IATION Curriculum Framework

Course structure of Chemistry

First Year – NHEQF Level- 4.5

[w.e.f. ACADEMIC SESSION 2026-27]

Course Category	Chemistry (B.Sc. 1st Year) Semester-I				
	Subject/Title	Paper Name (Theory)	No. of paper	Credits	
				T	P
Discipline Specific core (2 subjects)	DSC -I (Major) Chemistry	Atomic Structure, Bonding and General Organic Chemistry (Major)	1	3	-
	DSC -I (Major) Practical Chemistry	Practical - Inorganic Chemistry-I, Organic Chemistry-I (Major)	1	-	1
	DSC -I (Minor) Chemistry	Atomic Structure, Bonding and General Organic Chemistry (Minor)	1	3	-
	DSC -I (Minor) Practical Chemistry	Practical - Inorganic Chemistry-I, Organic Chemistry-I (Minor)	1	-	1
M.D/I.D. (Minor)-1 Subject	M.D/I. D (M)-I Environmental Chemistry	Environmental Chemistry and Pollutions (MD/ID)	1	3	-
	M.D/I. D (M)-I Practical Environmental Chemistry	Practical-Environmental Chemistry-I (MD/ID)	1	-	1
M.D/I.D (General)	M.D/I.D (G)-I	-	1	3	-
SEC/VAC	AEC-Communication Skills Or AMSC	-	1	3	-
VAC	Understanding and connecting with environment Or Life Skills & personality development	-	1	2	--
Total			9	17	3

NHEQF Level 4.5	***Student on exit after successfully completing first year (i.e., securing minimum required 40 credits + 4 Credits in*** one vocational course/skills-enhancement course of 4 credits***) will be awarded "Undergraduate Certificate" of one year, in related field/discipline/subject***

The student may opt for Communication Skills in one semester, and any one course from Additional Multidisciplinary skill Course (SEC--AMSC) in the other semester.

AMSC- Additional Multidisciplinary Skill Course (is offered as SEC)

List of Additional Multidisciplinary Skill course (SEC-AMSC) courses:

Following are the courses which will be offered by the University under AMSC under the 4-year U.G. program. University may add new courses under AMSC in future along with the following courses:

1. Plant Nursery Development and Management
2. Basic Yoga practices
3. Physical Education and Sports Management
4. Regional Folklores and their cultural context
5. Indian traditional music
6. Tour and travel Operations

M.D./I.D. (General)

Under the M.D./I.D. (General) category, students shall be offered a group of introductory-level courses, from which they shall be required to study one course in the first semester and one course in the second semester of their FYUP.

These courses are designed to broaden students' intellectual experience, foster interdisciplinary awareness, and form an integral component of liberal arts and science education, irrespective of the student's chosen core discipline.

Note: The seats distribution in Chemistry (major and minor) and Environmental Chemistry (MD/ID) will be done as per HNBGU Admission prospectus 2026-27 or guidelines.

Course Category	Chemistry (B.Sc. 1st Year) Semester-II				
	Subject /Title	Paper title (Theory)	No. of paper	Credits	
				T	P
Discipline Specific core (2 subjects)	DSC -II (Major) Chemistry	Chemical Energetics, Equilibria and Organic Chemistry (Major)	1	3	-
	DSC -II (Major) Practical Chemistry	Practical - Physical Chemistry-I and Organic Chemistry-II (Major)	1	-	1
	DSC -II (Minor) Chemistry	Chemical Energetics, Equilibria and Organic Chemistry (Minor)	1	3	-
	DSC -II (Minor) Practical Chemistry	Practical - Physical Chemistry-I and Organic Chemistry-II (Minor)	1	-	1
M.D/I.D (Minor)- 1 Subject	M.D/I.D (M) -II Environmental Chemistry	Atmospheric & Green Chemistry and Pollutions (MD/ID)	1	3	-
	M.D/I.D (M) -II Practical Environmental Chemistry	Practical-Environmental Chemistry-II (MD/ID)	1	-	1
M.D/I.D (General)	M.D/I.D (G) -II	-	1	3	-
SEC/VAC	AEC-Communication Skills Or AMSC	-	1	3	-
VAC	Understanding and connecting with environment Or Life Skills & personality development	-	1	2	-
Total			9	17	3

Course structure of Chemistry
Second Year – NHEQF Level- 5
[w.e.f. ACADEMIC SESSION 2026-27]

Course Category	Chemistry (B.Sc. 2nd Year) (Semester-III)				
	Subject/Title	Paper Name	No. of paper	Credits	
				T	P
Major-I (One Subject) Major	DSC (Major)-III Chemistry	Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry (Major)	1	4	-
	DSC (Major)-III Practical Chemistry	Practical - Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry (Major)	1	-	1
Minor-I (One Subject)	DSC (Minor)-III Chemistry	Solutions, Conductance, Electrochemistry & Functional Group Organic Chemistry (Minor)	1	3	-
	DSC (Minor)-III Practical Chemistry	Practical - Solutions, Conductance, Electrochemistry & Functional Group Organic Chemistry (Minor)	1	-	1
SEC	SEC (Major)-IV Chemistry	Green Chemistry and Pesticide Chemistry (SEC-Major)	1	3	-
M.D/I.D (Minor)	M.D/I.D (M)-III Environmental Chemistry	Environmental Pollution and Toxicology (MD/ID)	1	3	-
	M.D/I.D (M)-III Practical Environmental Chemistry	Practical-Environmental Chemistry-III (MD/ID)	1	-	1
AEC (Language based courses)	Indian, Modern, Regional Language-I	-	1	2	-
VAC/AEC	AEC-Indian Knowledge System Or VAC-Culture, traditions and moral values	-	1	2	-
Total			9	17	3

