Learning Outcomes based Curriculum Framework (LOCF) for (B.Sc. in Chemistry) undergraduate Programme 2021

MANIPUR UNIVERSITY

CANCHIPUR 795003

Course Structure	
Course	***Credits** **Theory + Practical**
I. Core Course (14 Papers)	
(11 Theory papers of 4 credit each ***3 Theory papers of 5 credit each)**	**11×4 = 44** **3 × 5 = 15**
Core Course Practical/Tutorial*	
(11 Practical Papers of 2 credit each ***3 Tutorials of 1 credit each)**	**11×2= 22** **3 × 1 = 3**
II. Elective Course (6 papers)	
(a)Discipline Specific Elective	
(2 Papers of 5 credit each) ***2 Tutorials of 1 credit each)**	**2 × 5 = 10** **2 × 1 = 2**
(b) Generic Elective/Interdisciplinary Course	
(3 Papers of 4 credit each) ***1 Paper of 5 credit)**	**3 × 4 = 12** **1 × 5 = 5**
Generic Elective Practical/Tutorial*	
(3 Practical Papers of 2 credit each ***1 paper tutorial of 1 credit)**	**3 × 2 = 6** **1 × 1 = 1**
III. Ability Enhancement Course (4 papers)	
(a) Ability Enhancement Course	
(2 Papers of 4 credit each) **English for Communications** **Environmental Studies**	**2 × 4 = 8**
(b) Skill Enhancement Course	
(2 Papers of 4 credit each)	**2 × 4 = 8**
IV. Value Addition Course	
(8 papers of 2 credit each)	**2 × 8 = 16**
Total	**152**

Core and DSE courses without practicals will have tutorial and have credit distribution of 5 credits for theory and 1 credit for tutorial, total 6 credits, same as the papers with practical.

Course Structure at a Glance

Core Courses (CC)

Sr. No.	Name of the course	Type of course	L	T	P	Credits
CC 1	Inorganic Chemistry-I	Core course	3	1	0	**4**
	Inorganic Chemistry Laboratory-I	Core course	0	0	2	**2**
CC 2	Organic Chemistry-I	Core course	3	1	0	**4**
	Organic Chemistry Laboratory-I	Core course	0	0	2	**2**
CC 3	Analytical Chemistry	Core course	3	1	0	**4**
	Analytical Chemistry Laboratory	Core course	0	0	2	**2**
CC 4	Physical Chemistry-I	Core course	3	1	0	**4**
	Physical Chemistry Laboratory-I	Core course	0	0	2	**2**
CC 5	Green Chemistry	Core course	3	1	0	**4**
	Green Chemistry Laboratory	Core course	0	0	2	**2**
CC 6	Inorganic Chemistry-II	Core course	3	1	0	**4**
	Inorganic ChemistryLaboratory-II	Core course	0	0	2	**2**
CC 7	Physical Chemistry-II	Core course	3	1	0	**4**
	Physical Chemistry Laboratory-II	Core course	0	0	2	**2**
CC 8	Molecular Spectroscopy & Photochemistry	Core course	5	1	0	**6**
CC 9	Inorganic Chemistry-III	Core course	3	1	0	**4**
	Inorganic Chemistry Laboratory-III	Core course	0	0	2	**2**
CC 10	Organic Chemistry-II	Core course	3	1	0	**4**
	Organic Chemistry Laboratory-II	Core course	0	0	2	**2**
CC 11	Introduction to Quantum Chemistry	Core course	5	1	0	**6**
CC 12	Organic Chemistry-III	Core course	3	1	0	**4**
	Organic Chemistry Laboratory	Core course	0	0	2	**2**
CC 13	Physical Chemistry-III	Core course	3	1	0	**4**
	Physical Chemistry Laboratory-III	Core course	0	0	2	**2**
CC 14	Materials Chemistry	Core course	5	1	0	**6**

CORE COURSES (PASS/HONOURS IN CHEMISTRY) ..... page no

Semester I

Semester II

Semester III

Semester IV

Semester V

**a)* *Generic Electives(GE) are to be taken preferably from Physics and Mathematics disciplines.*

b) *Students can choose minimum of two GE papers from two different disciplines or four papers from one discipline.*

c) *Some Universities in India require atleast two mathematics papers to be studied by the student for admission into M.Sc.(Chemistry).*

VALUE ADDITION COURSES (VAC) (08 papers) (Credit:02 each)

Semester I : CH-VAC-111; CH-VAC-112

Semester II: CH-VAC-123; CH-VAC-124

Semester III: CH-VAC-235

Semester IV: CH-VAC-246

Semester V: CH-VAC-357

Semester VI: CH-VAC-368

To be choosen from the following:

1. Yoga
2. Sports
3. Health Care
4. NCC
5. NSS
6. Ethics
7. Culture.

Structure of B. Sc. Pass/Honours (Chemistry) Programme

Semester	Type	Core	DSE	GEC	AECC	SEC	VAC
	Credits	14×6=84	2×6=12	4×6=24	2×4=8	2×4=8	8×2=16
I		CH-111			CH-AECC-111	CH-SEC-111/112/113	CH-VAC-111
		CH-112					CH-VAC-112
II		CH-120			CH-AECC-112	CH-SEC-121/122/123	CH-VAC-123
		CH-123					CH-VAC-124
III		CH-230		CH-GEC-231/232			CH-VAC-235
		CH-231					
		CH-233					
IV		CH-240		CH-GEC-241/242			CH-VAC-246
		CH-241					
		CH-242					
V		CH-350	CH-DSE-351/352/353/354	CH-GEC-351			CH-VAC-357
		CH-352					
VI		CH-360	CH-DSE-361/362/363/364	CH-GEC-361			CH-VAC-368
		CH-363					

SCHEME FOR CHOICE BASED CREDIT SYSTEM in B.Sc. Pass/Honours (Chemistry)

SEMESTER	COURSE CODE	COURSE NAME	Credits
I	CH-AECC-111	English for Communications	4
	CH-111	Inorganic Chemistry-I	4+2=6
		Inorganic Chemistry-Lab-I	
	CH-112	Organic Chemistry-I	4+2=6
		Organic Chemistry-Lab-I	
	CH-SEC-111/112/113	Skill Enhancement Course	4
	CH-VAC-111	Value Addition Course 1	2
	CH-VAC-112	Value Addition Course 2	2
		Total credits in Semester I	24
II	CH-AECC-112	Environmental Studies	4
	CH-120	Analytical Chemistry	4+2=6
		Analytical Chemistry Laboratory	

	CH-123	Physical Chemistry-I	4+2=6
		Physical Chemistry Laboratory-I	
	CH-SEC-121/122/123	Skill Enhancement Course	4
	CH-VAC-123	Value Addition Course 3	2
	CH-VAC-124	Value Addition Course 4	2
		Total credits in Semester II	24
III	CH-230	Green Chemistry	4+2=6
		Green Chemistry Laboratory	
	CH-231	Inorganic Chemistry-II	4+2=6
		Inorganic Chemistry Laboratory-II	
	CH-233	Physical Chemistry-II	4+2=6
		Physical Chemistry Laboratory-II	
	CH-GEC-231/232	Generic Elective Course	4+2/5+1=6
		Lab/tutorial	
	CH-VAC-235	Value Addition Course 5	2
		Total credits in Semester III	26
IV	CH-240	Molecular Spectroscopy & Photochemistry	5+1=6
	CH-241	Inorganic Chemistry-III	4+2=6
		Inorganic Chemistry Laboratory-III	
	CH-242	Organic Chemistry-II	4+2=6
		Organic Chemistry Laboratory-II	
	CH-GEC-241/242	Generic Elective Course	4+2/5+1=6
		Lab/tutorial	
	CH-VAC-246	Value Addition Course 6	2
		Total credits in Semester IV	26
V	CH-350	Introduction to Quantum Chemistry	5+1=6
	CH-352	Organic Chemistry-III	4+2=6
		Organic Chemistry Laboratory	
	CH-DSE-351/352/353/354	Discipline Specific Elective	4+2/5+1=6
		Lab/tutorial	
	CH-GEC-351	Generic Elective Course	4+2/5+1=6
		Lab/tutorial	
	CH-VAC-357	Value Addition Course 7	2
		Total credits in Semester IV	26
VI	CH-360	Materials Chemistry	5+1=6
	CH-363	Physical Chemistry-III	4+2=6
		Physical Chemistry Laboratory-III	

	CH-DSE-361/362/363/364	**Discipline Specific Elective**	**4+2/5+1=6**
		Lab/tutorial	
	CH-GEC-361	**Generic Elective Course**	**4+2/5+1=6**
		Lab/tutorial	
	CH-VAC-368	**Value Addition Course 8**	**2**
Total credits in Semester IV			**26**
Grand Total Credits			**152**

CORE COURSES

These are 12 courses. All courses are compulsory. These courses have the following credit pattern.

For Theory papers:

L	T	P	Cr
3	1	0	4

For Practical based papers:

L	T	P	Cr
0	0	2	2

SEMESTER -I

Core Course-1: CH-111: Inorganic Chemistry-I

L	T	P	Cr
3	1	0	4

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

Learning objective:

1. Atomic theory and its evolution.
2. Learning scientific theory of atoms, concept of wave function.
3. Elements in periodic table; physical and chemical characteristics, periodicity.
4. To predict the atomic structure, chemical bonding, and molecular geometry based onaccepted models.
5. To understand atomic theory of matter, composition of atom.
6. Identity of given element, relative size, charges of proton, neutron and electrons, andtheir assembly to form different atoms.
7. Defining isotopes, isobar and isotone.
8. Physical and chemical characteristics of elements in various groups and periods according to ionic size, charge, etc. and position in periodic table.
9. Characterize bonding between atoms, molecules, interaction and energetics (ii) hybridization and shapes of atomic, molecular orbitals, bond parameters, bond-distances and energies.

