit a chemical industry and ask the students to think critically for improving the conditions there.
- Screening of documentaries based on chemical accidents/ and then ask them to think about the solutions

Assessment Methods:

- Presentation/assignment by students
- Class Test at Periodic Intervals
- Written Assignment
- Continuous evaluation in practicals
- End Semester University Theory and Practical Exams

Keywords: Green chemistry, Twelve principles of green chemistry, Atom economy, Waste minimization, green metric, green solvents, Solvent free, Catalyst, Bio-catalyst, Renewable energy sources, Hazardous, Renewable feedstock, Ionic liquids, Supercritical fluids, Inherent safer design, green synthesis, combinatorial, Sustainable development, Presidential green chemistry awards.

Course Code: CHEMISTRY- GE-21

Course Title: Chemistry in Indology and Physical & Mental Well Being

Total Credit: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45, Practical-30

Objective: This course is being designed:

- To illuminate the students about the scientific basis and approaches related to the practices that promote physical and mental health/balance, that includes meditation, sports, Yoga and nutrition. The chemical/biochemical mechanisms that underscore the various states of the mind and body, which drives the general homeostasis or anomalies thereof, shall also be illustrated.
- To make students aware about role of metals in ancient and medieval India
- To make students aware of how Alchemists used metals, chemicals, compounds and ores in medicines
- To make students aware of the different types of instruments used in the ancient and medieval India
- To make students aware of the life and work of ancient and medieval scientists/chemists.

Learning Outcome:

By the end of the course, the students will:

- Understand about the scientific basis and approaches that promote physical and mental health.
- Know about the chemical/biochemical mechanisms that underline the states of the mind and body
- Understand the role of metals in ancient and medieval India
- Understand how alchemists used metals and chemical compounds in medicines
- Know about the life and contributions of ancient scientists and chemists

Unit 1: Physical Health Practices **Lectures: 08**

Principles of Physical Education, Body composition with respect to health and fitness and different methods of body composition analysis, Calculation of energy expenditure (at rest and during exercise), VO_2 and calculation of VO_2 max, respiratory exchange ratio, blood pressure, Means of fitness development- aerobic and anaerobic exercises, yoga and physical fitness, Exercises and their intensities related to heart rate zone, Different fitness levels for different age groups and gender, Kinesiology, Physiology of Exercise

Unit 2: Mind-body Practices **Lectures: 10**

States of mind and types of brain waves, mindfulness meditation in clinical psychology and psychiatry, Desbordes' recent studies on brain activities (Harvard's studies), MRI & functional MRI studies.

Types of meditations- focused attention meditation (FA), open monitoring meditation (OM), transcendental meditation (TM), loving–kindness meditation (LKM), mindfulness meditation (MM) and body–mind meditation (B-M).

Biochemical alterations, such as changes in activity/production of hormones, cytokines, chemokines, interferons, etc., oxygen saturation/desaturation, redox-condition and oxidative balance, progression/regression of certain diseases/health conditions, in response to various states of physical and mental well-being.

Unit 3: Nutrition for Mind/body Homeostasis **Lectures: 06**

Role of nutrition in physical and mental health. Nutrients: carbohydrates, Protein, Fat, Vitamins, Minerals, Water-their functions, role of hydration (water balance) during exercise, daily caloric requirement and expenditure.
Metabolism: An overview of ATP release in glycolysis, TCA cycle, electron transport chain. basic concept of balanced diet vs. fad diet (Atkins, ketogenic etc.), Concept of BMI (Body mass index) and BMR (Basal metabolic rate), Obesity and its hazard, Dieting versus exercise for weight control.

Unit 4: Concepts of Atoms, Molecules and Laws of Motion **Lectures: 02**

Concepts of atoms and molecules, properties and categories of atoms and molecules, Laws of motion.