NHEQF Level 5	***Student on exit after successfully completing Second year (i.e., securing minimum required 80 credits + 4 Credits in*** one vocational course/skills-enhancement course of 4 credits***) will be awarded "Undergraduate Diploma" of two year, in related field/discipline/subject.***
IKS- Indian Knowledge System- AEC	
Culture, Traditions and Moral Values- VAC	
Students are required to study both courses — *Indian Knowledge System (IKS)* and *Culture, traditions and moral values* — during the 3rd and 4th semesters. However, they will have the flexibility to study one course in each semester.	
IMR Language- 'Indian, Modern, Regional Language'- Hindi, Sanskrit and English (Student have to study 2 different languages in the second year with one language in one semester and other language in another semester). One additional course titled **"Heritage of Indian Languages"** shall be offered, which students may opt for **in lieu of any one prescribed language course**, subject to the applicable regulations of the programme.	
The department may offer a 3-credit SEC Major course as either a fully theory-based or fully practical-based module.	
Note: Student will continue with the same Discipline specific major & Minor in the second year (III & IV Semester) as studied in the first year (I & II semester) of the FYUP.	

Course Category	Chemistry (B.Sc. 2nd Year) (Semester-IV)				
	Subject /Title	Paper Name	No. of paper	Credits	
				T	P
Major-I (One Subject) Major	DSC (Major)-V Chemistry	Coordination Chemistry, States of Matter and Chemical Kinetics (Major)	1	4	-
	DSC (Major)-V Practical Chemistry	Practical - Coordination Chemistry, States of Matter and Chemical Kinetics (Major)	1	-	1
Minor-I (One Subject)	DSC (Minor)-IV Chemistry	Coordination Chemistry, Kinetics of Gases and Chemical Kinetics (Minor)	1	3	-
	DSC (Minor)-IV Practical Chemistry	Practical - Coordination Chemistry, Kinetics of Gases and Chemical Kinetics (Minor)	1	-	1
SEC	SEC (Major)-VI Chemistry	Drugs, Dyes, and Cosmetics (SEC-Major)	1	3	-
M.D/I.D. (Minor)	M.D/I.D (M)-IV Environmental Chemistry	Basics of Waste Treatment and Environmental Monitoring (MD/ID)	1	3	-
	M.D/I.D (M)-IV Practical Environmental Chemistry	Practical-Environmental Chemistry-IV (MD/ID)	1	-	1
AEC (Language based courses)	Indian, Modern, Regional Language-II		1	2	-
VAC/AEC	AEC-Indian Knowledge System Or VAC-Culture, traditions and moral values		1	2	-
Total			9	17	3

B.Sc. First Year
First Semester
Chemistry Syllabus

B.Sc. First Year (I Semester)
DSC-I (Major and Minor)
Chemistry (Theory)
Paper Name: Atomic Structure, Bonding and General Organic Chemistry

Note: The syllabus for Chemistry Major and Minor is same as the number of credits are same for Major and Minor.

Credits: 03
Theory: 45 Hours
Section A: Inorganic Chemistry-1

Unit I. Atomic Structure (10 Hours)

Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Quantum mechanics, Schrödinger equation for hydrogen atom. Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Significance of quantum numbers, orbital angular momentum and quantum numbers. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, electronic configurations of the atoms. Stability of half- filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit II. Chemical Bonding and Molecular Structure (10 Hours)

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

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination for orbitals, MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

Section B: Organic Chemistry-1

Unit III. Fundamentals of Organic Chemistry (08 Hours)

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative

study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Huckel's rule.

Unit IV. Stereochemistry (07 Hours)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E/ Z Nomenclature (for upto two C=C systems).

Unit V. Aliphatic Hydrocarbons (10 Hours)

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. KMnO4.

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
5 Structure and Reactivity, Pearson Education India, 2006.
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
8 Edition, 2013.
9 Sykes, P. A Guide book to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (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.

B.Sc. First Year (I Semester)
DSC-I (Major and Minor)
Chemistry (Practical)
Paper Name - Practical - Inorganic Chemistry-I, Organic Chemistry-I

Note:

- **The syllabus for Chemistry Major and Minor is same as the number of credits are same for Major and Minor.**
- **The practical of the DSC-I (Major and Minor) Chemistry Practical course is Skill-based.**

Credits: 1

Practical: 30 Hours

Section A: Inorganic Chemistry-Volumetric Analysis (15 Hours)

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry (15 Hours)

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements).
2. Separation of mixtures by Thin Layer Chromatography: Measure the Rf value in each case (combination of two compounds to be given).