10. Valence bond theory incorporating concepts of hybridization predicting geometry ofmolecules.
11. Importance of hydrogen bonding, metallic bonding.

Self-study:

1. Electronic configuration of various elements in periodic table
2. Predicting structure of molecules
3. How hydrogen bonding, metallic bonding is important in common materials' scientificapplications to material fabrication

UNIT-1 Atomic Structure: (10 classes of 60 minutes each)

Classical approach to understanding the matter and atoms, Rutherford model and its failure, Bhor's model and atomic spectra of atom and quantization of angular momentum, dual nature of electrons., limitations of Bohr's model and atomic spectra of hydrogen atom, de' Broglie equation, Heisenberg's Uncertainty Principle and its significance Schrödinger's wave equation, significance of wave functions, Quantum numbers and their significance, concept of orbit and orbitals. Shapes of *s*, *p*, *d* and *f* orbitals. Probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Electronic configuration, Variation of orbital energy with atomic number.

UNIT-2: Periodicity of Elements: (10 classes of 60 minutes each)

s, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block.
(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
(b) Atomic radii (van'der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy.Applications of ionization enthalpy.
(f) Electron gain enthalpy, trends of electron gain enthalpy.

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

UNIT-3: Chemical Bonding: (14 classes of 60 minutes each)

(i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Madelung constant, Born-Haber cycle and its application, Solvation energy.
(ii) *Covalent bond:* Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing *s*, *p* and *s*, *p*, *d* atomic orbitals, shapes of hybrid orbitals, Bents rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, MO diagrams of simple tri and tetra-atomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, HCHO, (idea of s-p mixing and orbital interaction to be given) NH_3, H_3O^+, SF_4, CIF_3, ICl_2. Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. ionic character from dipole moment and electronegativities difference.

UNIT-4: Metallic bonding and Weak chemical forces: (6 classes of 60 minutes each)

(i) *Metallic Bond:* Qualitative idea of valence bond and band theories, Semiconductors, Insulators, defects in solids.

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

UNIT-5: Oxidation-Reduction reactions: (4 classes of 60 minutes each)

Electronic concept of oxidation number, concept of oxidation-reduction, redox equations, standard electrode potential and its applications to inorganic reactions, principles involved in volumetric analysis to be carried out in the class

Recommended Books/References:

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

CH-111P : INORGANIC CHEMISTRY LABORATORY-1

L	T	P	Cr
0	0	2	2

(A) Titrimetric Analysis

(i) Calibration and use of apparatus.

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

(iii) Use of primary and secondary standard solutions.

(B) Acid-Base Titrations

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

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

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

(C) Oxidation-Reduction Titrimetry

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

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

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

Recommended Books/References:

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

Core course-2: CH-112: OrganicChemistry-I

L	T	P	Cr
3	1	0	4

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

Learning objectives:

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

Self-study:

1. Design and syntheses of organic molecules.
2. Structure identification through IR, NMR and Masss pectroscopic data.
3. Lab/Instrumentation techniques used for analyzing reaction mechanisms.
4. Advanced soft-wares / Models used for predicting stereochemistry / study of energy minimization of organic molecules.

UNIT-1: Basics of Organic Chemistry: (10 classes of 60 minutes each)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric,

Resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes).
Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

UNIT-2: Stereochemistry: (6 classes of 60 minutes each)

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

UNIT-3: Chemistry of Aliphatic Hydrocarbons: (18 classes of 60 minutes each)

A. Carbon-Carbon sigma bonds

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

B. Carbon-Carbon pi-bonds

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff / Anti-Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2- and 1, 4- addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethylbenzene; Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions.

C. Cycloalkanes and Conformational Analysis

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

UNIT-4: Aromatic Hydrocarbons (6 classes of 60 minutes each)

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

Recommended Books / References:

1. Morrison, R.N. and Boyd, R.N.*Organic Chemistry*, 6thEdn., Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).

2. Pine S.H. *Organic Chemistry*, Fifth Edition, McGraw Hill,(2007)
3. F.A.Carey, *Organic Chemistry*, Seventh Edition, Tata McGraw Hill (2008).
4. J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2nd Ed., (2012), Oxford University Press.
5. F. A. Carey, R. J.Sundberg, *Advanced Organic Chemistry, PartA: Structure and mechanism*, Kluwer Academic Publisher, (2000).

CH-112P : ORGANIC CHEMISTRY LABORATORY -I

L	T	P	Cr
0	0	2	2

1. Checking the calibration of the thermometer.

2. Purification of organic compounds by crystallization using the following solvents:

a.Water b. Alcohol c. Alcohol-Water

3. Determination of the melting points of given organic compounds and unknown organic compounds (using Kjeldahl method and electrically heated melting point apparatus).
4. Effect of impurities on the melting point–mixed melting point of two unknown organic compounds.
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than100°C by distillation and capillary method)
6. Chromatography

a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
b. Separation of a mixture of two sugars by ascending paper chromatography

c. Separation of a mixture of *o*- and *p*-nitrophenol or *o*- and *p*-amino phenol by thin layer chromatography(TLC).

Recommended Books/Reference:

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

SEMESTER - II

Core course-3 : CH-120: Analytical Chemistry

L	T	P	Cr
3	1	0	4

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

Learning objective:

1. Familiarization with fundamentals of analytical chemistry.
2. Basics of spectroscopic, thermal, electrochemical techniques
3. Learning basics of separation techniques and its applications.
4. Understanding analytical tools, statistical methods applied to analytical chemistry.
5. Understanding principle of UV-Vis spectroscopy and its applications.
6. Understanding principles of thermo-gravimetric analysis and study of thermal decomposition of materials/characterization of materials.
7. Understanding basics of electro-analytical techniques and its applications.
8. Understanding principles of separation technology and its use in advanced instrumentations.

Self-study:

1. Thermo-gravimetric Analysis of different compounds and application of mathematical models.
2. Study of different kinds of chromatograms; calculation of R_f,
3. Analysis of GC/HPLC data for known materials/compounds.

UNIT-1: Qualitative and quantitative aspects of analysis (4 classes of 60 minutes each)

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

UNIT-2: Spectroscopy (8 classes of 60 minutes each)

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

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

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

UNIT-2: Thermal analysis (6 classes of 60 minutes each)

Theory of thermogravimetry (TG and DTG), instrumentation, estimation of Ca and Mg from their mixture.

UNIT-3: Electroanalytical methods (6 classes of 60 minutes each)

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

UNIT-4: Separation techniques (16 classes of 60 minutes each)

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media.
Chromatography techniques: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development ofchromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis using LC, GLC, TLC and HPLC.

Recommended Books/Reference Books:

1. Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Willard, H.H. *et al.*: *Instrumental Methods of Analysis*, 7th Ed. Wardsworth Publishing California, USA, 1988.
3. Christian, G.D, *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: *Exploring Chemical Analysis*, 9th Ed. New York, W.H. Freeman, 2016.
5. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Saunder

CollegePublications, (1998).
6. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods,* Elles Harwood John Wiley 1979.
7. Ditts, R.V. *Analytical Chemistry; Methods of separation*, Van Nostrand, 1974.
8. Khopkar, S. M., *Basic Concepts of Analytical Chemistry*, New Age (Second edition) 1998
9. Skoog D.A., Holler F.J., Nieman T.A., *Principles of instrumental analysis*, 5th Edn., Brooks &Cole (1997).

CH-120P: ANALYTICAL CHEMISTRY LABORATORY

L	T	P	Cr
0	0	2	2

(Recommended to carry out at least two experiments from each section)

I. Chromatography:

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

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

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

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

II. Solvent Extractions:

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

ii. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

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

III. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt

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

IV. Ion exchange:

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

(ii) Separation of metal ions from their binary mixture.

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

V. Spectrophotometry

(i). Determination of pKa values of indicator using spectrophotometry.
(ii) Structural characterization of compounds by infrared spectroscopy.
(iii) Determination of dissolved oxygen in water.
(iv) Determination of chemical oxygen demand (COD).
(v) Determination of Biological oxygen demand (BOD).
(vi) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

Recommended text books/references:

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

Core Course 4: CH-123: Physical Chemistry – I

L	T	P	Cr
3	1	0	4

Learning Objectives:

1. Familiarization with various states of matter.
2. Physical properties of each state of matter and laws related to describe the states.
3. Calculation of lattice parameters.

4. Electrolytes and electrolytic dissociation, salt hydrolysis and acid-base equilibria.
5. Understanding Kinetic model of gas and its properties.
6. Maxwell distribution, mean-free path, kinetic energies.
7. Behavior of real gases, its deviation from ideal behavior, equation of state, isotherm, and law of corresponding states.
8. Liquid state and its physical properties related to temperature and pressure variation.
9. Properties of liquid as solvent for various household and commercial use.
10. Solids, lattice parameters – its calculation, application of symmetry, solid characteristicsof simple salts.
11. Ionic equilibria – electrolyte, ionization, dissociation.
12. Salt hydrolysis (acid-base hydrolysis) and its application in chemistry.

Self-study:

1. Determination of lattice parameters of given salt.
2. Study of X-Ray diffraction pattern and finding out reference from JCPDI file.
3. Numerical related to salt hydrolysis, ionic equilibria.

