Table 1: Proposed Chemistry Courses for CBCS in B.Sc. Program: Semester wise course types, Course codes, Course title, Delivery type, Workload, Credits, Marks of Examination, and Remarks if any.

Level	Semester	Course Type	Course Code	Course Title	Delivery type per week			Total hours	Credits	Total Credits	Internal marks	EoSE Marks	Max. Marks	Remarks
					L	T	P							
5	I	DCC	CHE5000T	Chemistry-I: Atomic Structure, Chemical Bonding and Stereochemistry	L	T	-	60	4	6	20	80	100	
			CHE5000P	Chemistry Lab-1: Chemical Analysis Lab-I	-	-	P	60	2		20	80	100	
		AECC	AES5200T		L	T		30	2	2	20	80	100	
	II	DCC	CHE5001T	Chemistry-II: Thermodynamics, Hydrocarbons and Halides	L	T	-	60	4	6	20	80	100	
			CHE5001P	Chemistry Lab-2: Chemical Analysis Lab-II	-	-	P	60	2		20	80	100	
		AECC	AES5201T		L	T		30	2	2	20	80	100	
Exit with Certificate in Science														
6	III	DCC	CHE6002T	Chemistry-III: s, p, d, f block elements, Coordination Chemistry and Organic Compounds of Oxygen	L	T	-	60	4	6	20	80	100	
			CHE6002P	Chemistry Lab-3: Chemical Analysis Lab-III	-	-	P	60	2		20	80	100	
		SEC-1		Communicative English	L	T		30	2	2	20	80	100	
	IV	DCC	CHE6003T	Chemistry-IV: Chemical kinetics, Electrochemistry, Organic Compounds of Nitrogen, Heterocycles	L	T	-	60	4	6	20	80	100	
			CHE6003P	Chemistry Lab-4:Chemical Analysis Lab-IV	-	-	P	60	2		20	80	100	
		SEC-2	SES5320T	Chemistry Laboratory Preparations	L	T		30	2	2	20	80	100	

Exit with Diploma in Science														
7	V	**Select anyone of the following Discipline specific Elective (DSE) Courses in V and VI semester**												
		DSE	CHE7300T	1. Spectroscopy and Instrumental Techniques	L	T	-	60	4	6	20	80	100	
			CHE7300P	1. Elective Chemistry Lab-I	-	-	P	60	2		20	80	100	
		DSE	CHE7301T	2. Green and Sustainable Chemistry	L	T	-	60	4	6	20	80	100	
			CHE7301P	2. Elective Chemistry Lab-II		-	P	60	2		20	80	100	
		DSE	CHE7302T	3. Polymer Chemistry	L	T	-	60	4	6	20	80	100	
			CHE7302P	3. Elective Chemistry Lab-III	-	-	P	60	2		20	80	100	
		SEC-3	SES5321T	Food Preservation and Adulteration	L	T		30	2	2	20	80	100	
	VI	DSE	CHE7303T	4. Organometallic Chemistry and Catalysis	L	T	-	90	6 (5+1)	6	20	80	100	
		DSE	CHE7304T	5. Molecules of Life	L	T	-	90	6 (5+1)	6	20	80	100	
		DSE	CHE7305T	6. Advanced Physical Chemistry	L	T		90	6 (5+1)	6	20	80	100	
		SEC-4	SES5322P	Water Pollution and Analysis			P	30	2	2	20	80	100	
Exit with Graduation Degree in Science (B.Sc.)														

DCC- Discipline Centric Compulsory Course (001 to 099); **DSE**- Discipline Specific Core Course (100 to 199)

AECC- Ability Enhancement Compulsory Course (English/MIL Communication/ Environmental Science) (201 to 299); **SEC**- Skill Enhancement Course (301 to 399)

The code has eight places. XYZ(subject name)Level(5/6/7)DCC/DSE/AEC/SEC(3 digits)T/P

If an AECC course is offered by commerce: AEC5201T; If an AECC course is offered by Science: AES5201T; If an AECC course is offered by Arts/Humanities/…..: AEA5201T

If an SEC course is offered by commerce: SEC53XXT; If an SEC course is offered by Science: SES63XXT; If an SEC course is offered by Arts/Humanities/…..: SEA53XXT

Semester I

DCC Chemistry I: CHE5000T

Atomic Structure, Chemical Bonding and Stereochemistry

Code of the Course: CHE5000T

Title of the Course: Atomic Structure, Chemical Bonding and Stereochemistry

Level of the Course: NHEQF Level 4.5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Chemistry courses of Central Board of Secondary Education (CBSE) or 10+2 level.

Objective of the Course: This course provides an introduction to the fundamental concepts of atomic structure, chemical bonding, and organic chemistry. It covers topics such as atomic models, covalent bonding, metallic bonding, ionic bonding, and organic chemistry and stereochemistry basics. The course aims to develop student's understanding of the fundamental principles underlying chemical bonding and the structure of atoms and molecules.

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

1. Understand the fundamental principles of atomic structure, including the arrangement of subatomic particles and the organization of electrons within an atom.
2. Describe and explain the different types of chemical bonds, including covalent, metallic, and ionic bonds, and understand the factors that influence their formation.
3. Understand the atomic structure and chemical bonding knowledge to predict the properties and behaviors of different elements and compounds.
4. Understand the basics of organic chemistry, including the structure, nomenclature, and properties of organic compounds.
5. Describe the principles of stereochemistry, including the three-dimensional arrangement of atoms in molecules and the effects of stereochemistry on chemical reactivity.
6. Apply stereochemical concepts to predict the behavior of chiral molecules and their interactions with other compounds.
7. Develop critical thinking and problem-solving skills through the application of theoretical concepts to real-world examples and chemical experiments.
   Overall, the course aims to provide students with a solid foundation in atomic structure, chemical bonding, and organic chemistry, preparing them for further studies in chemistry and related disciplines.

Syllabus:

UNIT I

Atomic structure: Bohr's theory and its limitations, dual behavior of matter and radiation, de Broglie's relation, Heisenberg's uncertainty principle, hydrogen atom spectra, radial and angular wave functions, probability distribution curves, shapes of s, p, d orbitals, nodal planes time independent Schrodinger equation, significance of ψ and ψ^2, Schrödinger equation for hydrogen atom.Significance of quantum numbers, orbital angular momentum, quantum numbers, rules for filling electrons in various orbitals, electronic configurations of the atoms, stability of half-filled and fully filled orbitals, concept of exchange energy, relative energies of atomic orbitals, anomalous electronic configurations.

(12 Lecture hours)

UNIT II

Covalent Bond: Valance bond approach of covalent bond, shapes of some inorganic molecules and ions on the basis of VSEPR theory, the concept of hybridization with suitable examples of linear, trigonal planar, tetrahedral, trigonal pyramidal, trigonal bipyramidal, octahedral, and square planar arrangements. Concept of resonance and resonating structures in various inorganic compounds.

Metallic bond: Introduction, free electron theory, concept of band theory, importance of metallic bond, properties of semiconductors, insulators with examples.

(12 Lecture hours)

UNIT III

Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy, solvation energy, their importance in the context of stability and solubility of ionic compounds, statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power, and polarizability, Fajan's rules, ionic character in covalent compounds, dipole moment and percentage ionic character.

Weak Chemical Interactions: van der Waals forces, ion-dipole forces, dipole-dipole interactions, instantaneous dipole-induced dipole interactions, induced dipole interactions, repulsive forces, hydrogen bonding, theories of inter- and intra-molecular hydrogen bonding, valence bond treatment, effects of chemical forces on melting point, boiling point and solubility.

(12 Lecture hours)

UNIT IV

Fundamentals of Organic Chemistry: Covalent bond, hybridization and shapes of molecules, geometry and structure of sp^3, $sp^2$and sp hybridized orbitals, influence of hybridization on bond properties.

Electronic displacements: Inductive, electromeric, resonance and field effect. Hyperconjugation, concept of dipole moment, homolytic and heterolytic fission, curved arrow notation, electrophiles and nucleophiles, types of organic reactions.

Types of reactive intermediates: Generation, shape and relative stability of different reactive intermediates namely carbocation, carbanion, free radicals, nitrene, carbene and benzyne.

Aromaticity: Introduction, Electronic structure and Huckel's rule, aromaticity in carbocyclic, heterocyclic, benzenoid, non-benzenoid, anti-aromatic and non-aromatic compounds.

(12 Lecture hours)

UNIT V

Stereochemistry: Concept and significance of isomerism, structural isomersim and stereoisomerism, types of stereoisomerism, geometrical and optical isomerism.

Chirality: Concept of chirality (chirality upto two carbon atoms), stereogenic centre, optical activity, Cahn-Ingold-Prelog (CIP) rules and priority assignments, enantiomers, diastereomers and meso compounds.

Nomenclature systems: Cis-trans nomenclature, E/Z nomenclature, R/S nomenclature (up to two chiral carbon atoms), threo and erythro, D and L nomenclature

Conformational isomerism: Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge formula, Newmann, Sawhorse and Fischer representations.