Reference Books:

1 Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2 Mendham, J.V ogel's Quantitative Chemical Analysis, Pearson, 2009.
3 Vogel,A.I., Tatchell, A. R., Furnis,B.S., Hannaford, A. J. & Smith, P. W. G., Text book of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4 Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.

B.Sc. First Year (I Semester)
Chemistry (M.D./I.D. (M)-I, Theory)
Environmental Chemistry
Paper Name: Environmental Chemistry and Pollutions

Credits – 03
Theory: 45 Hours

Unit I: Introduction to Environmental Chemistry and Pollution (10 Hours)

Environmental chemistry - introduction, Environmental segments – Lithosphere: components of soils, Hydrosphere: water resources, Biosphere, Atmosphere - regions of atmosphere – Troposphere, stratosphere, mesosphere, thermosphere. Environmental pollution – Concepts and definition – Pollutant, contaminant, receptor and sink – Classification of pollutants – Global, regional, local, persistent and non-persistent pollutants.

Unit II. Air Pollution (10 Hours)

Tropospheric pollution – Gaseous air pollutants – Hydrocarbons, oxides of sulphur, nitrogen and carbon – Global warming, greenhouse effect, acid rain – Particulates – Smog: London smog and photochemical smog – effects and control of photochemical smog – stratospheric pollution - depletion of ozone layer, chlorofluorocarbons - Automobile pollution. Control of air pollution – Alternate refrigerants – Bhopal Gas Tragedy.

Unit III. Water Pollution (15 Hours)

Impurities in water – cause of pollution – natural and anthropogenic – Marine water pollution – Underground water pollution. Sources of water pollution – Industrial waste, Municipal waste, Agricultural waste, Radioactive waste, Petroleum, Pharmaceutical, heavy metal, pesticides, soaps and detergents. Types of water pollutants: Biological agents, physical agents and chemical agents – Eutrophication - biomagnification and bioaccumulation. Water quality parameters: DO, BOD, COD, alkalinity, hardness, chloride, fluoride and nitrate. Toxic metals in water and their effects: Cadmium, lead and mercury – Minamata disaster, itai-itai disease, oil pollution in water. International standards for drinking water.

Unit IV. Soil Pollution (10 Hours)

Soil pollution: Sources by industrial and urban wastes. Pollution due to plastics, pesticides, biomedical waste, and e-waste (source, effects and control measures) – Control of soil pollution - Solid waste Management – Open dumping, landfilling, incineration, re-use, reclamation, recycle, composting. Non-degradable, degradable and biodegradable wastes. Hazardous waste.

Books Suggested:

1. A. K. De, Environmental Chemistry, 7th Edn., New Age International, 2012.
2. A. K. Ahluwalia, Environmental Chemistry, The Energy and Resources Institute, 2017.
3. Balram Pani, Textbook of Environmental Chemistry, I. K. International Pvt Ltd, 2010.
4. S. K. Banergy, Environmental Chemistry, 2nd Edn., Prentice-Hall of India Pvt. Ltd., 2005.
6. S. E. Manahan, Environmental Chemistry, 8th Edn., CRC Press, Florida, 2004.
7. A. K. Ahluwalia, Environmental Chemistry, The Energy and Resources Institute, 2017.
8. Balram Pani, Textbook of Environmental Chemistry, I. K. International Pvt. Ltd., 2010.
9. S. K. Banergy, Environmental Chemistry, 2nd Edn., Prentice-Hall of India Pvt. Ltd.,2005.
10. J. M. H. Selendy, Water and Sanitation-Related Diseases and the Changing Environment, John Wiley & Sons, 2011.

B.Sc. First Year (I Semester)
Chemistry (M.D./I.D. (M)-I, Practical)
Environmental Chemistry
Paper Name: Practical-Environmental Chemistry-I

Note: The practical of the Chemistry (M.D./I.D., Practical) of Environmental Chemistry course is Skill-based.

Credits: 01

Practical: 30 Hours

1. Estimation of the chlorine in water using Mohr's method.
2. Determine the total hardness of water.
3. Determination of the sulphate ion in water using turbidimetric method.
4. Estimate the biochemical oxygen demand of water.
5. Determination of pH of soil of different places using digital pH meter.
6. Preparation of 0.1N HCl or NaOH solution.
7. Electrical conductivity measurement of soil extract.
8. Practice environmental sampling techniques by collecting water or soil samples using grab and composite sampling methods and preserving them properly for analysis.
9. Determine the Biochemical Oxygen Demand (BOD) of a wastewater sample to evaluate the amount of biodegradable organic matter present.
10. Determine the Chemical Oxygen Demand (COD) of a water sample using a titration method to estimate total oxidizable pollutants.

Perform some of the experiments from the given list. Additional relevant practicals may also be performed depending on the resources available in the institution.