UNIT-1: Gaseous State (18 classes of 60 minutes each)

Deviations from ideal gas behavior, compressibility factor and its variation with pressure for different gases. Causes of deviation from ideal behavior. van der Waals equation of state, its derivation and application in explaining real gas behaviour; Berthelot and Dieterici equation; virial equation of state; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states.

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

UNIT-2: Liquid State (6 classes of 60 minutes each)

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

UNIT- 3: Solid State (16 classes of 60 minutes each)

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

UNIT-4: Ionic Equilibria (20 classes of 60 minutes each)

Strong, moderate and weak electrolytes; degree of ionization; factors affecting degree of ionization; ionization constant and ionic product of water. Ionization of weak acids and bases; pH scale; common ion effect; dissociation constants of mono-, di- and tri-protic acids.

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

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

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

Recommended Books:

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

CH-123P: Physical Chemistry Laboratory – I (60 Lab sessions)

L	T	P	Cr
0	0	2	2

1. Surface tension measurements

a) Determine the surface tension by (i) drop number, and (ii) drop weight method.

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

2. Viscosity measurements using Ostwald's viscometer

a) Determination of viscosity of aqueous solutions of (i) polymer, (ii) ethanol, and (iii) sugar at room temperature.
b) Viscosity of sucrose solution with the concentration of solute.

3. pH metry

a) Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
b) Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid, (ii) Ammonium chloride-ammonium hydroxide
c) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
d) Determination of dissociation constant of a weak acid.

Recommended Books:

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

SEMESTER – III

Core course-5: CH-230: Green Chemistry

L	T	P	Cr
3	1	0	4

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

Learning objective:

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

Self-study:

1. Use of green chemistry in designing new laboratory experiments.
2. Use of principle of atom economy and design experiments using the principle.
3. Use of green chemistry in combinatorial chemistry and biomimetic catalyst.

UNIT-1: Introduction to Green Chemistry (4 classes of 60 minutes each)

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

UNIT-2: Principles of Green Chemistry and Designing a Chemical synthesis (12 classes of 60 minutes each)

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on Designing a Green Synthesis using these principles (Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final

products,

Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions).

UNIT-3: Green Synthesis / Reactions: (16 classes of 60 minutes each)

1. Green Synthesis of adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis).
2. Microwave assisted reactions in water: (Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols) and reactions in organic solvents (Diels-Alder reaction and Decarboxylation reaction).
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)
4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents withCO_2 for precision cleaning and dry cleaning of garments.
5. Designing of Environmentally safe marine antifoulant.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid)made from corn.
7. Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification for production of noTrans-Fats and Oil

UNI-4: Future Trends in Green Chemistry (8 classes of 60 minutes each)

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

Recommended Books/References:

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

CH-230P: Green Chemistry Laboratory

L	T	P	Cr
0	0	2	2

(Following is the list of suggestive experiments. However, depending upon available resources, experiments may be added/changes may be incorporated): (six experiments may be conducted)

1. Preparation and characterization of nanoparticles of gold using tea leaves.

2. Preparation of biodiesel from vegetable/ waste cooking oil.

3. Use of molecular model kit to stimulate the reaction to investigate how the atom economyillustrates Green Chemistry.

4. Reactions like addition, elimination, substitution and rearrangement may also be studied forthe calculation of atom economy.

5. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide).

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

7. Mechanochemical solvent free synthesis of azomethines

8.Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II) complex.

9. Photoreduction of benzophenone to benzopinacol in presence of sunlight.

Recommended Books/References:

1. Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press(1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*.American Chemical Society, Washington DC (2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society,Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K. I.K. *Green Chemistry Experiment: Amonograph*, International Publishing ISBN 978-93-81141-55-7 (2013).
5. Cann, M.C. and Connelly, M. E. *Real world cases in Green Chemistry*, American ChemicalSociety (2008).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, Second Edition, 2010.
7. Pavia, D. L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic LaboratoryTechniques: A Microscale and Macro Scale Approach*, W.B.Saunders, 1995

Core Course-6 : CH-231: Inorganic Chemistry-II

L	T	P	Cr
3	1	0	4

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

Learning objective:

1. Oxidation-Reductions and their use in metallurgy.
2. Chemistry of s and p-block elements.
3. Chemistry of noble gases.
4. Inorganic polymers and their use.
5. Understanding redox reactions in hydrometallurgy processes.
6. Structure, bonding of s and p block materials and their oxides/compounds.
7. Understanding chemistry of boron compounds and their structures.
8. Chemistry of noble gases and their compounds; application of VSEPR theory in explaining structure and bonding.
9. Understanding chemistry of inorganic polymers, their structures and uses.

Self-study:

1. Extraction of metals through metallurgical operations and their uses.
2. Bonding of various s and p block elements.
3. Use of boron compounds.
4. Chemistry of inorganic polymers and their uses.

UNIT-1: Acids and Bases (8 lectures of 60 minutes each)

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

UNIT-2: General principle of metallurgy (8 classes of 60 minutes each)

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

UNIT-3: Chemistry of *s* and *p* Block Elements (16 classes of 60 minutes each)

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

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

UNIT-4: Noble Gases (8 classes of 60 minutes each)

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

UNIT-5: Inorganic Polymers (8 classes of 60 minutes each)

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Silicates-Clays and Zeolites, molecular sieves, polyphosphagens, Borazines, and polyphosphazenes, and polysulphates.

Recommended books/references:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry,3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N., Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
4 Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5 Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* Fourth Ed., Pearson, 2010.
7. Atkins, P. W and Shriver D. N. *Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

CH-231P: INORGANIC CHEMISTRY LABORATORY-II

L	T	P	Cr
0	0	2	2

(A) Iodo / Iodimetric Titrations

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

(ii) Estimation of (i) arsenite and (ii) antimony iodimetrically

(iii) Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

(i) Cuprous Chloride, Cu_2Cl_2

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

Recommended books/references:

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

(The above list of experiments are suggestive. Faculty/academic bodies may incorporaterevision/may incorporate text and reference books as per need).

CH-233: Physical Chemistry – II

L	T	P	Cr
3	1	0	4

Learning Objectives:

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

Self-study:

1. Use of thermochemical equations for calculation of energy and related terms.
2. Use of thermodynamics in explaining chemical behavior of solute/solvent and reactions.
3. Study of calorimeter principle and its use.

UNIT-1: Introduction to Thermodynamics (36 classes of 60 minutes each)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. Laws of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

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

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

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

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

UNIT-2: Partial Molar Quantities (8 classes of 60 minutes each)

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

UNIT-3: Chemical Equilibrium (8 classes of 60 minutes each)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in

ideal gases; concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between various equilibrium constants K_p, K_c and K_x. Le Chatelier principle; equilibrium between ideal gases and pure condensed phase.

UNIT- 4: Solutons and Colligative Properties (8 classes of 60 minutes each)

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

Recommended Books:

1. Atkins, P. and De Paula, J. *Physical Chemistry* 10th Ed. (2014).
2. Castellan, G. W. *Physical Chemistry* 4th Ed., Narosa (2004).
3. Engel, T. and Reid, P. *Physical Chemistry* 3rd Ed., Prentice Hall (2012).
4. McQuarrie, D. A. and Simon, J. D. *Molecular Thermodynamics* Viva Books (2004).
5. Roy, B. N. *Fundamentals of Classical and Statistical Thermodynamics* Wiley (2001).
6. Assael, M.J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A.; Will, S. *Commonly Asked Questions in Thermodynamics*. CRC Press (2011).
7. Levine, I. N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
8. Metz, C.R. *2000 solved problems in chemistry*, Schaum Series (2006).

CH-233P: Physical Chemistry – II (60 lab sessions)

L	T	P	Cr
0	0	2	2

1. Thermochemistry

(a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).

(b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.

(c) Calculation of the enthalpy of ionization of ethanoic acid.

(d) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for

different additions of a base. Also calculation of the enthalpy of neutralization of the first step.

(e) Determination of enthalpy of hydration of salt such as copper sulphate.

(f) Study of the solubility of benzoic acid in water and determination of change in enthalpy.

(g) Study of the effect of concentration of solute on elevation of boiling point of water.

2. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

3. Study the equilibrium of at least one of the following reactions by the distribution method:

(a) I_2 (aq) + I $\rightarrow$ I_3^-(aq)

(b) Cu^{2+} (aq) + $n$$NH_3$ $\rightarrow$ $Cu(NH_3)_n$

4. Study the kinetics of the following reactions.

(a) Acid hydrolysis of methyl acetate with hydrochloric acid.

(b) Saponification of ethyl acetate.

5. Adsorption: Verification of Freundlich and Langmuir isotherms for adsorption of acetic acid and selected organic dye(s) on activated charcoal. (Use of calorimeter for calculation of heat of reactions may be demonstrated)

Recommended Books:

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

SEMESTER -IV

Core course-8: CH-240: Molecular Spectroscopy and Photochemistry

L	T	P	Cr
3	1	0	4

Learning objectives:

1. To understand the interaction of electromagnetic radiation with molecules.
2. To understand basic principles of spectroscopy.
3. Franck-Condon principles and electronic transitions.
4. Photochemical reactions.

UNIT-1: (15 classes of 60 minutes each)

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

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

Unit-2: (10 classes of 60 minutes each)

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

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

Unit-3: Photophysical and photochemical processes (15 classes of 60 minutes each)

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

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition (International) 1999
2. Levine I. N., *Physical Chemistry,* Fourth Edition, McGraw-Hill (International), 1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,* UniversityScience Books, 1998
4. Rohatgi-Mukherjee K. K. *Fundamentals of Photochemistry*, New age (revised second edition).
5. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. TataMcGraw-Hill: New Delhi (2006).