(12 Lecture hours)

E-resources:

1. https://www.britannica.com/science/atom
2. https://www.youtube.com/watch?v=OH-aSu-rWgk
3. https://collegedunia.com/exams/metallic-bonds-properties-examples-and-importance chemistry-articleid-1747

4. https://byjus.com/jee/covalent-bond/
5. https://ncert.nic.in/textbook/pdf/kech104.pdf
6. https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Boundless)/02%3A_Chemistry/2.02%3A_Chemical_Bonds/2.2.02%3A_Colvalent_Bonds_and_Other_Bonds_and_Interaction
7. https://gtu.ge/Agro-Lib/McMurry%20J.E.%20-%20Fundamentals%20of%20Organic%20Chemistry,%207th%20ed.%20-%202010.pdf
8. https://faculty.ksu.edu.sa/sites/default/files/1-chem_109_introduction_modified_0.pdf
9. https://www.uou.ac.in/lecturenotes/science/MSCCH-17/CHEMISTRY%20LN%201%20STERIOCHEMISTRY.pdf

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
4. Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
5. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in InorganicChemistry*, John Wiley & Sons.
6. Huheey, J.E., Keiter, E.A., Keiter, R.L. &Medhi, O.K. *Inorganic Chemistry:Principles of Structure and Reactivity*, Pearson Education India, 2006.
7. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, JohnWiley & Sons (2014).
8. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning IndiaEdition, 2013.
9. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, NewDelhi (1988).
10. Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education,2000.
11. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
12. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
13. Bahl, A. &Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

Semester I

Chemistry Lab1: CHE500P

Chemical Analysis Lab-I

Code of the Course: CHE500P

Title of the Course: Chemical Analysis Lab-I

Level of the Course: NHEQF Level 4.5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. Inorganic Chemistry **40 Marks**

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

Cations: NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+},Ba^{2+}, $Sr^{2+,}$ Ca^{2+}

Anions: CO_3^{2-}, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, NO_2^-,SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2}$, F^-(Spot tests should be carried out wherever feasible)

2. Organic Chemistry: Purification of organic compounds: **20 Marks**

a) **Crystallization:**

- Phthalic acid from hot water
- Acetanilide from boiling water
- Benzoic acid from water
- Decolourisation and crystallization using charcoal
- Decolorisation and crystallization of impure naphthalene (100g of naphthalene mixed with 0.3 g of Congo Red using 1 g decolorising carbon) from ethanol.

b) **Sublimation**:

- Camphor, Naphthalene, Phthalic acid and succinic acid
- Mixed melting point determination

- Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)

c). Identification of functional group in given organic compounds *i.e.* Carboxylic acid, Phenols, Alcohols, Carbohydrates, Aldehydes, Ketones, Nitro compounds, Amino compounds, Anilides, Amides, Esters, Thioamides, Hydrocarbons and halogen containing compounds

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. https://byjus.com/chemistry/salt-analysis/
2. https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXII/chemistry/lelm107.pdf
3. https://byjus.com/chemistry/crystallization/
4. https://chem.libretexts.org/Courses/Los_Medanos_College/Chemistry_6_and_Chemistry_7_Combined_Laboratory_Manual/Experiment_727_Organic_Compound_Functional_Groups__1_2_0
5. https://pubs.acs.org/doi/10.1021/ac60052a036

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
5. Advanced Practical Physical Chemistry; Eighteenth Edition J.B.Yadav; Goel Publishing House, Meerut, 2015.
6. Practical Chemistry,Ameta, Punjabi &Ameta, Himanshu Publications, New Delhi, 2020.

Semester II

DCC Chemistry II: CHE5001T

Thermodynamics, Hydrocarbons and Halides

Code of the Course: CHE5001T

Title of the Course: Thermodynamics, Hydrocarbons and Halides

Level of the Course: NHEQF Level 4.5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) course for chemistry discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Chemistry courses of central board of secondary education or equivalent.

Objective of the Course: To learn the basic principles involved in energetic of chemical reactions, role of enthalpy in chemical reactions and the behaviour of electrolytes in solution with the concepts of pH measurements. This course also provides knowledge about alkanes, alkenes, alkynes, alkyl and aryl halides.

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

1. Understand the principles and definitions of thermochemistry, first law of thermodynamics and Joule's law.
2. Calculate standard enthalpies of formation and understand the concept of a standard state. Calculate bond energy, bond dissociation energy, and resonance energy using thermochemical data.
3. Understand the second law of thermodynamics and its different statements; Carnot cycle and its efficiency; entropy.
4. Comprehend the concepts of free energy and work function and analyze their variations with pressure, volume, and temperature. Apply the Clausius-Clapeyron equation and its applications.
5. Differentiate between strong, moderate, and weak electrolytes. Determine the degree of ionization and factors affecting, ionization constants and ionic product of water.
6. Analyze the ionization of weak acids and bases and understand the pH scale. Apply the common ion effect and calculate hydrolysis constants and pH for different salts. Understand buffer solutions and solve problems related to solubility and solubility product.
7. Understand the functional group approach for the preparation and reactions of alkanes, alkenes, and alkynes. Identify various methods for the preparation of alkanes, alkenes, and alkynes.
8. Explain the mechanisms and outcomes of various reactions in aliphatic hydrocarbons.
9. Understand the preparation methods for alkyl halides from alkenes and alcohols.

10. Analyze the reactions of aryl halides, including aromatic nucleophilic substitution and the effect of nitro substituents. Differentiate between different types of nucleophilic substitution reactions (S_N1, S_N2 and S_Ni).

Syllabus:

UNIT I

Chemical Energetics-I: Review of thermodynamics and firstlaw of thermodynamics, Joule'slaw, Joule-Thomson coefficient and inversion temperature, important principles and definitions of thermochemistry,concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution,calculation of bond energy, bond dissociation energy and resonance energy fromthermo-chemical data,variation of enthalpy of a reaction with temperature - Kirchhoff's equation.

(12 Lecture hours)

UNIT II

Chemical Energetics-II: Second law of thermodynamics, different statements of the law, Carnot cycle and its efficiency, Carnot theorem, Concept of entropy, entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical processes, third law of thermodynamics, calculation of absolute entropies of substances,free energy(G), work function(A), variation of G and A with P,V and T. Reaction isotherm and reaction isochore, Clausius-Claperyron equation and applications.

(12 Lecture hours)

UNIT III

Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water,ionization of weak acids and bases, pH scale, common ion effect,salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts,buffer solutions,solubility and solubility product of sparingly soluble salts and its applications.

(12 Lecture hours)

UNIT IV

Alkanes: Preparation, physical properties and chemical reactions, mechanism of free radical substitution with reference to halogenation, orientation, reactivity and selectivity.

Cycloalkanes: Nomenclature, preparation, chemical reactions, Baeyer strain theory and its limitation, ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings, banana bond in cyclopropane.

Alkene: Introduction of alkenes, preparation, physical properties and relative studies of alkenes, their preparation with reference to mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration, Saytzeff's rule, Hofmann elimination. Chemical reactions of alkenes-mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration-oxidation, oxymecuration-demercuration, epoxidation, ozonolysis, hydration, hydroxylation, oxidation with $KMnO_4$, polymerization of alkenes, substitution at the allylic and vinylic positions of alkene, industrial applications of ethylene and propene.

Dienes: Nomenclature, classification, isolated, conjugated and cumulated dienes, structure of allenes and butadiene, preparation, chemical reactions- polymerization, 1,2- and 1,4- additions, Diels-Alder reaction.

Alkynes: Nomenclature, preparation, physical properties and chemical reactions, mechanism of electrophilic and nucleophilic addition reactions, hydroboration, metal ammonia reductions, oxidation and polymerization.

(12 Lecture hours)

UNIT V

Alkyl and Aryl Halides: Nomenclature and classification of alkyl halides, preparation, physical propertiesand chemical reactions, mechanismof nucleophilic substitution (S_N1, S_N2 and S_Ni)reactions, hydrolysis, nitrite and nitro formation, nitrile and isonitrile formation. Williamson'sether synthesis, haloform reaction, freons.Preparation of aryl halides, nuclear and side chain reactions, addition-elimination and elimination-addition reactions, mechanism of nucleophilic aromatic substitution reactions.Relative reactivities of alkyl halides v/s allyl, vinyl, and aryl halides, synthesis and uses of DDT and BHC.

(12 Lecture hours)

E-resources:

1. https://byjus.com/physics/thermodynamics/
2. https://www.chemguide.co.uk/physical/energetics/basic.html
3. https://chem.libretexts.org/Courses/University_of_South_Carolina__Upstate/USC_Upstate%3A_CHEM_U109__Chemistry_of_Living_Things_(Mueller)/07%3A_Energy_and_Chemical_Processes/7.6%3A_Energetics_and_Kinetics
4. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/ch105-chapter-8/

5. https://byjus.com/chemistry/preparation-alkyl-halides/#:~:text=The%20key%20difference%20between%20alkyl,between%20carbon%20atoms%20forming%20rings).