Reference Books:

1. A Laboratory Manual for Environmental Chemistry by R. Gopalan, Amirtha Anand, R. Wilgred Sugumar, I. K. International Pvt Ltd.
2. https://eee.poriyaan.in/topic/5--determination-of-chloride-content-of-water-sample-by-argentometric-method--mohr-s-method--10316/
3. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://egyankosh.ac.in/bitstream/123456789/43328/1/Exp-6.pdf
4. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://web.iitd.ac.in/~arunku/files/CEL212_Y13/Lab7%20BOD,COD.pdf

B.Sc. First Year
Second Semester
Chemistry Syllabus

Course Category	Chemistry (B.Sc. 1st Year) Semester-II				
	Subject /Title	Paper title (Theory)	No. of paper	Credits	
				T	P
Discipline Specific core (2 subjects)	DSC -II (Major) Chemistry	Chemical Energetics, Equilibria and Organic Chemistry (Major)	1	3	-
	DSC -II (Major) Practical Chemistry	Practical - Physical Chemistry-I and Organic Chemistry-II (Major)	1	-	1
	DSC -II (Minor) Chemistry	Chemical Energetics, Equilibria and Organic Chemistry (Minor)	1	3	-
	DSC -II (Minor) Practical Chemistry	Practical - Physical Chemistry-I and Organic Chemistry-II (Minor)	1	-	1
M.D/I.D (Minor)- 1 Subject	M.D/I.D (M) -II Environmental Chemistry	Atmospheric & Green Chemistry and Pollutions (MD/ID)	1	3	-
	M.D/I.D (M) -II Practical Environmental Chemistry	Practical-Environmental Chemistry-II (MD/ID)	1	-	1
M.D/I.D (General)	M.D/I.D (G) -II	-	1	3	-
SEC/VAC	AEC-Communication Skills Or AMSC	-	1	3	-
VAC	Understanding and connecting with environment Or Life Skills & personality development	-	1	2	-
Total			9	17	3

B. Sc. First Year (II Semester)
DSC-II (Major and Minor)
Chemistry (Theory)
Paper Name: Chemical Energetics, Equilibria and Organic Chemistry

Note: The syllabus for Chemistry Major and Minor is same as the number of credits are same for Major and Minor.

Credits: 03

Theory: 45 Hours

Unit I. Thermodynamics (07 Hours)

Review of thermodynamics and the Laws of Thermodynamics. 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 from thermochemical data. Variation of enthalpy of are action with temperature– Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit II. Chemical Equilibrium (05 Hours)

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and Go, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

Unit III. Ionic Equilibrium (08 Hours)

Ionic Equilibrium: 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 – applications of solubility product principle.

Unit IV. Alkyl Halides and Aryl Halides (10 Hours)

Alkyl Halides: (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides: Preparation, (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by–OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit IV. Alcohols and Phenols (10 Hours)

Alcohols Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenations and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten–Baumann Reaction.

Unit V. Aldehydes and Ketones (05 Hours)

Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from nitriles. Reactions– Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff-Kishner reduction. Meerwein-Pondorff Verley reduction.

Reference Books:

1 Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S. A. Organic Chemistry, John Wiley & Sons (2014).
2 McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3 Sykes, P. A Guide book to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4 Finar, I. L. Organic Chemistry (Vol. I & II), E.L.B.S.
5 Morrison, R. T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6 Bahl, A. & Bahl, B. S. Advanced Organic Chemistry, S. Chand, 2010.
7 Barrow, G. M. Physical Chemistry Tata McGraw-Hill (2007).
8 Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
9 Kotz, J. C., Treichel, P. M. & Townsend, J. R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
10 Mahan, B. H. University Chemistry 3rd Ed. Narosa (1998).
11 Petrucci, R. H. General Chemistry 5th Ed. Macmillan Publishing Co. New York (1985).

B. Sc. First Year (II Semester)
DSC-II (Major and Minor)
Chemistry (Practical)
Paper Name: Practical - Physical Chemistry-I and Organic Chemistry-II

Note:

- **The syllabus for Chemistry Major and Minor is same as the number of credits are same for major and minor.**
- **The practical of the DSC Chemistry (Practical) course is Skill-based.**

Credits: 01
Practical: 30 Hours

Section A: Physical Chemistry
Thermochemistry:
1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).

Ionic equilibria:
a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
b) Preparation of buffer solutions-
(i) Sodium acetate-acetic acid
(ii) Ammonium chloride-ammonium hydroxide

Section B: Organic Chemistry
1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed.
Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
(b) Benzoylation of amines /phenols
(c) Oxime and 2,4-dinitrophenyl hydrazone of aldehyde/ketone

Reference Books

1 Vogel, A.I., Tatchell, A. R., Furnis, B.S., Hannaford, A. J. & Smith, P.W.G., Text book of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2 Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.
3 Khosla, B.D.; Garg, V.C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co. New Delhi (2011).

B.Sc. First Year (II Semester)
Chemistry (M.D./I.D. (M)-II, Theory)
Environmental Chemistry
Paper Name: Atmospheric & Green Chemistry and Pollutions

Credits – 03
Theory: 45 Hours

Unit I: Atmospheric chemistry **(10 Hours)**

Introduction to atmospheric chemistry and its relevance with environment, Photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), Chemistry of particulate matters, aerosols; chemistry of acid rain, chemistry of NOx and SOx; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit II. Green chemistry **(15 Hours)**

Introduction to green chemistry and its relevance with environment, Principles of Green Chemistry, the concept of atom economy and chemical synthesis, Important techniques used in green chemistry. Application of green chemistry, viz. replacement of ozone depleting substances including CFCs, manufacture of biodegradable polymers, use of H_2O_2 as benign bleaching agents in paper industry.