Course Course-9: CH-241: INORGANIC CHEMISTRY-III

L	T	P	Cr
3	1	0	4

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

Learning objective:

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

Self-study:

1. IUPAC nomenclature of coordination compounds/complexes.

2. Prediction of structure of complexes using various theories; color and magnetic properties of different complexes.
3. Use of lanthanide/actinide compounds in industries.
4. Toxicity of various metals and mechanism of metal-biological system interactions.

UNIT-1: Coordination Chemistry (10 classes of 60 minutes each)

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

UNIT-2: Transition Elements (10 classes of 60 minutes each)

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

UNIT-3: Lanthanides and Actinides (10 classes of 60 minutes each)

Electronic configuration, oxidation states, color, spectra and magnetic behavior, lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT-4: Bioinorganic Chemistry (10 classes of 60 minutes each)

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

Recommended text books/References:

1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.

2. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company1994.
4. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
5. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
6. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

CH-241P: INORGANIC CHEMISTRY LABORATORY- III

L	T	P	Cr
0	0	2	2

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

Carbonate, nitrate, nitrite, sulphide, sulphate, sulphite, acetate, fluoride, chloride, bromide, iodide, borate, oxalate, phosphate, ammonium, potassium, lead, copper, cadmium, bismuth, tin, iron, aluminum, chromium, zinc, manganese, cobalt, nickel, barium strontium, calcium, magnesium. Mixtures containing one interfering anion, or insoluble component ($BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-,Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot analysis/tests should be done whenever possible.

2. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamicfactors.

3. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. (Also find the λ_{max} of the preparedcomplex using instrument).

4. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentateligands like acetylacetone, DMG, glycine) by substitution method.

5. Preparation of any two of the following complexes and measurement of their conductivitymeasurement:

- tetraamminecarbonatocobalt (III) nitrate
- tetraamminecopper (II) sulphate
- potassium trioxalatoferrate (III) trihydrate

Recommended books/reference books

1. *Synthesis of organometallic compounds: A practical guide*, S. Komiya, Wiley.
2. A.I. Vogel: *Qualitative Inorganic Analysis*, Prentice Hall, 7th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook ofPractical Organic Chemistry*, Prentice-Hall,
4. Vogel's *Qualitative Inorganic Analysis*, Revised by G. Svehla. Pearson Education, 2002.

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Core course-10 : CH-242: Organic Chemistry-II

L	T	P	Cr
3	1	0	4

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

Learning objective:

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

Self-study:

1. Elucidating reaction mechanisms for organic reactions.
2. Organometallic compounds and their uses.
3. Use of active methylene groups in organic mechanism and preparation of new organiccompounds.

UNIT-1: Chemistry of Halogenated Hydrocarbons (8 classes of 60 minutes each)

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

Aryl halides: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.
Relative reactivity of alkyl, allyl / benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg and Li and their use in synthesis.

UNIT-2: Alcohols, Phenols, Ethers and Epoxides (6 classes of 60 minutes each)

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.
Phenols: Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism.
Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

UNIT-3: Carbonyl Compounds (10 classes of 60 minutes each)

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC); Addition reactions of unsaturated carbonyl compounds: Michael addition; Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications ofdiethyl malonate and ethyl acetoacetate.

UNIT-4: Carboxylic Acids and their Derivatives (10 classes of 60 minutes each)
Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions ofdicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric,citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, estersand amides; Comparative study of nucleophilic substitution at acyl group - Mechanism of acidicand alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions,Hofmann bromamide degradation and Curtius rearrangement.

UNIT-5: Sulphur containing compounds (6 classes of 60 minutes duration each)

Preparation and reactions of thiols, thioethers and sulphonic acids.

Recommended Books/references:

1. Solomons, T.W G., Fryhle, B. Craig. *Organic Chemistry*, John Wiley & Sons, Inc (2009).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, Seventh edition Cengage Learning, 2013.
3. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), OrientLongman, New Delhi.
4. Morrison R. T. and Boyd R. N. *Organic Chemistry*, Sixth Edition Prentice Hall India, 2003.

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CH-242P: Organic Chemistry Laboratory-II

L	T	P	Cr
0	0	2	2

(List of experiments given are suggestive. One experiment from each group to be demonstrated)

1. Identification of elements (N, S, and halogen) and Functional group tests for alcohols, phenols,carbonyl, carboxylic acid and amine group of compounds.

2. Organic preparations:

i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method: (Using conventional method and Using green chemistry approach)

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

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination (any one)

a. Acetanilide by conventional methods

b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration: (any one)

a. Acetanilide / nitrobenzene by conventional method

b. Salicylic acid by green approach (using ceric ammonium nitrate).

vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.

vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.

x. *S*-Benzylisothiouronium salt of one each of water soluble/ insoluble acids (benzoic acid,oxalic acid, phenyl acetic acid and phthalic acid).

xi. Aldol condensation with either conventional or green method.

xii. Benzil-Benzilic acid rearrangement.

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

Recommended Books/References:

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

SEMESTER-V

Core Course-11: CH-350: Introduction to Quantum Chemistry

L	T	P	Cr
3	1	0	4

UNIT-1: (15 classes of 60 minutes each)

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

UNIT-2: (15 classes of 60 minutes each)

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

UNIT-3: (10 classes of 60 minutes each)

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

Recommended books/References:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition (International)1999
2. Levine I. N., *Physical Chemistry,* Fourth Edition), McGraw-Hill (International), 1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach,*

University Science Books, 1998.

4. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
5. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).

Core course-12 : CH-352: Organic Chemistry-III

L	T	P	Cr
3	1	0	4

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

Learning objective:

1. Nitrogen containing functional groups and their reactions.
2. Familiarization with polynuclear hydrocarbons and their reactions.
3. Heterocyclic compounds and their reactions.
4. Alkaloids and Terpenes
5. Understanding reactions and reaction mechanism of nitrogen containing functional groups.
6. Understanding the reactions and mechanisms of diazonium compounds.
7. Understanding the structure and their mechanism of reactions of selected polynuclearhydrocarbons.
8. Understanding the structure, mechanism of reactions of selected heterocyclic compounds.
9. Classification, structure, mechanism of reactions of few selected alkaloids and terpenes.

Self-study:

1. Use of benzene diazonium salt in organic synthesis.
2. Applications of heterocyclic compounds in pharmaceutics/drugs and the mechanism ofactions.
3. Pharmaceutics / Biomedical applications of alkaloids and terpenes.
4. Nitrogen containing organic compounds / heterocyclic compounds in synthetic chemistry.

UNIT-1: Nitrogen Containing Functional Groups (8 classes of 60 minutes each).

Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation,

Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium salts: Preparation and synthetic applications.

UNIT-2: Polynuclear Hydrocarbons (8 classes of 60 minutes each)

Reactions of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene; Polynuclear hydrocarbons.

UNIT-3: Heterocyclic Compounds (12 classes of 60 minutes each)

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

UNIT-4: Alkaloids (6 classes of 60 minutes each)

Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

UNIT-5: Terpenes (6 classes of 60 minutes each)

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

Recommended Text Books/references:

1. Morrison, R. T., Boyd, R. N., Bhatterjee, S.K., Organic Chemistry, 7th Edn., Pearson.
2. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* John Welly & Sons(1976).
3. Solomons, T.W., Fryhle Craig, *Organic Chemistry,* John Wiley & Sons, Inc (2009).
4. McMurry, J.E. *Fundamentals of Organic Chemistry,* 7th Ed. Cengage Learning India Edition,2013.
5. Kalsi, P. S. *Organic reacations and their mechanisms,* New Age Science (2010).
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University

PressInc., New York (2001).

7. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry,* Prajati Parakashan (2010).
8. Bansal R. K. *Heterocyclic Chemistry: Syntheses, Reactions and Mechanisms*, New Age, ThirdEdition (1999).
9. Clayden J., Greeves N., Warren S., *Organic Chemistry*, (2nd Ed)., (2012), Oxford UniversityPress.

CH-352P: Organic Chemistry Laboratory-III

L	T	P	Cr
0	0	2	2

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, amines and amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols, etc.
2. Identification of functional groups of simple organic compounds by IR spectroscopy and NMR spectroscopy (IR and NMR of simple organic compounds may be done wherever facilities are available, otherwise sample spectra may be provided for simple organic compounds like Ethanol, Aniline, Phenol, acetic acid, other simple aldehydes, carboxylic acid, etc., for identification of functional groups. References from standard spectroscopy books may also be taken for such purpose for enhancing students understanding and skill).
3. Preparation of methyl orange.

4. Extraction of caffeine from tea leaves.

5. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars using simple lab procedures.

Recommended Books/References:

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

SEMESTER- VI

Core Course-13: CH-360: Materials Chemistry

L	T	P	Cr
3	1	0	4

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

Learning objective:

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

Self-study:

1. Hybrid materials/functionalized hybrid materials and their applications in industry.
2. Applications of nano-structured materials in targeted drug delivery/pharmaceutical applications/industrial applications.
3. Use of composites in industry.

UNIT-1: Basics of crystalline solids (8 classes of 60 minutes each)

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

UNIT-2: Silica based materials (8 classes of 60 minutes each)

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

UNIT-3: Inorganic solids/ionic liquids of technological importance (8 classes of 60 minutes each)

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

UNIT-4: Nanomaterials (8 classes of 60 minutes each)

Overview of nanostructures and nano-materials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nano-architecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

UNIT-5: Composite materials (8 classes of 60 minutes each)

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

Recommend books/References:

1. Atkins P, Overton T., Rourke J. Weller M. and Armstrong F Shriver and Atkins. *InorganicChemistry* Oxford University Press, Fifth Edition, 2012.
2. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structural chemistry*. John Wiley,1974.
3. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley 2003.
4. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning, 2002.