Reference Books:

1. A Text Book of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2002.
2. The Elements of Physical Chemistry; P.W. Atkins; Oxford University Press, 1996.
3. Physical Chemistry; Seventh Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 1987.
4. Physical Chemistry Through Problems S.K. Dogra and S.Dogra; Wiley Eastern Ltd, New Delhi, 2001.
5. Physical Chemistry, Suresh Ameta, RakshitAmeta, Hemleta; Himanshu Publications, New Delhi, 2020
6. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
7. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
8. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
9. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
10. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
11. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

Semester II

Chemistry Lab-2: CHE5001P

Chemical Analysis Lab-II

Code of the Course: CHE5001P

Title of the Course: Chemical Analysis Lab-II

Level of the Course: NHEQF Level 4.5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. **Potentiometric & Conductometric titrations** **40 Marks**
   a) Titration of acetic acid against NaOH potentiometrically.
   b) Determination of solubility and solubility product of a sparingly soluble salt (leadsulfate/ barium sulfate/ silver chloride/ calcium sulfate/ lead chromate) by conductance measurement.

   Thermochemistry
   a) Determination of solubility of benzoic acid at different temperatures and determine ΔH of the dissolution process.
   b) Determine enthalpy of neutralization of a weak acid/weak base vs strong base / strong acid.
   c) Determine the enthalpy of the solution of solid $CaCl_2$ and calculate the lattice energy using Born-Haber Cycle.

   Preparation of buffer solutions:
   a) Sodium acetate-acetic acid
   b) Ammonium chloride-ammonium hydroxide
   c) Measurement of the pH of buffer solutions and comparison of the values withtheoretical values.
2. **Identification of organic compounds through functional group analysis and preparation of their derivatives:** **20 Marks**
   a) Hydrocarbons: Benzene, Toluene, Naphthalene, Anthracene

b) Carboxylic acid: Oxalic, Tartaric, Citric, Benzoic, Succinic, Cinnamic, Salicylic, Phthalic acids

c) Alcohols: Methyl, Ethyl, Propyl, Isopropyl, *n*-butyl, isobutyl, tertbutyl alcohols

d) Phenols: Phenol, Resorcinol, Hydroquinone, *p*-Cresol, α-Naphthol, β-Naphthol

e) Carbohydrates: Glucose, Fructose, Cane sugar, Starch

f) Aldehydes: Formaldehyde, Acetaldehyde, Benzaldehyde

g) Ketones: Acetone, Ethyl methyl ketone, Acetophenone, Benzophenone

h) Esters: Methyl acetate, Ethyl acetate

i) Halogen Containing Compounds: Chloroform, Chloral hydrate, Iodoform, Chlorobenzene, *p*-Dichlorobenzene, *p*-Dibromobenzene

j) Nitro compounds: Nitrobenzene, *p*-Nitrotoluene, *m*-Dinitrobenzene

k) Amino compounds: Aniline, *o*-, *m*- and *p*-Toluidine, α-Naphthylamine and β-Naphthylamine

l) Anilides: Acetanilide and Benzanilide

m) Amides: Acetamide, Benzamide, Urea

n) Thioamide: Thiourea

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. **https://chem.libretexts.org/Courses/Los_Medanos_College/Chemistry_6_and_Chemistry_7_Combined_Laboratory_Manual/Experiment_727_Organic_Compound_Functional_Groups__1_2_0**
2. **https://pubs.acs.org/doi/10.1021/ac60052a036**
3. **https://byjus.com/jee/buffer-solutions/**
4. **https://www.youtube.com/watch?v=Bfo6vccc0KY**
5. **https://www.youtube.com/watch?v=VzMiTg0Qz3g**

Reference Books:

1. Advanced Practical Physical Chemistry; Eighteenth Edition J.B.Yadav; Goel Publishing House, Meerut, 2015.
2. Practical Chemistry,Ameta, Punjabi &Ameta, Himanshu Publications, New Delhi, 2020.

Semester-III

DCC Chemistry III: CHE6002T

s, p, d, f Block Elements, Coordination Chemistry and Organic Compounds of Oxygen

Code of the Course: CHE6002T

Title of the Course: s, p, d, f Block Elements, Coordination Chemistry and Organic Compounds of Oxygen

Level of the Course: NHEQF Level 5

Credit of the Course: 04

Type of the Course: DCC

Delivery type of the course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Foundation and introductory courses of inorganic and organic chemistry

Objective of the course: This course is mainly focuses on basic facts and concepts of chemical bonding, theories of covalent bonding including VBT and MOT. Basics of ionic solids, its structures, lattice defects, metallic bond and weak interactions, coordination bond theories of coordination bond (VBT and CFT). General properties of s-block elements, p-block elements, 3d transition metals and their important chemical reactions. This course also comprises classification, nomenclature, preparation and important chemical reactions of alcohols, phenols, aldehydes, ketones, carboxylic acids and their derivatives, with special emphasis on naming reactions.

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

1. Understand various properties of s-block elements, complexation and solvation tendencies of s-block elements and their role in biological systems.
2. Know about basic chemistry, physical and chemical properties of p-block elements and preparation and structure of compounds of p-block elements.
3. Understand the facts of 3d transition elements covering general properties and important chemical reactions.
4. Understand the facts of lanthanides and actinides covering general properties and important chemical reactions and their separation.
5. Explain the concept of coordination bond, nomenclature, isomerism in coordination compounds, valance bond theory, hybridization, crystal field theory, magnetic proprieties and colour of the complexes.
6. Explain the preparation and chemical reactions of alcohols, phenols, aldehydes and ketones, carboxylic acid and their derivatives

7. Explain the naming reactions like; Fries rearrangement, Clasien rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer Manasse reaction, Reimer-Tiemann reaction, Benzoin, Aldol, Perkin and Knoevenagel condensations, Wittig reaction, Mannichreaction, Cannizzaro reaction. Baeyer-Villigeroxidation, Meerwein-Ponndorf-Verley, Clemmenson, Wolff-Kishner, reductions, Hell-Volhard-Zelinsky reaction, Hofmann-bromamide reaction.

Syllabus:

UNIT I

s-block elements: General characteristics, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water, common features of hydrides, oxides, carbonates, nitrates, sulphates of alkali and alkaline earth metal compounds, complex formation tendency and solutions of alkali metals in liquid ammonia.

p-block elements: Periodicity in properties of p-block elements with special reference to atomic and ionic radii, ionization energies, electron-affinity, electronegativity, allotropy, inert pair effect, catenation including diagonal relationship. Structure, bonding and properties of hydrides of group 13, oxides of phosphorus and sulphur, oxoacids of phosphorus, halides of silicon and phosphorus, borazine, silicates, silicones.

(12 Lecture hours)

UNIT II

Transition elements (3d series): General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states.

Lanthanides and actinides: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides and actinides (ion exchange method only).

(12 Lecture hours)

UNIT III

Coordination chemistry: Introduction, classification of ligands, chelation, polynuclear complexes, Werner's coordination theory, IUPAC nomenclature of coordination compounds and structural and stereoisomerism in complexes with coordination numbers 4 and 6.Valence bond theory (VBT), Inner and outer orbital complexes of 3d series and limitations of VBT.

Crystal field theory: Main postulates, crystal field splitting of d-orbitals in octahedral and tetrahedral complexes and square planner complexes, factors affecting the magnitude of Δ_o, calculation of crystal field stabilization energy, strong field and weak field ligands, spectrochemical series, distortion of octahedral complexes and Jahn-Teller theorem.

(12 Lecture hours)

UNIT IV

Alcohols: Classification, nomenclature, preparation and important chemical reactions of monohydric, dihydric (glycol) and trihydric (glycerol) alcohols.

Phenols: Nomenclature, structure and bonding, preparation of phenols, physical properties, acidic character, comparative acidic strength of alcohols and phenols and stability of phenoxide ion. Reactions of phenol-electrophilic aromatic substitution(acylation and carboxylation), Fries rearrangement, Clasien rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer Manasse reaction and Reimer-Tiemann reaction with their mechanism.

Aromatic aldehydes and ketones: Preparation,physical propertiesand chemical reactions of aromatic aldehydes and ketones. Mechanism of nucleophilic addition to carbonyl group with particular emphasis on Benzoin, Aldol, Perkin and Knoevenagel condensations, condensation with ammonia and its derivatives, Wittig reaction, Mannich reaction, Cannizzaro reaction, Baeyer-Villiger oxidation, Meerwein-Ponndorf-Verley, Clemmenson, Wolff-Kishner, $LiAlH_4$, and $NaBH_4$ reductions, halogenation of enolizable ketones.

(12 Lecture hours)

UNIT V

Carboxylic acids: Nomenclature, structure and bonding, acidity of carboxylic acids, effects, substituents on acid strength. Preparation, physical properties and chemical reactions of monocarboxylic, dicarboxylic acids (oxalic, malonic, succinic and phthalic acid), substituted acids (halo acids), hydroxy acids (lactic, malic, salicyclic, tartaric and citric acid), unsaturated acids (acrylic and cinnamic acid).