Unit III. Noise pollution **(10 Hours)**

Noise pollution-sources; frequency, intensity and permissible ambient noise levels; measurement of noise indices (Leq, L10, L90, L50, LDN, TNI) effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; Noise abatement strategies.

Unit IV: Radioactive and thermal pollution **(10 Hours)**

Radioactive material and sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); radiation standards, radiation protection. Thermal Pollution-Sources of Thermal Pollution, Heat Islands, causes and effects of thermal pollution.

Reference Books:

1. Fundamentals of Air Pollution by Daniel A. Vallero, 6th Edition — April 25, 2025
2. Green Chemistry: Theory and Practice by Paul Anastas & John Warner — 1998 (First edition).
3. Green Chemistry: Environmentally Benign Reactions by V. K. Ahluwalia.
4. Green Chemistry: An Introductory Text by Mike Lancaster.
5. Textbook of Noise Pollution and Its Control by S.C. Bhatia — 2007.
6. Advanced Environmental Chemistry by V.K. Ahluwalia.
7. Environmental Chemistry: Fundamentals by Mohan Singh & Fregoso-.
8. Understanding Environmental Pollution by Marquita Hill — 4th Edition, 2022.
9. Environmental Chemistry: A Global Perspective by van Loon & Duffy — Latest edition 2017.

B. Sc. First Year (II Semester)
Chemistry (M.D./I.D. (M)-II, Practical)
Environmental Chemistry
Paper Name: Practical-Environmental Chemistry-II

Note: The practical of the Chemistry (M.D./I.D., Practical) Environmental Chemistry course is Skill-based.

Credits: 01

Practical: 30 Hours

1. Particulate Matter Collection with Sticky Slides: Coat glass microscope slides with Vaseline or tape and expose them indoors and outdoors for 24 hours. Observe under a microscope to compare PM deposition rates.
2. SO_2 Detection via Flame Color or Gas Sampling: Burn sulfur-impregnated material and pass combustion gas through lead acetate paper—turning it black due to SO_2. Alternatively, detect SO_2 in industrial area air using a simple bubbler + indicator solution (permanganate or pararosaniline).
3. Mini Acid Rain Simulation: Bubble generated NO_2 or SO_2 through distilled water and measure final pH. Use citric acid (a weak, safe acid) to mimic acid rain in a basic IA-style experiment
4. H_2O_2 as a Benign Bleach in Paper Whitening: Compare bleaching efficiency of H_2O_2 versus traditional chlorine bleach on fabric or paper strips—monitor color change, analyze oxidation via starch-iodide test.
5. Ambient Noise Measurement: Use a decibel meter (or smartphone app calibrated with standard source) in various settings (classroom, street, near traffic). Calculate indices like Leq by sampling A-weighted dB readings every minute and averaging.
6. Effect of Noise on Concentration: Conduct a simple attention task (e.g., sequential number recognition or reading comprehension) with and without simulated roadway or factory noise. Compare accuracy/time across conditions to illustrate cognitive impacts.
7. Heat a small water sample to 40–50 °C and add it to a larger sample at room temperature: Monitor dissolved oxygen levels (with a DO kit or simple indicator) to show how elevated temperature reduces aquatic oxygen levels.

   Perform some of the experiments from the given list. Additional relevant practicals may also be performed depending on the resources available in the institution.

Reference Books:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J.V ogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Vogel, A.I., Tatchell, A. R., Furnis, B.S., Hannaford, A. J. & Smith, P. W. G., Text book of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960. Environmental Chemistry in the Lab by David Peng.
5. Experiments in Environmental Chemistry: A Laboratory Manual – Classic manual with hands-on detection of atmospheric pollutants (NO_x, SO_2, oxidants) and radiation.

B.Sc. Second Year

Third Semester

Chemistry Syllabus

Course structure of Chemistry
Second Year – NHEQF Level- 5
[w.e.f. ACADEMIC SESSION 2026-27]

Course Category	Chemistry (B.Sc. 2nd Year) (Semester-III)				
	Subject/Title	Paper Name	No. of paper	Credits	
				T	P
Major-I (One Subject) Major	DSC (Major)-III Chemistry	Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry (Major)	1	4	-
	DSC (Major)-III Practical Chemistry	Practical - Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry (Major)	1	-	1
Minor-I (One Subject)	DSC (Minor)-III Chemistry	Solutions, Conductance, Electrochemistry & Functional Group Organic Chemistry (Minor)	1	3	-
	DSC (Minor)-III Practical Chemistry	Practical - Solutions, Conductance, Electrochemistry & Functional Group Organic Chemistry (Minor)	1	-	1
SEC	SEC (Major)-IV Chemistry	Green Chemistry and Pesticide Chemistry (SEC-Major)	1	3	-
M.D/I.D (Minor)	M.D/I.D (M)-III Environmental Chemistry	Environmental Pollution and Toxicology (MD/ID)	1	3	-
	M.D/I.D (M)-III Practical Environmental Chemistry	Practical-Environmental Chemistry-III (MD/ID)	1	-	1
AEC (Language based courses)	Indian, Modern, Regional Language-I	-	1	2	-
VAC/AEC	AEC-Indian Knowledge System Or VAC-Culture, traditions and moral values	-	1	2	-
Total			9	17	3

B.Sc. Second Year (III Semester)
DSC (Major)-III
Chemistry (Theory)
Paper Name: Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry

Credits: 04
Theory: 60 Hours
Section A: Physical Chemistry

Unit I. Solutions (10 Hours)

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

Unit II. Phase Equilibrium (8 Hours)

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

Unit III. Conductance (8 Hours)

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit IV. Electrochemistry (10 Hours)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations –qualitative treatment (acid-base and oxidation-reduction only).