Core Course 14: CH-363: Physical Chemistry – III (60 lectures)

L	T	P	Cr
3	1	0	4

Learning Objectives:

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

Self-study:

1. Application of phase diagram.
2. Study of reaction kinetics, Fast reactions.
3. Heterogeneous catalysis used in industry and its mechanism of action.
4. Application of adsorption isotherms in metal adsorption, significance.

UNIT-1: Phase Equilibria (28 classes of 60 minutes each)

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

UNIT-2: Chemical Kinetics (18 classes of 60 minutes each)

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated rate laws for first, second and fractional order reactions, pseudounimolecular reactions,

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

UNIT-3: Catalysis (8 classes of 60 minutes each)

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

UNIT-4: Surface Chemistry (6 classes of 60 minutes each)

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

Recommended Books:

1. Atkins P. W. and De Paula J., *Physical Chemistry*, 10th Ed. Oxford University Press (2014).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books (2004).
4. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed., Prentice-Hall (2012).
5. Zundhal, S.S. *Chemistry Concepts and Applications* Cengage India (2011).
6. Ball, D. W. *Physical Chemistry* Cengage India (2012).
7. Mortimer, R. G. *Physical Chemistry* 3rd Ed., Elsevier (2009).
8. Levine, I. N. *Physical Chemistry* 6th Ed., Tata McGraw-Hill (2011).
9. Metz, C. R. *Physical Chemistry* 2nd Ed., Tata McGraw-Hill (2009).

CH-363P: Physical Chemistry – III (60 lab sessions)

L	T	P	Cr
0	0	2	2

Conductometry

1 Determination of cell constant

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

3 Conductometric titrations of: (i) strong acid versus strong base, (ii) weak acid versus strong base, (iii) mixture of strong acids, (iv) weak acid versus strong base, (v) strong acid versus weak base.

Potentiometry

Potentiometric titrations of: (i) Strong acid versus strong base (ii) Weak acid versus strong base (iii) Dibasic acid versus strong base (iv) Potassium dichromate versus Mohr's salt.

Recommend Books:

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

(List of experiments and references are suggestive. However, more experiments can be added/list of experiments can be revised as per available facilities).

DISCIPLINE SPECIFIC ELECTIVE COURSES

These courses have the following credit pattern.For Theory based courses:

L	T	P	Cr
3	1	0	3

For laboratory based courses:

L	T	P	Cr
0	0	2	2

SEMESTER - V

CH-DSE -351: Medicinal Chemistry

L	T	P	Cr
3	**1**	**2**	**6**

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

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

UNIT-1: Bio-physicochemical properties

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

UNIT-2: Structural properties

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

UNIT-3: Drug target understanding

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

UNIT-4: Medicinal Chemistry of Therapeutic Agent

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

UNIT-5: Steroids, Prostaglandins, Enzyme, Hormone and Vitamins

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

UNIT-6: Concept of rational drug design

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

Recommended books/References:

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

Practical wok suggested:

1. Purification Techniques of Solvents by Fractional Distillation and Vacuum Distillation

2. Thin Layer Chromatography Technique and Purification of commercially available drugs/Synthesized Compounds by Column Chromatography.

3. Preparation of Acid/Basic Salts of Drugs and Evaluation of their Physicochemical Properties.(Benzilic Acid & Sodium Benzoate)

4. Synthesis & Purification of following Compounds using:

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

Suggsted books/references:

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

(The list of experiments and books are purely suggestive; University/institute may incorporate further changes in number of experiments and books/refererences (updated version from time to time) based on course design and available infrastructure facilities).

CH-DSE 352: Electro Chemistry

L	T	P	Cr
3	1	2	6

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

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

UNIT-1:

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

UNIT-2:

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb2O3 electrodes. Concentration cells with andwithout transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

UNIT-3: Electroanalytical methods: Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

UNIT-4: Electrical & Magnetic Properties of Atoms and Molecules: Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation, Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and their measurements. Diamagnetism, paramagnetism, magnetic susceptibility and its measurement, molecular interpretation.

Recommended books/reference books

1. Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press (2014).2.Castellan, G. W. *Physical Chemistry* 4th Ed., Narosa (2004).
2. Mortimer, R. G. *Physical Chemistry* 3rd Ed., Elsevier: NOIDA, UP (2009).
3. Barrow, G. M., *Physical Chemistry* 5th Ed., Tata McGraw Hill: New Delhi (2006).
4. Engel, T. & Reid, P. *Physical Chemistry* 3rd Ed., Prentice-Hall (2012).
5. Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).
6. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry* 4th Ed., John Wiley &Sons, Inc. (2005).

List of suggested laboratory experiments

1. Determination of pH of a given solution using glass electrode.
2. Determination of cell constant.
3. Determination of equivalent conductance, degree of dissociation, and dissociation constant ofweak acid.
3. Conductometric titration : strong acid *vs*. strong base, weak acid *vs*. strong base.
4. Potentiometric titration : strong acid *vs*. strong base, weak acid *vs*. strong base, potassiumdichromate vs. mohr's salt.

Recommended books/reference books:

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

CH-DSE 353: Organic Spectroscopy and Applications

L	T	P	Cr
3	1	2	6

UNIT-1: Basic Principles of UV Spectroscopy

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

UNIT-2: Basic principles of IR Spectroscopy

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

UNIT-3: NMR (^{1}H and ^{13}C NMR) Spectroscopy

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

UNIT-4: Basic principles of Mass Spectroscopy

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

Recommended Books/References:

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

Suggested laboratory experiments

1. Purification method for liquid, solid organic substance (distillation, recrystallization, chromatorgrapy)
2. Analysis of spectra of UV-Vis, FTIR, NMR and Mass of simple organic compounds. (students may encourage to prepare simple organic compounds following given protocol (azodyes, acetanilides, benzoic acid, etc.) (or may use commercially available organic componds) and can be trained to identify/analyze important peaks/functionality, determine mass of the molecules (mass-spectra). They can submit a report regarding their analysis to course teacher.

CH-DSE 354: Nuclear and Radiation Chemistry

L	T	P	Cr
3	1	2	6

UNIT-1: Nucleus and its classification, nuclear forces, nuclear stability, binding energy, nuclear models. Radioactive decay (Radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, half life, mean life period), units of radioactivity, Transient and secular equilibria, Carbon dating and its usefulness.
Nuclear reactions: Bethe notation, types of nuclear reactions (n, p, α, d and γ), conservation of quantities (mass-energy and linear momentum) in nuclear reactions, reaction cross-section, compound nucleus theory and nuclear reactions. Nuclear fission: the process, fragments, mass distribution, and fission energy.

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

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

UNIT-4: Nuclear pollution and Radiological safety: Interaction of radiation with matter, Radiolysis of water, Radiation dosimetry. Radioactive isotopes and their applications, Isotopic dilution analysis, Neutron activation analysis, diposal of nuclear waste, nuclear disaster and its management (nuclear accidents and holocaust – discussion about case studies).

Recommended Books/references:

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

Suggested laboratory practicals:

1. The safe laboratory use of radionuclide and radioisotopes
2. Demonstration of activity on Geiger-Muller and scintillation based counter.
3. Liquid scintillation counting, alpha spectrometry, gamma spectrometry – to identify and quantify radioisotopes
4. Occurrence of radon daughter particles in environmental samples.
5. Liquid-liquid separation/extraction of radio nuclide from environmental samples/water samples.
6. Isotopic application in removal process adsorption / ion exchange.

(The above list is just suggestive. More experiments can be added/incorporated based on facility/expertise available. Since above experiments require certified labs which may not be available at all places, therefore, it is advised that institute/university/teacher may arrange/allow academic visit of students to nuclear chemistry labs in the country following proper procedure and to prepare comprehensive report of the visit/viva voce of students which can also form a lab course until available facilities are available).

SEMESTER-VI

CH-DSE 361: Heterocyclic Chemistry

L	T	P	Cr
3	1	2	6

UNIT-1: Three-membered rings with one heteroatom: Chemistry of oxiranes, aziridines andepisulphides - synthetic approaches and reactivities.

UNIT-2: Three-membered heterocycles with two heteroatoms: oxaziranes, diaziridines and diazirines - synthetic approaches and reactivities.

UNIT-3: Four-membered heterocycles: oxitanes, azatidanes and thietanes - synthetic approaches and reactivities. natural products: Synthesis of Peniciline and cephalosporine.

UNIT-4: Five-membered aromatic heterocycles:

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

UNIT-5: Condensed five-membered Heterocycles:

Benzofuran, indoles and benzothiazoles - general synthetic approaches, with greater emphasis on the chemistry of Indoles.

Recommended Books/references:

1. J.A. Joule, K. Mills, *Heterocyclic Chemistry*, Wiley, 2010.
2. A. R. Parikh, H. Parikh, R. Khunt, *The Essence of heterocyclic Chemistry*, New Age Int.Publication,
3. L. A. Paquette, W. A. Benjamin, *Principles of Modern Heterocyclic Chemistry*, New York, 1968.
4. J.A. Joule and G. F. Smith, *Heterocyclic Chemistry*, Van Nostrand, London, 1978.

5. *Comprehensive Heterocyclic Chemistry. The structure, reactions, synthesis and use of Heterocyclic compounds*, (Ed. A.R. Katritzky and C. W. Rees),. Vol 1-8, Pergamon Press, 1984.
6. A. R. Katritzky, *Handbook of Heterocyclic Chemistry*, Pergamon Press, 1985.
7. Van der plas, H. C. *Ring transformations of Heterocycles, Vols 1 and 2*, Academic Press, 1974.