Unit 5: **Metallurgy** **Lectures: 05**

Gold, Silver, Copper, Bronze and other alloys; Copper smelting blast furnace and copper extraction; Tron and Steel; Iron smelting blast furnaces from Southern India; Ironworks in Ancient and medieval India; Delhi Iron Pillar; Dhar and Kodachadri Iron pillars; Wootz steel; Zinc and its extraction.

Unit 6: **Chemicals** **Lectures: 04**

Drugs, dyes, pigments, glass, cosmetics and perfumes, etc.

Unit 7: **Drugs** **Lectures: 05**

Eight categories of Gandhasara; Compounds of mercury (Hg) made and used by the Indian Alchemists for medicinal purposes; Use of chemical, compounds and ores in medicines.

Unit 8: Life and work of Ancient Indian Scientists/Chemists **Lectures:05**

(i) Maharshi Kanada (Ancient text and manuscripts), (ii) Nagarjuna (Ras Ratnakar, Kakshaputtantra, Arogya Manjari, Yog Saar, Yoasthak), (iii) Vaagbhatt (Rasratna Samuchchay), (iv) Govindacharya (Rasarnava), (v) Yashodhar (Ras Prakash Sudhakar), (vi) Ramachandra (Rasendra Chintamani), (vii) Somdev (Rasendra Chudamani)

References:

1. Baer cites Kabat-Zinn, J. (1994): **Wherever you go, there you are: Mindfulness meditation in everyday life.** New York: Hyperion, p.4.
4. Buchholz L (October 2015). "**Exploring the Promise of Mindfulness as Medicine**". JAMA. 314 (13): 1327–1329. doi:10.1001/jama.2015.7023. PMID 26441167.
5. Harrington A, Dunne JD (October 2015). "**When mindfulness is therapy: Ethical qualms, historical perspectives**". The American Psychologist. 70 (7): 621–631. doi:10.1037/a0039460. PMID 26436312.
6. Blanck P, Perleth S, Heidenreich T, Kröger P, Ditzen B, Bents H, Mander J (March 2018). "**Effects of mindfulness exercises as stand-alone intervention on symptoms of anxiety and depression: Systematic review and meta-analysis**". Behaviour Research and Therapy. 102: 25–35. doi:10.1007/s12671-014-0379-y. PMID 29291584.
7. Khoury B, Sharma M, Rush SE, Fournier C (June 2015). "**Mindfulness-based stress reduction for healthy individuals: A meta-analysis**". Journal of Psychosomatic Research. 78 (6): 519–528. doi:10.1016/j.jpsychores.2015.03.009. PMID 25818837.
8. Jain FA, Walsh RN, Eisendrath SJ, Christensen S, Rael Cahn B (2015). "**Critical analysis of the efficacy of meditation therapies for acute and subacute phase treatment of depressive disorders: a systematic review**". Psychosomatics. 56 (2): 140–152. doi:10.1016/j.psym.2014.10.007. PMC 4383597. PMID 25591492.
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11. Hofmann SG, Sawyer AT, Witt AA, Oh D (April 2010). "**The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review**". Journal of Consulting and Clinical Psychology. 78 (2): 169–183. doi:10.1037/a0018555. PMC 2848393. PMID 20350028.
12. Chiesa A, Serretti A (April 2014). "**Are mindfulness-based interventions effective for substance use disorders? A systematic review of the evidence**". Substance Use &