Section B: Organic Chemistry

Unit V. Preparations & reactions of the following functional groups (10 Hours)

Carboxylic acids and their derivatives:

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell–Vohlard-Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Up to 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives.
Reformatsky Reaction, Perkin condensation.
Amines and Diazonium Salts:
Amines (Aliphatic and Aromatic):
Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.
Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten –Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.
Diazonium salts: *Preparation:* from aromatic amines. R*eactions:* conversion to benzene, phenol, dyes.

Unit VI. Amino Acids, Peptides and Proteins (7 Hours)

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.
Reactions of Amino acids: ester of –COOH group, acetylation of–NH_2 group, complexation with Cu2+ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

Unit VII. Carbohydrates (7 Hours)

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Reference Books:

• Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
• Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
• Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
• Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
• Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co.: New York (1985).
• Morrison, R. T. & Boyd, R.N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I.L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Finar, I.L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
• Nelson, D.L. & Cox, M.M. *Lehninger's Principles of Bioch*emistry *7th Ed.,* W.H. Freeman.
• Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

B.Sc. Second Year (III Semester)
DSC (Major)-III
Chemistry (Practical)
Paper Name: Practical - Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry

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Note: The practical of the DSC (Major)-III Chemistry Practical course is Skill-based.

Credits: 01

Theory: 30 Hours

Section A: Physical Chemistry

Distribution

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

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

$Cu^{2+}(aq) + xNH_2(aq) \longrightarrow [Cu(NH_3)x]^{2+}$

Phase equilibria

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

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

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

Conductance

I. Determination of cell constant

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

III. Perform the following conductometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

Potentiometry: Perform the following potentiometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

1. Systematic Qualitative Analysis of Organic Compounds containing functional groups (-COOH, phenolic, aldehydic, ketonic, amide, amines) and preparation of their derivatives.
2. Separation of amino acids by paper chromatography.
3. Determination of the concentration of glycine solution by formylation method.
4. Titration curve of glycine
5. Action of salivary amylase on starch
6. Effect of temperature on the action of salivary amylase on starch.
7. Differentiation between a reducing and a non-reducing sugar.

Reference Books:

- Vogel, A. I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Khosla, B. D.; *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

B.Sc. Second Year (III Semester)
DSC (Minor)-III
Chemistry (Theory)
Paper Name: Solutions, Conductance, Electrochemistry & Functional Group Organic Chemistry

Credits: 03
Theory: 45 Hours
Section A: Physical Chemistry

Unit I. Solutions (8 Hours)

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

Unit II. Conductance (7 Hours)

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit III. Electrochemistry (8 Hours)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations –qualitative treatment (acid-base and oxidation-reduction only).

Section B: Organic Chemistry

Unit IV. Preparations & reactions of the following functional groups (8 Hours)

Carboxylic acids and their derivatives:

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell–Vohlard-Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Up to 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:* Comparative study of nucleophilicity of acyl derivatives.

Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts:

Amines (Aliphatic and Aromatic):

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten –Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: *Preparation:* from aromatic amines. R*eactions:* conversion to benzene, phenol, dyes.

Unit V. Amino Acids, Peptides and Proteins (8 Hours)

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

Reactions of Amino acids: ester of –COOH group, acetylation of–NH_2 group, complexation with Cu2+ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

Unit VI. Carbohydrates (6 Hours)

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Reference Books:

• Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).

• Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).

• Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).

• Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).

• Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co.: New York (1985).

• Morrison, R. T. & Boyd, R.N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Finar, I.L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Finar, I.L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

• Nelson, D.L. & Cox, M.M. *Lehninger's Principles of Bioch*emistry *7th Ed.,* W.H. Freeman.

• Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

B.Sc. Second Year (III Semester)
DSC (Minor)-III
Chemistry (Practical)
Paper Name: Practical - Solutions, Conductance, Electrochemistry & Functional Group Organic Chemistry

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Note: The practical of the DSC (Minor)-III Chemistry Practical course is Skill-based.

Credits: 01

Theory: 30 Hours

Section A: Physical Chemistry

Distribution

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

$I_2\,(aq) + I^-\,(aq) \longrightarrow I_3^-\,(aq)$

$Cu^{2+}(aq) + xNH_2\,(aq) \longrightarrow [Cu(NH_3)_x]^{2+}$

Conductance

I. Determination of cell constant

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

III. Perform the following conductometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

iii. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

1. Systematic Qualitative Organic Analysis of Organic Compounds possess in mono functional groups (-COOH, phenolic, aldehydic, ketonic, amide, amines) and preparation of one derivative.
2. Separation of amino acids by paper chromatography
3. Determination of the concentration of glycine solution by formylation method.
4. Titration curve of glycine
5. Action of salivary amylase on starch
6. Effect of temperature on the action of salivary amylase on starch.
7. Differentiation between a reducing and a non-reducing sugar.