Carboxylic acids derivatives: Preparation, properties and uses of acid halides, amides, anhydrides and esters, interconversion of acid derivatives by nucleophilic acyl substitution, mechanism of Hell-Volhard-Zelinsky reaction, Hofmann-bromamide reaction and ester hydrolysis.

(12 Lecture hours)

E-resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. https://www.accessscience.com/content/book/9780071811118/chapter/chapter16
3. https://www.angelo.edu/faculty/kboudrea/index_2353/Chapter_03_2SPP.pdf
4. https://www.egyankosh.ac.in/bitstream/123456789/59594/1/Unit19.pdf
5. https://www.geo.utexas.edu/courses/376m/coord_chem.htm

Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
5. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
7. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
8. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
9. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
10. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
11. Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
12. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
13. Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
14. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
15. Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
16. Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
17. Wulfsberg, G. *Inorganic Chemistry*, Viva Books Pvt. Ltd.
18. Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd., 2008.

Semester III

Chemistry Lab 3: CHE6002P

Chemical Analysis Lab-III

Code of the Course: CHE6002P

Title of the Course: Chemical Analysis Lab-III

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. **Binary mixtures** **30 Marks**

   Separation and identification of organic compounds in solid-solid binary mixture

2. **Surface tension and viscosity measurement** (organic solvents excluded). **30 Marks**

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

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

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

   Volumetric analysis

   a) Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

   b) Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

   c) Estimation of total hardness of a given sample of water by complexometric titration.

   d) Determination of the strength of ferrous ammonium sulphate (Mohr's salt) solution.

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. https://soe.unipune.ac.in/studymaterial/ashwiniWadegaonkarOnline/mixturechartfinalwatermark.pdf
2. https://www.youtube.com/watch?v=cPdRGbD31-A

3. https://davjalandhar.com/dbt/chemistry/SOP%20LabManuals/B.Sc.%20BT%20SEM%20III.pdf
4. https://pdfkeys.com/download/2588723-A%20Volumetric%20Analysis%20Complexometric%20Titration%20Of.pdf

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011)
2. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

Semester IV

DCC Chemistry IV: CHE6003T

Chemical Kinetics, Electrochemistry, Organic Compounds of Nitrogen, Heterocycles

Code of the course: CHE6003T

Title of the course: Chemical kinetics, Electrochemistry, Organic Compounds of Nitrogen, Heterocycles

Level of the Course: NHEQF Level 5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline/Subject

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Foundation and introductory courses

Objective of the Course: To know about rate of reaction, factors affecting, theories of chemical kinetics, conductance, its types, theory of weak and strong electrolytes, electrode potential, cell EMF, electrochemical cells, etc. This course also provides the knowledge aboutnitro compounds, amines (Aliphatic and Aromatic), diazzonium salts, heterocyclic compounds (furan, thiophene, pyrrole, and pyridine) and their characteristic reactions.

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

1. Understand the scope of chemical kinetics, factors affecting rate of reaction, integrated rate law for different order reactions, theories of chemical kinetics
2. Conductance, applications of conductivity measurements, Conductometric titrations.
3. Electrolytic and electrochemical cell, electrochemical series, standard electrode potential.
4. Preparation and chemical reactions of aliphatic and aromatic nitro compounds, amines, and diazonium compounds
5. Introduction and basic Nomenclature of heterocyclic compounds, method of synthesis, mechanistic view of various reactions of pyrrole, furan, thiophene and pyridine

Syllabus:

UNIT I

Chemical Kinetics: Introduction and its scope, rate of a reaction, factors influencing rate of reaction; mathematical characteristics of simple chemical reactions- zero order, first order, second order, pseudo order, half life and mean life, determination of the order of reaction-differential, integration, half life period and isolation methods, radioactive decay as a first order phenomenon. Theories of chemical kinetics- Arrhenius equation and activation energy,

collision theory and transition state theory, introduction and type of catalysis, specificity and selectivity, enzyme catalysis and Michalis-Menten mechanism.

UNIT II

Electrochemistry-I: Charge transport, conductance in metals and electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution and temperature. Migration of ions and Kohlrausch law, Arrhenius theory of electrolytic dissociation, Ostwald dilution law, Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only).

Applications of conductivity measurements- determination of degree of dissociation, acid dissociation constant (K_a), solubility product of sparingly soluble salts, conductometric titrations.

UNIT III

Electrochemistry-II: Types of reversible electrodes – gas-metal ion, metal-metal ion, metal insoluble salt-anion and redox electrodes, electrode reactions, Nernst equation-derivation of cell E.M.F,single electrode potential,standard hydrogen electrode,reference electrodes, standard electrode potential, electrochemical chemical series and its significance.

Electrochemical Cells: Electrolytic and Galvanic cells- reversible and irreversible cells, conventional representation of electrochemical cells.EMF of a cell and its measurements, computation of cell EMF,calculation of thermodynamic quantities of cell reactions (ΔG, ΔH & K) and overpotential.

UNIT IV

Nitro compounds: Preparation of nitro compounds (Aliphatic and Aromatic), reactivity of nitro substituted arenes,chemical reactions and uses of primary nitro compounds and nitrobenzene.

Amines: Preparation and chemical reactions of amines (Aliphatic and Aromatic), properties and uses of primary amino compounds, aniline, acetanilide, nitroanilines.

Basic strength of amines - similarities and differences between aliphatic and aromatic amines

Diazonium Salts: Preparation, properties and synthetic uses of benzene diazonium salt, diazo coupling and its mechanism.

UNIT V

Heterocyclic Compounds: Introduction and basic nomenclature, molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, preparation and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, mechanism of nucleophilic substitution reactions in pyridine derivatives, comparison of basicity of pyridine, piperidine and pyrrole.

E-resources:

1. https://www.vssut.ac.in/lecture_notes/lecture1425072667.pdf
2. https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000661/M019105/ET/1515648331CHE_P6_M25_e-Text.pdf
3. https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/heterocy.htm
4. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202003291608409191arun_sethi_Diazonium_compounds.pdf
5. https://uou.ac.in/sites/default/files/slm/BSCCH-202.pdf

Reference books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. A Text Book of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2002.
4. The Elements of Physical Chemistry; P.W. Atkins; Oxford University Press, 1996.
5. Physical Chemistry; Seventh Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 1987
6. Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Wiley Eastern Ltd, New Delhi, 2001.

Semester IV

Chemistry Lab 4: CHE6003P

Chemical Analysis Lab-IV

Code of the course: CHE6003P

Title of the course: Chemical Analysis Lab-IV

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline/Subject

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. Synthesis of Inorganic complexes and organic compounds 20 Marks

Inorganic Complexes

(a) Preparation of sodium trisoxalato ferrate (III)

(b) Preparation of Ni-DMG complex.

(c) Preparation of cis-and trans-bisoxalatodiaquo chromate (III) ion.

(d) Cuprous chloride

(e) Sodium thiosulphate

(f) Ferrous sulphate from Kipp's waste

(g) Mercury tetrathiocyanate

Organic Synthesis

(a) Acetylation of salicylic acid, aniline, glucose and hydroquinone, benzoylation of aniline and phenol.

(b) Aliphatic electrophilic substitution: Preparation of iodoform from ethanol and acetone.

(c) Aromatic electrophillic substitution-

Preparation of m-dinitrobenzene from nitrobenzene.

Preparation of p-nitroacetanilide from acetanilide.

Preparation of p-bromoaccetanilide from acetanilide.

Preparation of 2,4,6-tribromophenol from phenol.

(d) Diazotization/coupling - Preparation of methyl orange and methyl red.

(e) Oxidation: Preparation of benzoic acid from toluene

(f) Reduction: Preparation of aniline from nitrobenezene.

2. Thin Layer Chromatography : 10 Marks

Determination of Rf values and identification of organic compounds.

(a) Separation of green leaf pigments (spinach leaves may be used)

(b) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5)

Paper Chromatography: Determination of Rf values and identification of organic compounds in a mixture of amino acids / monosaccharides.

3. Physical Chemistry: 30 Marks

(a) First order reaction kinetics: Acid hydrolysis of an ester
(b) Second order reaction kinetics: base hydrolysis of an ester (saponification)
(c) Determination of cell constant of a given cell.
(d) Determination of specific and equivalent conductance of the given electrolyte (NaCl) at different dilutions
(e) Conductometric titrations of Strong Acid-Strong Base, Strong Acid-Weak Base, Weak Acid-Strong Base, Weak Acid-Weak Base.

4. Viva-Voce 10 Marks

5. Evaluation of record book of experiments performed in semester. 10 Marks

E-resources

1. https://mobiroderic.uv.es/bitstream/handle/10550/77746/Handout%20LQI_II_revised.pdf?sequence=1&isAllowed=y
2. https://www.youtube.com/watch?v=DdGToO-qbY8
3. https://lab-training.com/thin-layer-chromatography-tlc/
4. https://www.chm.uri.edu/mmcgregor/chm114/chm114exp2.pdf
5. https://www.youtube.com/watch?v=QfS1DSOw3Og

References:

1. Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
2. Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.