List of suggested laboratory experiments

1. Identification of hetero atoms (S, N, X) in given organic compounds in lab.

2. Identification/separation of simple organic compounds containing hetero atoms using column chromatorgapy/TLC) in lab.
3. Spectroscopic identification of simple organic compounds (spectra may be provided to the students and teachers may help the students to identify the compounds using spectra). Melting point/boiling point of the compounds may be checked for its purity.
4. Teacher may guide the students for preparation of : Indigo (using aldol condensation reaction of 2-nitrobenzaldehyde with acetone in basic condition);

(Depending upon laboratory facilities, more preparation of heterocyclic group of compoundsmay be incorporated by teacher).

CH-DSE 362: Organometallic and Bioinorganic Chemistry

L	T	P	Cr
3	1	2	6

UNIT-1: Chemistry of 3d metals: Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$.

UNIT-2: Organometallic Compounds

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and

binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

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

UNIT-3: Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignardreagent and their structures, Schlenk equilibrium.

UNIT-4: Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

UNIT-5: Bioinorganic chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

Recommended books/reference books

1. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company1994.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
3. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY,1967.
4. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997

List of Laboratory experiments

(Necessary infrastructure may be developed and adequate precaution should be maintained to conduct such experiments; instructor may demonstate the experiment to students).

1. Reaction of metal with halide – preparation of Grignard reagent. (only demonstration purpose)
2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline) (only demonstration purpose)
3. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.

CH-DSE: 363: Introduction to Nanochemistry and Applications

L	T	P	Cr
3	1	2	6

UNIT-1: Introduction to nanoscience, nanostructure and nanotechnology (basic idea), Overview of nanostructures and nano-materials, classification, (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot); Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

UNIT-2: Size dependent properties of nanomaterials (basic idea with few examples only): Quantum confinement, Electrical, Optical (Surface Plasmon resonance), variation in colors (Blueshift & Red shift), Magnetic, thermal and catalytic properties.

UNIT-3: Synthesis of Nanomaterials: Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis, Solvothermal process, Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-controlof nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires.

UNIT-4: Material characterization techniques (basic idea of use of following instruments in nanomaterial characterization need to be emphasized): Electron microscopic technique, diffraction technique, photoelectron spectroscopy, zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed).

Recommended Books/References books:

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

List of Laboratory Experiments suggested:

1. Synthesis of ZnO nanoparticles.
2. Preparation of Silver nanoparticles. (Diverse nanoparticles can be prepared by various routes).
3. Verification of Beer-Lambert law using nano-particles (above prepared nano-particles may be used for the study).

(Depending upon the availability of infrastructure facilities, instructor may encourage the students to prepare bimetallic nano-particles, etc. and characterized them, study their various properties like magnetism, adsorption, etc.)

CH-DSE 364: Biochemistry

L	T	P	Cr
3	1	2	6

UNIT-1: Carbohydrates (8 classes of 60 minutes each)

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

UNIT-2: Proteins: (8 classes of 60 minutes each)

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

UNIT-3: Enzymes (8 classes of 60 minutes each)

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

UNIT-4: Lipids (8 classes of 60 minutes each)

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

UNIT-5: Structure of DNA/RNA (8 classes of 60 minutes each)

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

Recommended Books/References:

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

(The above course structure/number of classes are suggestive. Faculty/academic bodies may incorporate revision/may incorporate text and reference books as per need).

Suggested Practical in Biochemistry

1. Quantitative estimation of protein using Lowry's method. Determine the concentration of the unknown sample.
2. Action of salivary amylase at optimum conditions

3. Effect of pH on the action of salivary amylase

4. Effect of temperature on salivary amylase

5. Effect of inhibitor on salivary amylase
6. Study of the activity of Trypsin using fresh tissue extracts.
7. Effect of temperature, organic solvents, on semi-permeable membrane.

8. Isolation of Genomic DNA from E Coli

(The above course structure/number of classes are suggestive. Faculty/academic bodies may incorporate revision/may incorporate text and reference books as per need).

GENERIC ELECTIVE COURSES

Generic elective courses are both theory and practical based. Both Honours and Pass students can chose the course as outlined in the pattern of modeled credit distribution. Some of the courses are based largely on practical. These courses shall have the following credit pattern.

SEMESTER-III

CH-GEC-231: Maths-I: Mathematical Methods in Chemistry

L	T	P	Cr
3	1	2	6

UNIT-1: Fundamentals of mathematics (10 classes of 60 minutes each)

Mathematical functions, polynomial expressions, logarithms, exponential function, units of a measurement, inter-conversion of units, constants and variables, equation of a straight line, plotting graphs, data representation, pi-charts, histogram.

Uncertainty in experimental techniques: Displaying uncertainties and measurements in chemistry,decimal places, significant figures, combining quantities.

Uncertainties in measurement: types of uncertainties, combining uncertainties. Use of statistical tools, Data reduction and the propagation of errors, binomial, Poisson and Gaussian distributions, Graphical and numerical data reduction. Numerical curve fitting: the method of least squares (regression).

Algebraic operations on real scalar variables, Roots of quadratic equations analytically and iteratively, Numerical methods of finding roots (Newton-Raphson, binary –bisection).

UNIT-2: Mathematical series (10 classes of 60 minutes each)

Power series, Maclaurin, Taylor series, convergence (e.g. pressure virial equation of state, colligative properties). Pythagoras theorem in three dimensions. Trigonometric functions, identities.

UNIT-3: Differential calculus (10 classes of 60 minutes each)

The tangent line and the derivative of a function, numerical differentiation, differentials of higher order derivatives, discontinuities, stationary points, maximum-minimum problems, inflexionpoints, limiting values of functions: L'Hopital's rule, combining limits.

Calculus of several variables*:* Functions, change of variables, total differential, chain rule, partial differentiation, Euler's theorem, exact and inexact differentials (applications tin the domains of thermodynamics, surface chemistry), line/surface-integrals.

UNIT-4: Integral calculus (10 classes of 60 minutes each)

Integration, odd-even functions, indefinite integrals, standard integrals, methods of integration (by parts, substitution, partial fractions and others. Examples from kinetics, thermodynamics, nuclear chemistry and surface chemistry, numerical integration (Trapezoidal and Simpson rules, e.g. entropy/enthalpy change from heat capacity data), probability distributions and mean values.Tri-gonometric functions (applications in chemistry need to be emphasized throughout)

Recommended Books/References:

1. Chemical Maths Book, E. Steriner, Oxford University Press (1996).
2. Maths for Chemists, Vols 1 and 2 M. C. R. Cockett and G. Dogget, Royal Society of Chemistry, Cambridge (2003).

(The above course structure, number of classes and recommended books/references aresuggestive. Faculty/academic bodies may incorporate revision as per need).

(PRACTICALS/COMPUTATIONAL TOOL WORKS NEED TO BE DESIGNED BY FACUTLIES BASED ON THE AVAILABLE FACILITIES)

CH-GEC-232: Life Science/Biology-I

L	T	P	Cr
3	1	2	6

UNIT-1: Cell and Cellular Processes (24 classes of 60 minutes each)

The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components

Cell Organelles

Mitochondria: Structure, marker enzymes, composition; mitochondrial biogenesis; Semiautonomous organelle; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA

Chloroplast: Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA

ER, Golgi body & Lysosomes: Structures and roles. Signal peptide hypothesis, N-linked glycosylation, Role of golgi in O-linked glycosylation. Cell secretion, Lysosome formation.

Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants andbiogenesis.

UNIT-2: Nucleus (10 classes of 60 minutes each)

Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome

Recommended books/References:

1. Campbell, N.A. and Reece, J. B. *Biology* (Eighth edition) Pearson Benjamin Cummings, SanFrancisco, (2008).
2. Raven, P.H *et al Biology*, Seventh edition Tata McGraw Hill, New Delhi (2006).
3. Sheeler, P and Bianchi, D.E. *Cell and Molecular Biology* (Third edition) John Wiley (2006).

(The above course structure, number of classes and recommended books/references are suggestive. Faculty/academic bodies may incorporate revision as per need).

Tutorials/practical for Biology (preferably any six from the following list)

1. Study of prokaryotic cells (bacteria), viruses, eukaryotic cells using microscope.

2. Study of the photomicrographs of cell organelles

3. To study the structure of plant cell through temporary mounts.

4. To study the structure of animal cells by temporary mounts-squamous epithelial cell and nervecell.
5. Preparation of temporary mounts of striated muscle fiber
6. To prepare temporary stained preparation of mitochondria from striated muscle cells/ cheekepithelial cells using vital stain Janus green.
7. To prepare temporary stained squash from root tips of *Allium cepa* and to study the variousstages of mitosis.
8. Study the effect of temperature, organic solvent on semi permeable membrane.
9. Demonstration of dialysis of starch and simple sugar.
10. Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.
11. Measure the cell size (either length or breadth/diameter) by micrometry.
12. Study the structure of nuclear pore complex by photograph (from Gerald Karp).

SEMESTER-IV

CH-GEC-241: Life Science/Biology-II

L	T	P	Cr
3	1	2	6

UNIT-1: Functions of membranes (8 classes of 60 minutes each)

The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of themembranes; Selective permeability of the membranes; Cell wall

UNIT-2: Cell Cycle (10 classes of 60 minutes each)

Role of Cell division; Overview of Cell cycle; Molecular controls; Meiosis Interphase, Mitosisand Meiosis.

UNIT-3: Instrumentation techniques (15 classes 60 minutes each)

Principles of microscopy; Light Microscope; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Introduction to Electron microscopy (EM)- Scanning EM and sample analysis with examples.