Reference Books:

- Vogel, A. I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman,1960.
  Khosla, B. D.; Garg, V.C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

B.Sc. Second Year
(III Semester)
Chemistry (SEC (Major)-IV, Theory)
Paper Name: Green Chemistry and Pesticide Chemistry

Note: The Chemistry (SEC (Major)-IV, Theory); Green Chemistry and Pesticide Chemistry course is Skill-based.

Credits: 03

Theory: 45 Hours

Unit I. Introduction of Green Chemistry (12 Hours)

Introduction: Definitions of Green Chemistry. Brief introduction of twelve principles of Green Chemistry with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability.

Unit II. Real world Cases in Green Chemistry (17 Hours)

Use of surfactants in supercritical carbon dioxide for precision cleaning and dry cleaning, replacing toxic solvents like perchloroethylene, the design of environmentally safe marine antifoulants, the development of right-fit pigments such as synthetic azo pigments to replace hazardous heavy-metal pigments, and the green synthesis of biodegradable polymers like poly lactic acid (PLA) from renewable resources such as corn, CO_2 as an eco-friendly industrial solvent, synthesis of greener pharmaceuticals, production of biodiesel and alternative fuels, catalytic and solvent-free reactions, and the design of recyclable and biodegradable materials.

Unit III. Pesticide Chemistry (16 Hours)

General introduction to pesticides (natural and synthetic), Types: Insecticides, Herbicides, benefits and adverse effects, changing concepts of pesticides, structure activity relationship. Biopesticides, uses and future perspectives Pesticidal poisoning, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines: Gammexene, Organophosphates (Malathion, Parathion, pyrethroids), Carbamates (Carbofuran and carbaryl); Quinones. Pheromones, repellents and rodenticides.

Reference Books:

- Anastas, P. T. & Warner, J.K. *Green Chemistry-Theory and Practical*, Oxford University Press (1998).
- Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
- Cremlyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, New York, 1978.

B.Sc. Second Year
(III Semester)
Chemistry (M.D/I.D. (M)-III, Theory)
Environmental Chemistry
Paper Name: Environmental Pollution and Toxicology

Credits: 03
Theory: 45 Hours

Unit I. Waste Classification **(10 Hours)**

Solid waste (municipal, industrial, agricultural), Hazardous waste (toxic, corrosive, reactive, flammable), Biomedical waste (infectious, pathological, sharps), E-waste (electronic components, heavy metals), Radioactive waste (low-level, high-level), Plastic waste and microplastics, Waste characteristics (toxicity, persistence, degradability), Sources and generation of waste, Waste segregation and labeling.

Unit II. Industrial Pollution **(10 Hours)**

Types of industries (petrochemical, textile, pharmaceutical, mining), Sources of industrial pollution, Industrial effluents (organic waste, dyes, acids, heavy metals), Air pollutants (SO_2, NO_x, CO, particulate matter, VOCs), Water pollution from industries, Soil contamination, Thermal pollution, Noise pollution from industries, Occupational exposure hazards, Industrial accidents and case studies.

Unit III. Heavy Metals & Hazardous Chemicals **(12 Hours)**

Mercury: sources, methylmercury formation, Minamata disease, Lead: sources, neurological and developmental effects, Cadmium: sources, Itai-itai disease, Arsenic: groundwater contamination, carcinogenic effects, Chromium, nickel, and other toxic metals, Persistent Organic Pollutants (POPs): DDT, PCBs, dioxins, Properties of POPs (persistence, bioaccumulation, transport), Pesticides (organochlorines, organophosphates, carbamates), Industrial chemicals and solvents, Emerging contaminants (pharmaceuticals, PFAS, microplastics, nanoparticles).

Unit IV: Environmental Toxicology **(13 Hours)**

Definition, scope, and importance of toxicology, Branches of toxicology (environmental, occupational, forensic), Classification of toxic substances (organic, inorganic, biological, radioactive), Sources of toxicants (natural and anthropogenic), Routes of exposure (inhalation, ingestion, dermal), Types of toxic agents (carcinogens, mutagens, teratogens, endocrine disruptors), Dose-response relationship (graded and quantal response), LD_{50}, ED_{50}, NOAEL, LOAEL, Threshold and non-threshold limits, Acute, chronic, sub-chronic toxicity, Local vs systemic toxicity, Factors influencing toxicity.