Semester V

DSE-1 :CHE7300T

Spectroscopy and Instrumental Techniques

Code of the Course: CHE7300T

Title of the Course: Spectroscopy and Instrumental Techniques

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) course for chemistry discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Intermediate level courses.

Objectives of the Course: This course focuses on the principles and applications of various instrumental techniques used in chemistry. It covers topics such as electromagnetic radiation, UV-Visible, AAS (Atomic Absorption Spectroscopy), and IR (Infrared) spectroscopy, mass spectrometry, chromatography, NMR (Nuclear Magnetic Resonance) spectroscopy, potentiometry, voltammetry, and flame photometry. The course provides a comprehensive understanding of these analytical techniques and their role in chemical analysis and characterization.

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

1. Understand the electromagnetic radiation, interaction of light with matter and the determination of absorption spectra, principles, instrumentation and applications of UV-Visible, AAS, FT-IR spectroscopy.
2. Explain the principles of mass spectrometry and its applications in determining molecular mass, molecular structure, and isotopic composition.
3. Understand the principles and various types of chromatography, including gas chromatography, liquid chromatography, and thin-layer chromatography, and apply these techniques to separate and analyze complex mixtures.
4. Interpret NMR spectra to determine the structure and composition of organic compounds, including the identification of functional groups and stereochemistry.
5. Explain the principles and applications of potentiometric analysis including voltammetry, cyclic voltammetry, flame photometry and its applications.

Overall, the course aims to equip students with a strong foundation in analytical techniques

used in chemistry, enabling them to apply these techniques effectively in various scientific and industrial settings.

Syllabus:

UNIT I

Introduction to spectroscopic methods of analysis: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, Beer-Lambert's law, classification of analytical methods and the types of instrumental methods, consideration of electromagnetic radiation.

UV-Visible Spectroscopy: Basic principle, molar absorbtivity, types of electronic transitions, effect of conjugation and solvents, instrumentation (choice of source, monochromator and detector) for single and double beam instruments, and applications of UV-Vis spectroscopy.

Atomic Absorption Spectroscopy (AAS): Introduction, principle, sample atomization, flame atomizer, types of flames, factors affecting atomization efficiency, radiation sources-HCL, EDL and instrumentation for AAS, standard addition, internal standard method of analysis and applications of AAS.

(12 Lecture hours)

UNIT II

Infrared spectroscopy: Basic principle, Hooke's law, mode of molecular vibrations, finger print and functional group region, structural illustration through interpretation of data (common functional groups), instrumentation (choice of source, monochromator & detector), sampling techniques and applications of IR spectroscopy.

Mass spectrometry: Basic principle, fragmentation methods (EI, CI, electrospray, ED, LD, FAB), fragmentation of simple organic molecules, base peak, molecule ion peak, and brief idea about instrumentation, and applications of mass spectrometry.

(12 Lecture hours)

UNIT III

Chromatography: Classification, basic principle, mechanism of separation- adsorption, partition and ion exchange, development of chromatograms-frontal, elution and displacement methods, qualitative and quantitative aspects of chromatographic methods of analysis- paper chromatography, TLC (Thin Layer Chromatography), HPLC (High-Performance

Chromatography) and GLC (Gas Liquid Chromatography).

(12 Lecture hours)

UNIT IV

Nuclear Magnetic Resonance Spectroscopy: Introduction, basic principle, instrumentation, nuclear shielding and deshielding, chemical shift, factors affecting chemical shift, spin-spin interaction, coupling constant, area of signals, interpretation of PMR spectra of organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone.

(12 Lecture hours)

UNIT V

Potentiometry: Basic principle, instrumentation, ion-selective electrodes,applications of ion-selective electrodes.

Voltammetry: Basic principle, instrumentation, classification (cyclic voltammetry, linear sweep voltammetry, and pulse voltammetry), and applications.

Flame Photometry: Basic principles, instrumentation, and applications.

(12 Lecture hours)

E-resources:

1. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/110
2. https://swayam.gov.in/explorer
3. https://swayamprabha.gov.in/index.php/search
4. https://swayamprabha.gov.in/index.php/module_details
5. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

Reference Books:

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook ofQuantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. Instrumental Methods of analysis, 7thEd. Wadsworth Publishing Company Ltd., 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, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles
8. Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
9. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.
10. Donald L. Pavia, Thompson. Introduction to Spectroscopy: 2009.

Semester V

DSE Lab-1 :CHE7300P

Elective Chemistry Lab-I

Code of the Course: CHE7300P

Title of the Course: Elective Chemistry Lab-I

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

1. Colorimetric analysis **30 Marks**

a) To verify Beer-lambert law for $KMnO_4$/ $CoCl_2$ using colorimetric analysis.

b) Job's Method

c) Mole-ratio Method

2. Potentiometric analysis **30 Marks**

a) To titrate the given ferrous ammonium sulphate (FAS) solution using $KMnO_4$ as titrant and calculate the redox potential of Fe^{2+}/Fe^{+3} system on hydrogen scale.

b) To determine the strength of HCl/CH_3COOH by titrating with NaOH solution potentiometrically.

Spectroscopy

To elucidate the structure of organic compounds with the help of UV, IR and NMR spectra.

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. https://chemistlibrary.files.wordpress.com/2015/05/practical-inorganic-chemistry-1984-vorobyova-dunaeva-ippolitova-tamm.pdf
2. https://nie.lk/pdffiles/other/eALOM%20Chemistry%20Practical%20Handbook.pdf
3. https://www.youtube.com/watch?v=9WO9ggFEtp8
4. https://www.youtube.com/watch?v=WDx4lQUYBUk&t=111s

Reference Books:

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. *Vogel's Textbook of Quantitative*

Chemical Analysis, John Wiley & Sons, 1989.

2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York,2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
7. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. *Analytical Chemistry; Methods of Separation*, van Nostrand, 1974.

Semester V

DSE 2: CHE7301T

Green and Sustainable Chemistry

Code of the Course: CHE7301T

Title of the Course: Green and Sustainable Chemistry

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: DSE

Delivery type of the course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Intermediate level courses.

Objectives of the course: This course collectively aims to advance the adoption of green chemistry principles, hazardous waste, explore sustainable alternatives in solvents and reagents, understand environmental chemistry, and develop expertise in pollution analysis to foster a greener and more sustainable chemical industry.

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

1. Understand and explain the importance of using environmentally friendly practices in chemistry.
2. Identify and assess the use of eco-friendly solvents in chemical processes to reduce harm to the environment.
3. Use safer and greener reagents to design and improve chemical reactions.
4. Analyze and understand how pollutants behave in the environment and develop solutions to prevent and remediate pollution.
5. Learn and apply techniques to measure and evaluate pollution levels in different environments.
6. Propose innovative solutions to environmental challenges in the chemical industry.
7. Effectively communicate scientific concepts and findings related to environmental issues.
8. Consider the ethical and social impact of chemical processes and suggest sustainable alternatives.
9. Work well in teams to address environmental problems in chemistry.
10. Stay updated on new developments and continue learning about green chemistry and environmental practices.

Syllabus:

UNIT I

Green Chemistry: Introduction, definition, principles, atom economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions, reducing

toxicity.

Hazardous Waste-: Introduction, production, problems and preventions problem caused by waste, source of waste, waste minimization techniques.

(12 Lecture hours)

UNIT II

Green solvents: Supercritical fluids, water as a solvent for organic reactions, organic solvents, solvent-free systems, dry synthesis.

Green reagents: Introduction, toxic functional groups, examples of greener reagents and other polymer supported regents, solid state polymerization.

(12 Lecture hours)

UNIT-III

Green synthesis: Classification and applications of green synthesis including microwave assisted synthesis and ultrasound assisted synthesis, green synthesis of polycarbonates, paracetamol, ibuprofen, citral, adipic acid, urethane, styrene, phase transfer catalyst.

(12 Lecture hours)

UNIT-IV

Environmental chemistry: Oxygen and ozone chemistry, greenhouse gases and effect, sewage treatment, smoke formation acid rains, a brief idea of toxicological effects of arsenic, lead, cadmium, and pesticides.

(12 Lecture hours)

UNIT-V

Analysis of pollution: Sampling and monitoring of air and water, determination of total dissolved solids (TDS), conductivity, acidity, alkalinity, hardness, sulphate, chloride, DO, BOD, COD, water pollution laws and standards.

(12 Lecture hours)

E-Resources:

1. https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf
2. https://www.youtube.com/watch?v=EvoN6vmiCfI&list=PLKSeO-scpOo33zdDN0i2uw1Xh3zh_UfGO

Reference Books:

1. Green Chemistry: An Introductory Text, Mike Lancaster, Royal Society of Chemicals, Cambridge, 2002.
2. Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes, Edited by Paul T. Anastas & Tracy C. Williamson, Oxford University Press.
3. Green Chemical Syntheses and Processes: Edited by Paul T. Anastas, Lauren G. Heine & Tracy C. Williamson, ACS Symposium Series.
4. Green Chemistry: Environment Friendly Alternatives, Edited by Rashmi Sanghi, M. M. Srivastava, Narosa Publishing House, New Delhi.
5. Green Chemistry: Microwave Synthesis, K. R. Desai, Himalaya Publishing House.
6. Green Chemistry: A Teaching Resource, Dorothy Warren, Royal Society of Chemicals, 2001.
7. Green Chemistry: Williams, Charlotte.
8. Environmental Chemistry, S. E. Manahan, Lewis Publishers.
9. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
10. Environmental Chemistry, A. K. De, Wiley Eastern.
11. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
12. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.