Recommended books/References:

1. Campbell, N.A. and Reece, J. B. *Biology* (Eighth edition) Pearson Benjamin Cummings, SanFrancisco, (2008).
2. Raven, P.H *et al Biology*, Seventh edition Tata McGraw Hill, New Delhi (2006).
3. Sheeler, P and Bianchi, D.E. *Cell and Molecular Biology* (Third edition) John Wiley (2006).

(The above course structure, number of classes and recommended books/references are suggestive. Faculty/academic bodies may incorporate revision as per need).

CH-GEC-242: Physics-I

L	T	P	Cr
3	1	2	6

UNIT-1: Mathematical Physics (8 classes of 60 minutes each)

Scalar and vector products, polar and axial vectors, triple and quadruple products.

Vector calculus:

Scalar and vector fields, differentiation of a vector, gradient, divergence, curl and O operations and their meaning, idea of line, surface and volume integrals, Gauss and Stokes' theorem.

UNIT-2: Classical Mechanics (18 classes of 60 minutes each)

Particle dynamics: Newton's laws of motion, conservation of linear momentum, center of mass, conservative forces, work energy theorem, particle collision.
Rotational kinematics and dynamics: Rotational motion, forces and pseudo forces, torque and angular momentum, kinetic energy of rotation, rigid body rotation dynamics, moment of inertia, conservation of angular momentum, comparison of linear and angular momentum, motion of a top.
Oscillations: Linearity and superposition principle, free oscillation with one and two degrees of freedom, simple pendulum, combination of two simple harmonic motions. Lissajous figures, free and damped vibrations, forced vibrations and resonance, Q factor; wave equation, travelling and standing waves, superposition of waves, phase and group velocity.

UNIT-3: Wave optics (14 classes of 60 minutes each)

Interference, division of amplitudes, Young's double split, Fresnel's biprism, interference in thin films and wedged shaped films. Fresnel diffraction: Diffraction at a single slit and a circular aperture, diffraction at a double split, plane transmission grating, resolving power of a telescope and a microscope, resolving and dispersive power of a plane diffraction grating. Polarization: Polarization by reflection and refraction, Brewster's law, double refraction, nicol prism, quarter and half-wave plates, Production and analysis of circularly and elliptically polarized light.

Recommended Text books/references:

1. Spiegel, M. R. *Vector Analysis* Schaum Outline Series. McGraw-Hill (1974)

2. Beiser, A. *Concepts of Modern Physics* McGraw-Hill (2002).

3. Resnick, R., Halliday, D. and Krane, K. S. Physics I and II Fifth Ed. John Wiley (2004)

4. Serway, R. A. & Jewett, J. W. *Physics for Scientists and Engineers* Sixth Ed.

(The above course structure, number of classes and recommended books/references are suggestive. Faculty/academic bodies may incorporate revision as per need).

Physics-I– Practicals

(Recommended that physics practical to be carried out from mechanics and optics as per availability of facilities with minimum 3 experiments from each group)

Group-A: Mechanics

1. Determination of spring constant of a spring by (i) static, and (ii) dynamic methods.
2. Study of damped harmonic oscillator- Q factor.
3. Determination of temperature coefficient of resistance using platinum resistance thermometer.
4. Study of thermal couple calibration and inversion temperature.
5. LCR study of resonance Q-factor.
6. Kator's pendulum- Bar pendulum.

Group-B:Optics

7. Determination of wavelength of light by Fresnel's biprism.
8. Determination of wavelength of sodium light by Newton's arrangement.
9. Determination of refractive index of tint glass using a spectrometer.
10. Determination of dispersive power of a glass prism using Cauchy's constant. Also determinethe resolving power of a prism.
11. Determination of wavelength of sodium light using a plane transmission grating and resolving power of a diffraction grating.
12. Determination of specific rotation of cane sugar solution using a polarimeter.

SEMESTER- V

CH-GEC-351: Physics-II

L	T	P	Cr
3	1	2	6

UNIT-1: Electrostatics and magnetism (15 classes of 60 minutes each)

Electric field, potential due to a charge distribution and due to a dipole, electrical potential energy, flux, Gauss's law, electric field in a dielectric, polarization, energy stored in an electric field. Magnetic field due to a current-carrying conductor, Biot Savart law, magnetic force on a current, Lorentz force, electromagnetic induction, Lenz's law, magnetic properties of matter, para- dia- and ferromagnetism, spinning of a magnetic dipole in an external magnetic field. Modification of Ampere's law, equation of continuity and displacement current, Maxwell's equations, wave equation and its plane wave solution, nature of electromagnetic waves, tranversality and polarization, propagation of electromagnetic plane waves in dielectric media.

UNIT-2: Electronics (15 classes of 60 minutes each)

Half-wave, full-wave and bridge rectifiers, ripple factor, rectification efficiency, filters (series in inductor, shunt capacitator, LC and π sections), voltage regulations, load regulation, Zener diode as voltage regulator. Characteristic curves of bipolar transistors, static and dynamic load line, biasing (fixed and self) of transistor circuit, thermal instability of bias, the black box idea of CE, CB and CC transistor circuits as two-port network, small signal active output, hybrid model of a CE transistor circuit, analysis of a small signal amplifier: its voltage and current gains, negative and positive feedback. Barkhausen's criterion for self-sustaining oscillations, LC and phase shift oscillators.

UNIT-3: Digital electronics (10 classes of 60 minutes each)

Number systems (binary, BCD, octal and hexadecimal), 1's and 2's complements. Logic gates, AND, OR, NAND, NOR, XOR and NXOR. Boolean algebra (Boolean laws and simple expressions), binary adders, half adder, half subtractor, full adder and full subtractor.

Recommended Text books/References:

1. Griffiths, D. J. *Introduction to Electromagnetism* 3rd Ed. Prentice-Hall (1999).
2. Malvino, A.P. & Leach, D. P. *Digital Principles and Applications*, Tata McGraw- Hill (2008).
3. Ryder, J. D. *Electronic Fundamentals and Applications: Integrated and Discrete*

Systems. 5thEd. Prentice-Hall, Inc. (2007).

4. Floyd, T. L. & Buchla, D. M. *Electronics Fundamentals: Circuits, Devices and Applications* (8th Ed.) Prentice-Hall (2009).

(The above course structure/number of classes are suggestive. Faculty/academic bodies may incorporate revision/may incorporate text and reference books as per need).

Physics Practical

1. Ballistic Galvanometer: resistance, current sensitivity, charge sensitivity, and critical dampingresistance of the galvanometer.
2. Determination of high resistance by leakage method.
3. Determination of mutual inductance by Ballistic Galvanometer.
4. Operations and measurements by Cathode Ray Oscilloscope (CRO). Calibration of DC andAC voltages, frequency and phase measurements of a signal.
5. Study of transistor characteristics (CB, CE, CC configurations).
6. Study of power supply (rectification factor, voltage and load regulation for C, L, CL and πfilters).
7. Study of basic RC coupled amplifier (frequency response and band width).
8. Self-inductance measurement by Owen's bridge.
9. Measurement of magnetic field by search coil.
10. To verify experimentally OR, NAD, NOT, NOR, NAND gates.

SEMESTER-VI

CH-GEC-361: Mathematics-II

L	T	P	Cr
3	1	2	6

UNIT-1: Differential equations (8 classes of 60 minutes each)

Solving differential equations with separable variables, series solution, numerical solutions of differential equations those appear in Newtonian mechanism, harmonic oscillator, Linear differential equations with constant coefficients.

UNIT-2: Partial differential equations: separation of variables (10 classes of 60 minutes each)

Multiple integrals. Change variables. Vector derivative operators. Multiple integrals involving other coordinate systems (spherical polar). Maximum and minimum of functions of several variables. Stationary points, complex numbers, complex plane, Euler's formula and polar form ofcomplex numbers, complex conjugates, modulus of a complex number.

UNIT-3: Operators (6 classes of 60 minutes each)

Operator algebra, linear and Hermitian operators, eigenfunctions and eigenvalues, commutators of operators.

UNIT-4: Vectors and coordinate systems (6 classes of 60 minutes each)

Unit vectors (application in solid state), addition and subtraction of vectors, multiplication of vectors. Vector calculus. Vectors and coordinate systems in three dimensions (Cartesian, spherical polar and their inter-conversion), Jacobian.

UNIT-5: Determinants and Matrices (10 classes of 60 minutes each)

Determinant, Matrix algebra, Simultaneous equations: method of substitution and elimination, consistency and independence. Homogeneous linear equations. Simultaneous equations with more than two unknowns, Cramer's rule, matrix inversion, orthogonal and unitary matrices, diagonalization of a matrix.

Recommended Books/references:

1. McQuarrie D. A. *Mathematics for Physical Chemistry Opening Doors*, University Science Books (2008).

(The above course structure/number of classes are suggestive. Faculty/academic bodies may incorporate revision/may incorporate text and reference books as per need). (Suitable Laboratory Practicals may be designed by the faculty of Mathematics/Chemistry based on above course modules and available facilities)

ABILITY ENHANCEMENT COURSES (AECC)

SEMESTER- I

L	T	P	Cr
3	1	0	4

CH-AECC-111: English for communications

Learning Objectives:

1. Composition of english
2. Communicative skills
3. Writing and technical writing skills
4. Coherance
5. Drafting of letters, notices, minutes, etc.

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

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

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

(The above course is suggestive. However, the course teacher/academic bodies may incorporate changes as per the need with incorporation of appropriate text books, reference materials).