Misuse. 49 (5): 492–512. doi:10.3109/10826084.2013.770027. PMID 23461667. S2CID 34990668.
13. Garland EL, Froeliger B, Howard MO (January 2014). "**Mindfulness training targets neurocognitive mechanisms of addiction at the attention-appraisal emotion interface**". Frontiers in Psychiatry. 4: 173. doi:10.3389/fpsyt.2013.00173. PMC 3887509. PMID 24454293.
14. Sancho M, De Gracia M, Rodríguez RC, Mallorquí-Bagué N, Sánchez-González J, Trujols J, et al. (2018). "**Mindfulness-Based Interventions for the Treatment of Substance and Behavioral Addictions: A Systematic Review**". Frontiers in Psychiatry. 9 (95): 95. doi:10.3389/fpsyt.2018.00095. PMC 5884944. PMID 29651257.
15. Paulus MP (January 2016). "**Neural Basis of Mindfulness Interventions that Moderate the Impact of Stress on the Brain**". Neuropsychopharmacology. 41 (1): 373. doi:10.1038/npp.2015.239. PMC 4677133. PMID 26657952.
16. Dunning DL, Griffiths K, Kuyken W, Crane C, Foulkes L, Parker J, Dalgleish T (March 2019). "**Research Review: The effects of mindfulness-based interventions on cognition and mental health in children and adolescents - a metaanalysis of randomized controlled trials**". Journal of Child Psychology and Psychiatry, and Allied Disciplines. 60 (3): 244–258. doi:10.1111/jcpp.12980. PMC 6546608. PMID 30345511.
17. Sharman, J. R. (1964). **Introduction to physical education**. New York: A.S. Barnes & Co.
18. William, J. F. (1964). **The principles of physical education. Philadelphia**: W.B. Saunders Co
19. Bucher, C. A. (n.d.) **Foundation of physical education.** St. Louis: The C.V. Mosby Co.
20. Sharkey, B. J. (1990). **Physiology of fitness**, Human Kinetics Book
21. Giam, C.K & The, K.C. (1994). **Sport medicine exercise and fitness**. Singapore: P.G. Medical Book.
22. Kenney, W.L., Wilmore, J.H., Costill, D.L. (six edition) **Physiology of sport and exercise.**
23. Vedas: (i) Rig Veda, (ii) Yajur Veda, (iii) Atharva Veda, (iv) Sama Veda
24. Deb, B. M., **The Peacock in Splendour**, Visva Bharti University.
25. Ray, P. C., **A History of Hindu Chemistry: from the Earliest Times to the Middle of the Sixteenth Century A.D.**, Volume 1 – 1902, Volume 2 – 1908, The Bengal Chemical and Pharmaceutical Works Ltd
26. "**History of Chemistry in Ancient and Mideaval India**" (Edited volume of Acharya Ray's "History of Hindu Chemistry"), Indian Chemical Society, Calcutta, 1956.
27. Harsha, N. M., Nagaraja, T. N., **The History of Hindu Chemistry**, Ancient Science of Life, 2010, 30, 58 – 61.
28. Ray, P. C., **Life and experiences of a Bengali chemist,** Two Volume Set. Calcutta: Chuckervertty, Chatterjee & Co. 1932 and 1935.
29. Ray, P. R., **Chemistry in Ancient India**, Journal of Chemical Education, 1948, 25 (6), 327.
30. Seal, B. N.(1915), **The Positive Sciences of the Ancient Hindus**, Longman Greens and Co., Kolkata.

Practicals: **Credits: 01**

(Laboratory periods: 30)

1. Extraction of essential oil from rose petal.
2. Extraction of casein from milk.
3. Determination of pulse rate/blood pressure/oxygen saturation before and after exercise.
4. Determination of acid value of given oil sample.
5. Isolation of piperine from black pepper.
6. Determination of Copper in a brass turnings.
7. Extraction of Butea monosperma (Palash) dye for its use in coloration of cloth.
8. Determination of mass loss in mild steel in acidic/basic media.
9. **Project on (Do any one):**
   Ayurveda as alternate medicine system,
   Homeopathy in India,
   Yogic Practices for mental wellness
   Ancient Chemists of India
   Other titles can also be suggested by the teacher.
10. **Visit to**
    Iron Pillar, the metallurgical marvel and prepare a brief report.
    Industries like Dabur India Ltd.

KEYWORDS: Metallurgy, Mental/Physical well-being, Drugs, Dyes, Yogic Exercises, Alternate Medicines System