Semester V

DSE Lab-2: CHE7301P

Elective Chemistry Lab-II

Code of the Course: CHE7301P

Title of the Course: Elective Chemistry Lab-II

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

1. **Green Synthesis** **30 Marks**
   a) Preparation of acetanilide
   b) Diels-Alder reaction between furan and maleic acid
   c) Benzil-benzilic acid rearrangement
   d) Nitration of phenol
   e) Synthesis of dibenzalpropanone
   f) Synthesis of adipic acid
   g) Bromination of acetanilide
2. **Use of enzymes as catalysts** **30 Marks**
   a) Biocatalysts (lipase, amylase, citrus fruit, yeast, etc) catalyzed reactions.
   b) Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.

   Alternative sources of energy
   a) Microwave-assisted synthesis of chalcones
   b) Photo-reduction of benzophenone to benzopinacol in the presence of sunlight.

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-Resources:

1. https://ia800206.us.archive.org/19/items/TextbookOfPracticalOrganicChemistry5thEd/VogelPracticalOrganicChemistry5thEditionnewfoundV_text.pdf
2. https://www.youtube.com/watch?v=OXPBuwatqco

3. https://www.youtube.com/watch?v=Y48UgKi33Ps
4. https://nie.lk/pdffiles/other/eALOM%20Chemistry%20Practical%20Handbook.pdf

Reference Books:

1. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
2. Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry,* American Chemical Society (2008).
3. Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society (2008).
4. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.
5. Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to OrganicLaboratory Techniques: A Microscale and Macro Scale Approach,* W.B.Saunders, 1995.
6. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013).

Semester V

DSE 3: CHE7302T

Polymer Chemistry

Code of the course: CHE7302T

Title of the course: Polymer Chemistry

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) course for chemistry discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Intermediate level courses of polymers, their structure and polymerization process.

Objectives of the Course: The course aims to strengthen the conceptual knowledge of polymers learn at school level and lay foundation for further learning of the subject through first course on polymers which is a prerequisite for higher courses in polymer chemistry.

Learning Outcomes:

1. It helps the students to invent, design, make and use materials for products, processes and services.
2. They deploy these activities based on an in-depth understanding of polymer processing, the structure of polymer and their properties, including the intricate relationships between them.
3. The general knowledge about the synthesis and mechanism of different polymers will be valuable in polymer and pharmaceutical industries.
4. Course helps to create skilled professionals who can operate in the design, fabrication, and testing of engineering materials.

Syllabus:

UNIT I

Polymeric materials: Introduction, history, classification, nomenclature, molecular forces and chemical bonding, texture of polymers.

Functionality and its importance: Formation of **s**ynthetic polymer, classification of polymerization processes, relationships between functionalities, extent of reaction and degree of polymerization, bifunctional systems, poly-functional systems.

(12 Lecture hours)

UNIT II

Type of polymerization: Condensation, addition polymerization, and their mechanism.

Kinetics of polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

(12 Lecture hours)

UNIT III

Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, morphology of crystalline polymers, factors affecting crystalline melting point.

Nature and structure of polymers- Structure Property relationships.

Determination of molecular weight of polymers (Mn, Mw, *etc.*) by end group analysis, viscometry, light scattering and osmotic pressure methods, molecular weight distribution and its significance, polydispersity index.

(12 Lecture hours)

UNIT IV

Glass transition temperature (Tg)**:** Introduction and its determination, free volume theory, WLF (Williams-Landel-Ferry) equation, factors affecting glass transition temperature (Tg).

Polymer Solution: Criteria for polymer solubility, solubility parameter, thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, lower and upper critical solution temperatures.

(12 Lecture hours)

UNIT V

Synthetic Polymers: Preparation, structure, properties (physical, thermal, Flow & Mechanical) and application of the following polymers- polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and poly(vinyl acetate), acrylic polymers, fluoro polymers, polyamides. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, polycarbonates, conducting polymers [polyacetylene, polyaniline, poly(p-phenylenesulphidepolypyrrole, polythiophene)].

(12 Lecture hours)

E-Resources:

1. https://www.vssut.ac.in/lecture_notes/lecture1541230922.pdf
2. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SCY1616.pdf

Reference Books:

1. Seymour, R.B. &Carraher, C.E. *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.
2. Odian, G. *Principles of Polymerization*, 4th Ed. Wiley, 2004.

3. Billmeyer, F.W. *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
4. Ghosh, P. *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
5. Lenz, R.W. *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers.

Semester V

DSE Lab3:CHE7302P

Elective Chemistry Lab-III

Code of the Course: CHE7302P

Title of the Course: Elective Chemistry Lab-III

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

1. S**ynthesis of Resins** **30 Marks**

a) Urea-formaldehyde resin
b) Phenol-formaldehyde resin
c) Novalac resin/resold resin

S**ynthesis of Polymers**

a) Preparation of nylon 66 or nylon 6
b) Preparation and purification of IPC (isophthaloyl chloride)
c) Preparation of polyester from (IPC) and phenolphthalein
d) Redox polymerization of acrylamide
e) Precipitation polymerization of acrylonitrile
f) Preparation of polyacrylamide and its electrophoresis

2. **Characterization and Analysis of Polymers** **30 Marks**

a) Determination of molecular weight by viscometry-
Polyacrylamide-aq.$NaNO_2$ solution and
Polyvinyl propylidine (PVP) in water
b) Determination of the viscosity-average molecular weight of poly(vinyl alcohol)(PVOH) and the fraction of “head-to-head” monomer linkages in the polymer.
c) Determination of molecular weight by end group analysis: Polyethylene glycol (PEG)(OH group).
d) Testing of mechanical properties of polymers.

e) Determination of hydroxyl number of a polymer using colorimetric method.

f) IR studies of polymers

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-Resources:

1. https://ia800206.us.archive.org/19/items/TextbookOfPracticalOrganicChemistry5thEd/VogelPracticalOrganicChemistry5thEditionnewfoundV_text.pdf
2. https://nie.lk/pdffiles/other/eALOM%20Chemistry%20Practical%20Handbook.pdf

Reference Books:

1. M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, *Contemporary Polymer Chemistry*, 3rd ed.Prentice- Hall (2003)
3. F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, *Polymer Science and Technology*, 2nd ed. Prentice-Hall (2003)
5. P. Munk& T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. JohnWiley & Sons (2002)
6. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley &Sons(2005)
7. M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press(2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Semester VI

DSE 4: CHE7303T

Organometallic Chemistry and Catalysis

Code of the Course: CHE7303T

Title of the Course: Organometallic Chemistry and Catalysis

Level of the Course: NHEQF Level 5.5

Credit of the Course: 6 (5+1)

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: Ninety hrs (75 hrs for lectures and 15 hrs tutorials).

Prerequisites: Intermediate level courses.

Objectives of the Course: This course provides an introduction to the fundamental concepts of organometallic compounds, metal alkyls, metal carbonyls, catalysis and organometallic catalysis. It covers topics such as nature of metal-carbon bond,multicenter bonding in metal alkyls, concept of aromaticity, structure, bonding and properties of metal carbonyls, homogenous catalysis and heterogenous catalysis. It also covers the basics of organometallic catalysis. The course aims to develop student's understanding of the fundamental principles underlying organometallic compounds and their applications in catalysis.

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

1. Understand the fundamentals of organometallic compounds, concept of the hapticity of organic ligands, EAN rule. Basics of Π-bonded organometallics such as alkene and alkyne complexes.
2. Describe and explain structure and bonding in methyl lithium (tetramer) and trialkyl aluminium (dimer), multicenter bonding in these compounds.
3. Explain structure and synthesis of ferrocene and learn its comparison with benzene.
4. To know the preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals, p-acceptor behaviour of carbon monoxide.
5. It covers the various aspects of catalysis, homogenous and heterogenous catalysis and their industrial applications.
6. Describe the General reaction involved in organometallic catalysis like oxidative addition, migratory insertion, and reductive elimination, isomerization and rearrangement.
7. Alkene metathesis, hydroboration, hydroamination, hydrosilation, hydrogenation, carbonylation, and the idea of C-C bond coupling.

Overall, the course aims to provide students with fundamentals about organometallic compounds, metal alkyls, metal carbonyls, catalysis, organometallic catalysis.

Syllabus:

UNIT I

Organometallic Compounds: Definition, nomenclature and classification of organometallic compounds on the basis nature of metal-carbon bond (ionic, s, p and multicentre bonds). Concept of hapticity of organic ligands, EAN rule. Structure and bonding of Π-bonded organometallics such as alkene and alkyne complexes.