SEMESTER- II

L	T	P	Cr
3	1	2	6

CH-AECC-112: Environmental Science

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

1. Composition of atmosphere
2. Biogeochemical cycles
3. Hydrological cycle
4. Water quality parameters
5. Atomospheric chemical phenomon and environmental pollution
6. Water pollution, parameters of water pollution, treatment of polluted water

UNIT-1: Environment

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

UNIT-2: Hydrosphere: Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand, Analytical methods for the determination fluoride, chromium and arsenic, residual chlorine and chlorine demand, purification and treatment of municipal water and waste water.

UNIT-3: Atmosphere

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

UNIT-4: Aquatic chemistry

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

Recommended Books/References:

1. De. A.K. *Environmental Chemistry*, Wiley Eastern Ltd, 1990.

2. Miller T.G.Jr., *Environmental Science,* Wadsworth publishingHouse, Meerut Odum.E.P., 1971.
3. Odum, E.P. (1971) *Fundamentals of Ecology,* Third Edition, W.B. Saunders Co., Philadelphia
4. Sharma and Kaur, *Environmental chemistry*, Krishna publishers, 2016.
5. S.M. Khopker, *Environmental Pollution, Monitoring and control*, New Age International, 2007.
6. C. Baird, M. Cann, *Environmental Chemistry*, 5th Edn, 2012, W.H.Freeman publication.
7. G. S. Sodhi, *Fundamental Concepts of Environmental Chemistry* (Third Edition) Narosa (2009).

List of suggested laboratory practicals

Determination of water quality parameters in following aspect:

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

List of Recommended books/Reference Books:

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

(The list of experiments and books are purly suggestive; University/institute may incorporate further changes in number of experiments and books/refererences (updated version from time to time) based on course design and available infrastructure facilities).

SKILL ENHANCEMENT COURSES (SEC)

SEMESTER – I

CH-SEC-111: Computer Applications for chemistry

L	T	P	Cr
2	0	0	2

Learning outcomes:

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

- Apply the basic operations of spreadsheet applications
- Recognize advanced resources for accessing scholarly literature from internet
- Utilize bibliography management software while typing and downloading citations
- Operate various software resources with advanced functions and its open office substitutes

Keywords:

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

UNIT-1: Spreadsheet Applications (8 classes of 60 minutes each)

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

UNIT-2: Internet Resources (7 classes of 60 minutes each)

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

UNIT-3: Bibliography management (8 classes of 60 minutes each)

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

UNIT-4: Other software resources (7 classes of 60 minutes each)

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

Suggested Readings

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

CH-SEC-112: Herbal Science & Technology

L	T	P	Cr
2	0	0	2

Learning outcomes:

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

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

Keywords:

Herbal medicines, Plant products, Biopesticides, Pharmacognosy, Adulteration, Secondary metabolites

UNIT-1: (7 classes of 60 minutes each)

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

UNIT-2: (7 classes of 60 minutes each)

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

UNIT-3: (8 classes of 60 minutes each)

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

UNIT-4: (8 classes of 60 minutes each)

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

Suggested Readings

1. Agarwal, P., Shashi, Alok., Fatima, A. and Verma, A. (2013). *Current scenario of HerbalTechnology worldwide: An overview*. *Int J Pharm Sci Res*; 4(11): 4105-17.
2. Arber, Agnes. (1999). *Herbal Plants and Drugs*. Mangal Deep Publications, Jaipur.
3. Varzakas, T., Zakynthinos, G, and Francis Verpoort, F. (2016). *Plant Food Residues as a Source of Nutraceuticals and Functional Foods*. Foods 5 : 88.
4. Aburjai, T. and Natsheh, F.M. (2003). *Plants Used in Cosmetics*. Phytotherapy Research 17:987-1000.
5. Patri, F. and Silano, V. (2002). *Plants in cosmetics: Plants and plant preparations used as ingredients for cosmetic products - Volume 1*. ISBN 978-92-871-8474-0, pp 218.
6. AYUSH (www.indianmedicine.nic.in). *About the systems—An overview of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy.* New Delhi: Department of Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry and Family Welfare, Government of India.
7. Evans, W.C. (2009): *Trease and Evans PHARMACOGNOSY*. 16th Edition, SAUNDERS/ Elsevier.
8. Sivarajan, V.V. and India, B. (1994). *Ayurvedic Drugs and Their Plant Sources.* Oxford& IBH Publishing Company, 1994 - Herbs - 570 pages.

9. Miller, L. and Miller, B. (2017). *Ayurveda & Aromatherapy: The Earth Essential Guideto Ancient Wisdom and Modern Healing.* Motilal Banarsidass, Fourth edition.
10. Kokate, C.K. (2003). *Practical Pharmacognosy*. Vallabh Prakashan, Pune.

CH-SEC-113: Water remediation & conservation studies

L	T	P	Cr
3	1	0	4

UNIT-1:

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

UNIT-2:

Introduction to water conservation and erosion of soil, forms of water erosion, factors affecting water erosion, types of water erosion, mechanics of water erosion control, agronomical measuresof water erosion control, Terraces for water erosion control:
Modeling of watershed processes, Case study of water-shed modeling for water conservation andwater quality.

Recommended Books/references:

1. Cittenden J. C., Trussell J. R., Hand D. W., Howe K. J., Tchobanoglous G., *Water treatment: Principles and Design*, MWH publication.
2. De A. K. *Environmental Chemistry*, Wiley Eastern
3. Clarson D., Dara S. S. *A text book of Environmental chemistry and pollution control*, S Chand Co.
4. Edzwald J., *Water Quality & Treatment: A Handbook on Drinking Water* (Water Resources and Environmental Engineering Series)

SEMESTER- II

CH-SEC-121: Renewable Energies (solar and biogas)

L	T/P	P	Cr
3	1	0	4

UNIT-1: Introduction to renewable energy sources – solar, wind, small hydro, biomass, geothermal and ocean energy, energy flow in ecosystem Solar Energy Resources Solar radiation: Spectrum of EM radiation, sun structure and characteristics, extraterrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectral distribution.

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

UNIT-2: Solar mapping using satellite data, Typical Meteorological Year

Models and methods for estimating solar radiation, estimation of global radiation, estimation of diffused components.

Basics Biomass resources: plant derived, residues, aquatic and marine biomass, various wastes, photosynthesis. Biomass resource assessment Estimation of woody biomass, non woody biomassand wastes, ASTM standards.

Bulk chemical properties Moisture content, proximate and ultimate analyses, calorific value, waste water analysis for solids.

UNIT-3: Chemical composition of biomass Cellulose, hemicelluloses and lignin content in commonagricultural residues and their estimation, protein content in biomass, extractable, COD. Structural properties Physical structure, particle size and size distribution, permeability. Physicalproperties: Bulk density, angle of repose, thermal analysis (thermogravimetric, differential thermal and differential scanning calorimetry). Properties of microbial biomass: Protein estimation, flocculating ability, relative hydrophobicity of sludge, sludge volume index.

CH-SEC-122: Biofertilizer

L	T	P	Cr
2	0	0	2

Learning outcomes:

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

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

Keywords:

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

UNIT-1: (9 classes of 60 minutes each)

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

UNIT-2: (7 classes of 60 minutes each)

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

UNIT-3: (7 classes of 60 minutes each)

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

UNIT-4: (7 classes of 60 minutes each)

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

Suggested Readings

1. Dubey, R.C. (2005). *A Text book of Biotechnology* S. Chand & Co, New Delhi.
2. John Jothi Prakash, E. (2004). *Outlines of Plant Biotechnology*. Emkay Publication, New Delhi.
3. Kumaresan, V. (2005). *Biotechnology*, Saras Publications, New Delhi.
4. NIIR Board. (2012). *The complete Technology Book on Biofertilizer and organicfarming*. 2nd Edition. NIIR Project Consultancy Services.
5. Sathe, T.V. (2004) *Vermiculture and Organic Farming*. Daya publishers.
6. Subba Rao N.S. (2017). *Biofertilizers in Agriculture and Forestry*. Fourth Edition.Medtech.

CH-SSC-123: Chemistry in everyday life

L	T	P	Cr
2	0	2	4

UNIT-1: Respiration and energy production in human body

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

UNIT-2: Chemical aspects of some common health hazards

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

UNIT-3: Vitamins and minerals:

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

UNIT-4: Significance of Radical chemistry in living system

Radical production in environment, superoxide and peroxide, health impact, action of radicals, cell mutation, diseases caused by free radical, cancer, radical quencher, anti-oxidants, natural

anti-oxidants like vegetables, beverages like tea and coffee, fruits.
Radical destroying enzymes: superoxide dismutase, catalase, peroxidase, mechanism of action.

UNIT-5: Chemistry of Materials

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

Recommended Books/references:

1. Kaim W, *Bioinorganic Chemistry*, Vol 4, Brigitte Scwederski, Wiley, 1994.
2. Crichton R. H. *Biological Inorganic Chemistry – An Introduction*, Elsevier, 2008.
3. Berg J. M., Tymoczeko J. L., Stryer l. *Biochemistry*, W. H. Freeman, 2008.
4. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) *BioinorganicChemistry.* University Science Books (1994)
5. Lippard S., Berg J. M. *Principles of Bioinorganic Chemistry*; University Science Books1994.
6. V. R. Gowariker, N. V.Viswanathan, J. Sreedhar, *Polymer science*, New Age International.

Suggested Laboratory experiments:

1. Analysis of soaps and detergents.
2. Analysis of Biofuels - flash point, pour point, cloud point
3. Preparation of Nylon6/6,6
4. Testing of adulterant in food, oil and vegetable, Vitamin-C preparation.