(12 Lecture hours)

UNIT II

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkylaluminium (dimer), concept of multicentre bonding in these compounds.Ferrocene- Preparation and reactions (acetylation, alkylation, metallation, MannichCondensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

(12 Lecture hours)

UNIT III

Metal carbonyls: Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. pi-acceptor behavior of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies)

(12 Lecture hours)

UNIT IV

Catalysis: General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.

(12 Lecture hours)

UNIT V

Organometallic catalysis: General reaction involved in organometallic catalysis like oxidative addition, migratory insertion, and reductive elimination, isomerization and rearrangement. Alkene metathesis, hydroboration, hydroamination, hydrosilation, hydrogenation, carbonylation, C-C coupling reactions.

(12 Lecture hours)

E-Resources:

1. https://www.swayamprabha.gov.in/index.php/search

Reference Books:

1. Mehrotra R.C. and Singh, A. Organometallic Chemistry, New Age International Publishers, 2nd Ed, 2000.
2. Gupta B. D. and Elias A. J., Basic organometallic Chemistry, 2nd Ed., University Press(2013).
3. Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.
4. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
5. Collman, J. P. et al. Principles and Applications of Organo-transition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
6. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
7. Shriver D. E., Atkins P. W., Inorganic Chemistry, Oxford University Press, 5th Ed.
8. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed.2010.
9. Mallick, Madan and Tuli, Selected Topic in Inorganic Chemistry, S. Chand Publisher.17th Ed. 2010.
10. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
11. Cotton, F.A., Wilkinson, G., Murrillo, C. A., Bochmann, M., Advanced Inorganic Chemistry 6thEd. 1999.Wiley.
12. Boy Cornils, Wolfgang A. Herrmann, et al., Applied Homogeneous Catalysis with Organometallic Compounds: A Comprehensive Handbook in Four Volumes 3rd, 2017, Wiley.
13. R.D. Adams, Comprehensive Organometallic Chemistry II, Volume 10: Heteronuclear Metal and Metal Bonds 1st Ed., 2004 Pergamon.

Semester VI
DSE 5: CHE7304T

Molecules of Life

Code of the course: CHE7304T

Title of the course: Molecules of Life

Level of the Course: NHEQF Level 5.5

Credit of the Course: 6

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: Ninety hrs (75 hrs for lectures and 15 hrs tutorials).

Prerequisites: Intermediate level courses of biomolecules (carbohydrates, amino acids, lipids, fats) and their structure.

Objectives of the Course: The course aims to strengthen the conceptual knowledge of biomolecules, and lay the foundation for further learning of the subject through the first course on Biomolecules of life. It also focuses on comprehending the relationship between structure and function as well as nucleic acid structure and properties of lipids.

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

1. To offer detailed knowledge of biomolecules for living systems.
2. To understand sugars from monosaccharides to polysaccharides.
3. To provide basic concepts of structural organization and characterization of proteins.
4. To acquire knowledge on physicochemical properties and characterization of lipids.
5. To understand the structure of DNA and RNA and their types.

Syllabus:

UNIT I

Carbohydrates: Classification of carbohydrates, reducing and non-reducing sugars, general properties of glucose and fructose, their open chain structure.Epimers, mutarotation and anomers.Determination of configuration of glucose (Fischer proof), cyclic structure of glucose and fructose, Haworthprojections.Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) andpolysacharrides (starch and cellulose) excluding their structure elucidation.

(12 Lecture hours)

UNIT II

Amino Acids, Peptides and Proteins: Classification of amino acids, Zwitter ion structure and isoelectric point. Overview of primary, secondary, tertiary and quaternary structure of proteins, determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme).Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyl oxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

(12 Lecture hours)

UNIT III

Enzymes: Introduction, mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action(including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition(competitive and noncompetitive inhibition including allosteric inhibition).

(12 Lecture hours)

UNIT IV

Nucleic Acids: Components of nucleic acids-adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides, structure of DNA (Watson-Crick model) and RNA (**types of RNA**), genetic code, biological roles of DNA and RNA-replication, transcription and translation.

(12 Lecture hours)

UNIT V

Lipids: Introduction to lipids, classification, oils and fats-common fatty acids present in oils and fats, omega fatty acids, trans fats, hydrogenation, saponification value, iodine number, iodine value, acid value. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

(12 Lecture hours)

E-resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
4. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7th Ed.,* W. H. Freeman.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

Semester VI

DSE-6: CHE7305T

Advanced Physical Chemistry

Code of the course: CHE7305T

Title of the course: Advanced Physical Chemistry

Level of the Course: NHEQF Level 5.5

Credit of the Course: 6 (5+1)

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline/Subject

Delivery Type of the Course: Ninety hrs (75 hrs for lectures and 15 hrs tutorials).

Prerequisites: Intermediate level courses of physical chemistry

Objectives of the Course: To learn the basic principles involved in quantum chemistry, surface chemistry, solid state, phase rule, nuclear and radiochemistry, and macromolecules.

Learning Outcomes: After studying this paper, students will be able to:

1. Contextualise the connection between quantum mechanics and thermodynamics.
2. Describe the different ensembles and the fundamental aspects of chemistry.
3. Understand the electric double layer (edl) structure.
4. General concepts, principles, kinetics and methodology of polymerization and kinetics of chain growth and step growth polymerization.
5. Properties and applications of polymers.
6. Demonstrate an ability to describe, with confidence, the features of the most common crystalline structures.
7. Crystalline structure with the bonding to predict materials properties.
8. Different defect structures in the solid state and its effects on the materials properties.
9. Band theory to describe the operation of modern semiconductor devices.

Syllabus:

UNIT I

Quantum Chemistry: Introduction, Black-body radiation, photoelectric effect, Planck's radiation law, the heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and

its defects, Compton effect, de-Broglie hypothesis, Heisenberg's uncertainty principle, Sinusoidal wave equation, Schrodinger wave equation and its importance, postulates of quantum mechanics, operators, Hamiltonian operator, Eigen function and Eigenvalues, physical interpretation of the wave function.

Applications of quantum mechanics: Particle in the one-dimensional and two-dimensional box, Schrodinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen-like wave functions, radial and angular wave functions, selection rule and spectra of the hydrogen atom.

(15 Lecture hours)

UNIT II

Macromolecules: Nomenclature, Classification, properties of the polymer, mass of macromolecules, number average and weight average molecular mass, determination of molecular weight by osmotic pressure, viscosity and light scattering and sedimentation (ultra centrifuge) method.

Surface Chemistry: Surface tension, measurement of surface tension, factors affecting surface tension, sorption of surfaces, physical and chemical adsorption, factors effecting adsorption, applications of adsorption, Freundlich, Langmuir and Gibbs adsorption isotherms and their derivation, Streaming Potential electrophoresis and Electro-osmosis.

(15 Lecture hours)

UNIT III

Solid State: Definition of space lattice, unit cell, Bravias lattices, laws of crystallography- law of constancy of interfacial angles, law of rationality of indices, Weiss and Miller indices, law of symmetry, symmetry elements in crystals, classification of crystals, X-ray diffraction by crystals, derivation of Bragg equation, determination of crystal structure of NaCl, KCl and CsCl (Laue's method and powder method).

(15 Lecture hours)

UNIT IV

Heterogeneous Equilibria: Introduction to phase rule, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system-water, CO_2 and sulfur system, Phase equilibria of two-component system-solid-liquid equilibria, simple eutectic – Bi-Cd, Pb-Ag systems, desilverization of lead.

Solid solutions: compound formation with congruent melting point (Mg-Zn), ($FeCl_3$ – H_2O)

and incongruent melting point (NaCl-H_2O) and ($CuSO_4$ – H_2O) system, freezing mixtures.

(15 Lecture hours)

UNIT- V

Nuclear and Radiochemistry: Elementary idea of the nucleus, nuclear forces, packing fraction, mass defect and binding energy, nuclear fission and fusion reactions, calculation of Q - values of nuclear reactions, liquid drop and shell models of nucleus, theory of radioactivity, G. M. counter, half-life period, average life, radioactive disintegration, radioactive steady state, group displacement law, radioactive series, separation and identification of isotopes, application of radioactivity and radioactive tracers.

(15 Lecture hours)

E-Resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

Reference Books:

1. A Text Book of Physical Chemistry; A.S. Negi, S.C.Anand; New Age International (P) Limited, New Delhi, 2002.
2. Quantum Chemistry Including Molecular Spectroscopy; B.K. Sen; Tata McGraw-Hill, Publishing Company Ltd, New Delhi, 1996.
3. Introductory Quantum Chemistry; A.K. Chandra; Tata McGraw Hill Publishing Company Limited. New Delhi, 1998
4. Quantum Chemistry; R.K. Prasad; New Age International (P) Ltd., New Delhi, 2003.
5. Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Wiley Eastern Ltd, New Delhi, 2001.
6. Exploring Chemistry with Electronic Structure Methods- by James B. Frishman and A. Frisel, Gaussian, Inc. Pittsburge, PA
7. Principles of Physical Chemistry: B. R. Puri and L.R. Sharma.
8. Physical Chemistry, Pt. I & II: C.M. Gupta, J.K. Saxena and M. C. Purohit.
9. Physical Chemistry (Hindi Ed.): Suresh Ameta, R.C. Khandelwal, R. Ameta & J. Vardia, Himanshu Pub.

Semester IV

Skill Course 2: SES5320T

Chemical Laboratory Preparation

Code of the Course: SES5320T

Title of the Course: Chemical Laboratory Preparation

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Skill Course

Delivery Type of the Course: Thirty Lectures (20 hrs for content delivery and 10 hrs on diagnostic and formative assessment and subject/ class activity, problem solving)

Prerequisites: Chemistry of XII standard

Objective of the Course: Laboratory training is a frequently used skill to develop advanced study or research and also minimize the risk of injury or illness to laboratory workers.

Learning outcomes: After studying this course-

1. Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. Majors to be certified by the American Chemical Society will have extensive laboratory work.
2. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
3. Students will be skilled in problem-solving, critical thinking, and analytical reasoning as applied to scientific problems.
4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
5. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of the safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
6. Students will be able to function as a member of an interdisciplinary problem-solving team.

Syllabus:

UNIT I

Chemistry Laboratory: General introduction to chemistry lab, safety rules and precautions in the chemistry laboratory, storage, ventilation, lighting, fumes, cupboard, hazards, precautions, maintenance of laboratory, cleaning of laboratory, apparatus and preparation room.

6 Lecture hours

UNIT II

Laboratory Apparatus: Basic idea about equipment/apparatus, (glass apparatus, Heating apparatus, Stirrer, Oven, Melting point apparatus, Kipp's apparatus).

6 Lecture hours

UNIT III

Laboratory Reagents and Solvents: Reagents-classification of reagents according to their action (i) acids (ii) bases (iii) salts (iv) complexing agents (v) oxidizing and reducing agents (vi) precipitating agents (vii) chelating agents.

6 Lecture hours

UNIT IV

Concentration Terms – Percentage (Mass, Volume, Mass-Volume), Mole percent, Mole fraction, Mass ppm, ppb, g/L, molarity, normality, molality,

6 Lecture hours

UNIT V

Solution Preparation: Solutions, components of a solution, types of solution, solubility, calculation of masses and volumes for preparation of solutions and their practical approach

6 Lecture hours

E-Resources:

1. https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXI/chemistry/kelm201.pdfhttps://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXI/chemistry/kelm201.pdf
2. https://www.acs.org/education/policies/middle-and-high-school chemistry/laboratory.html
3. https://link.springer.com/referenceworkentry/10.1007/978-3-642-41609-5_39-1

References Books:

1. Vogel, Arthur I: A Textbook of Quantitative Inorganic Analysis (Rev. by GH Jeffery and others) 5th Ed. The English Language Book Society of Longman
2. Willard, Hobert H. et. al: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. New York-John Willy, 2004.
4. Harris, Daniel C, Quantitative Chemical Analysis, 3rd Edition, W.H. Freeman and

Company, New York, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry New Age, International Publisher, 2009.

Semester V

Skill Course 3: SES5321T

Food Preservation and Adulteration

Code of the Course: SES5321T

Title of the Course: Food Preservation and Adulteration

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Skill Course

Delivery Type of the Course: Thirty Lectures (20 hrs for content delivery and 10 hrs on diagnostic and formative assessment and subject/ class activity, problem solving)

Prerequisites: Chemistry of XII standard

Objective of the Course: Enable students to understand the types of adulterants in food, the effect of adulteration and the detection of adulterants in food. Develop awareness among students to prevent adulteration.

Learning outcomes: After studying the concept, students will be able to:

1. Understand how microorganisms spoil food.
2. Recall food preservatives examples and explain how they are used to preserve foods.
3. Know about chemical food preservatives.
4. Understand what is canning, drying and freezing food preservation.
5. Know what pickle is and how various types of foods are preserved as pickles.
6. Understand what pasteurization is and why pasteurized milk is better for consumption.

Syllabus:

UNIT I

Food Preservation: Introduction, techniques of food preservation, physical and chemical methods, the importance of food preservation, food preservatives and food packing.

6 Lecture hours

UNIT II

Adulterants in Food Products: Introduction, definition, types of food adulteration, methods of food adulteration, effect of food adulteration.

6 Lecture hours

UNIT III

Adulterants in milk and milk products, oil, fats, mustard oil and, sweetening agents (natural and artificial).

6 Lecture hours

UNIT IV

Adulteration in spices and pulses: Turmeric powder, coriander powder, Chili Powder, food grains and their products, (gram flour etc.).

6 Lecture hours

UNIT V

Detection and prevention of food adulteration, sugar in honey, rhodamine B in ragi, differentiation between iodized and common salts, food safety and regulatory authorities in India

6 Lecture hours

E-Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9818512/
2. https://www.fssai.gov.in/upload/media/FSSAI_News_Adulteration_Express_05_08_2020.pdf

References Books:

1. G. SubbuLakshmi, S. A. Udipi and P. S. Ghugre, Food Processing and Preservation, New Age International Publisher New Delhi, second edition, 2021.
2. N. N. Potter and J. H. Hotchkiss, Food Science, 5th edition, CBS Publishers India, 2007.
3. Shalini Sehgal, A Laboratory Manual of Food Analysis, Dreamtech (Wiley) Publishers, 2020.
4. Sahay Devina, Aahar Vigyan, New Age International Publisher New Delhi, first edition, 2019.

Semester VI

Skill Course 4: SES5322P

Water Pollution and Analysis

Code of the Course: SES5322P

Title of the Course: Water Pollution and Analysis

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Skill Course

Delivery Type of the Course: Thirty practical hours (20 hrs for the hands on experiments, observations and the record of the data and 10 hrs on diagnostic and formative assessment and subject/ class activity, problem solving)

Prerequisites: Chemistry of XII standard

Objective of the Course: Enable students to understand environmental problems, looking at causal linkages between pollution sources, exposure pathways, and impacts on environmental quality and human health.

Learning outcomes: After studying the concept:

1. Students will be able to describe the processes of and importance of groundwater flow and aquifer systems.
2. Students will be able to compare chemical interactions that occur in various hydrologic settings and their importance to water resources, geological and biological systems, and water/wastewater treatment.
3. Students will be able to describe the role water plays in atmospheric systems and the climate system.
4. Students will be able to describe the interactions between water systems and ecosystems.
5. Students will be able to describe the challenges of maintaining surface and groundwater quality.
6. Students will apply their knowledge base and research skills to current issues pertaining to water resources, management, and remediation, with emphasis on related economic, social, and public policy dimensions.

Syllabus:

1. **Pollution:** Definition, history, types of pollutants, pollution control and measures, types of chemical pollution with examples, impact on ecosystem, e-waste and its toxic effects.
   Water Analysis: Chemistry of water, physical and chemical properties, water resources, water pollution.
2. Important water quality parameters and methods for their determination, turbidity, color,

taste, pH, acidity, alkalinity, metals, hardness, dissolved oxygen, standard for drinking water as per WHO specifications.

Determination of BOD, COD, DO, alkalinity, total hardness of drinking water.

3. **Soil Analysis:** Introduction, characteristics of soil (soil texture and structure), composition of soil (inorganic, organic components, water and air in soil), soil organisms, soil profile, soil reactions (cation and anion exchange reactions), essential elements (macronutrients and micronutrients).

Scheme of Examination

i) Experiment (Any Two)	**60 Marks**
ii) Viva-Voce	**10 Marks**
iii) Evaluation of record book of experiments performed in semester.	**10 Marks**

E-Resources:

1. https://www.nrdc.org/stories/water-pollution-everything-you-need-know
2. https://home.iitk.ac.in/~anubha/WQ.pdf
3. https://in.video.search.yahoo.com/search/video;_ylt=AwrPqgVRWPhk2boPgsi7HAx.;_ylu=Y29sbwNzZzMEcG9zAzEEdnRpZAMEc2VjA3BpdnM-?p=Determination+of+BOD%2C+COD%2C+DO%2C+alkalinity%2C+total+hardness+of+drinking+water.&fr2=piv-web&type=E210IN1485G0&fr=mcafee#id=1&vid=3981992b1b957a4483620e9c1c8c63f2&action=view
4. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/environmental_c hemistry/14.soil_composition,_micro_and_macronutrients/et/4781_et_et.pdf https://youtu.be/w1D_wqesJqU
5. https://youtu.be/h1qSFZ9aw94

Reference Books:

1. P.K. Goel, Water pollution causes, effects and control,
2. W. K . Berry, Water pollution, CBS Publisher, 2017.
3. A. K. De, Environmental Chemistry, New Age International Publisher New Delhi, first edition, 2016.
4. M. N. Rao, Wastewater treatment, 3rd edition, Oxford & IBH Publishing, 2020.