Reference Books:

- K. Maiti, Handbook of Methods in Environmental Studies Vol. 1: Water and Wastewater Analysis, 2004, 2nd Edition
- S. K. Maiti, Handbook of Methods in Environmental Studies: Air, Noise, Soil and Overburden Analysis, 2016, 1st Edition
- S. K. Panigrahi, L. Mohanty, Environmental Engineering Laboratory Manual, 2023, 1st Edition
- N. N. Basak, Laboratory Manual for Environmental Engineering, 2017, 2nd Edition
- M. R. Gidde, Environmental Engineering Laboratory Manual, 2013, 1st Edition
- William C. Lipps, Ellen Burton Braun-Howland, Terry E. Baxter, Standard Methods for the Examination of Water and Wastewater, 2023, 24th Edition
- E. W. Rice, R. B. Baird, A. D. Eaton, Standard Methods for the Examination of Water and Wastewater, 2017, 23rd Edition
- M. Alice Ottoboni, Patricia Frank, The Dose Makes the Poison: A Plain Language Guide to Toxicology, 2011, 3rd Edition
- S. C. Bhatia, Handbook of Industrial Pollution and Control, 2002, 1st Edition
- S. C. Bhatia, Managing Industrial Pollution, 2003, 1st Edition
- Des W. Connell, Gregory J. Miller, Chemistry and Toxicology of Pollution, 2022, 2nd Edition
- Richard J. Watts, Hazardous Wastes: Sources, Pathways, Receptors, 1998, 1st Edition.

B.Sc. Second Year
(III Semester)
Chemistry (M.D/I.D. (M)-III, Practical)
Environmental Chemistry
Paper Name: Practical-Environmental Chemistry-III

Note: The practical of the Chemistry (M.D./I.D., Practical) of Environmental Chemistry course is Skill-based.

Credits: 01

Practical: 30 Hours

Perform some of the experiments from the given list. Additional relevant practicals may also be performed depending on the resources available in the institution.

1. Study and classify different types of waste samples such as municipal, industrial, and agricultural waste based on their physical characteristics and sources.
2. Perform segregation of mixed waste into biodegradable, recyclable, and hazardous categories using standard labeling and identification methods.
3. Measure the pH of an industrial wastewater sample using a digital pH meter to assess its acidity or alkalinity.
4. Estimate the concentration of heavy metals such as lead or others in water using colorimetric or simple analytical methods.
5. Detect arsenic contamination in groundwater samples using standard chemical test kits or field methods.
6. Determine the presence of chromium or other toxic metals in industrial effluents through basic laboratory analysis.
7. Carry out water quality monitoring by measuring parameters such as turbidity, conductivity, and temperature.
8. Determine the moisture content of a given solid waste sample by drying it in an oven and calculating weight loss.
9. Analyze the biodegradable and non-biodegradable fractions of waste through manual sorting and percentage estimation.
10. Detect and separate microplastics from water or soil samples using filtration and microscopic observation techniques.
11. Estimate total suspended solids (TSS) in wastewater by filtration and drying method to assess pollution load.
12. Measure dissolved oxygen (DO) in a water sample using Winkler's method to evaluate water quality.
13. Conduct a noise level measurement in an industrial or roadside area using a sound level meter and analyze the results.
14. Perform extraction and basic analysis of pesticide residues from contaminated water or soil samples.
15. Study the dose-response relationship of a toxic substance using experimental data or simulation models.
16. Demonstrate bioaccumulation by modelling pollutant transfer through a simple food chain experiment.

Reference Books:

- S. K. Maiti - Handbook of Methods in Environmental Studies Vol. 1: Water and Wastewater Analysis, 2004, 2nd Edition
- S. K. Maiti - Handbook of Methods in Environmental Studies: Air, Noise, Soil and Overburden Analysis, 2011, 1st Edition
- S. K. Panigrahi & L. Mohanty - Environmental Engineering Laboratory Manual, 2023 - 1st Edition
- N. N. Basak, Laboratory Manual for Environmental Engineering, 2017, 2nd Edition
- M. R. Gidde - Environmental Engineering Laboratory Manual, 2013, 1st Edition
- APHA, AWWA, WEF - Standard Methods for the Examination of Water and Wastewater, 2017, 23rd Edition
- Sudha Goel - Laboratory Manual for Environmental Chemistry, 2017, 1st Edition.

B.Sc. Second Year
Fourth Semester
Chemistry Syllabus

Course Category	Chemistry (B.Sc. 2nd Year) (Semester-IV)				
	Subject /Title	Paper Name	No. of paper	Credits	
				T	P
Major-I (One Subject) Major	DSC (Major)-V Chemistry	Coordination Chemistry, States of Matter and Chemical Kinetics (Major)	1	4	-
	DSC (Major)-V Practical Chemistry	Practical - Coordination Chemistry, States of Matter and Chemical Kinetics (Major)	1	-	1
Minor-I (One Subject)	DSC (Minor)-IV Chemistry	Coordination Chemistry, Kinetics of Gases and Chemical Kinetics (Minor)	1	3	-
	DSC (Minor)-IV Practical Chemistry	Practical - Coordination Chemistry, Kinetics of Gases and Chemical Kinetics (Minor)	1	-	1
SEC	SEC (Major)-VI Chemistry	Drugs, Dyes, and Cosmetics (SEC-Major)	1	3	-
M.D/I.D (Minor)	M.D/I.D (M)-IV Environmental Chemistry	Basics of Waste Treatment and Environmental Monitoring (MD/ID)	1	3	-
	M.D/I.D (M)-IV Practical Environmental Chemistry	Practical - Environmental Chemistry-IV (MD/ID)	1	-	1
AEC (Language based courses)	Indian, Modern, Regional Language-II		1	2	-
VAC/AEC	AEC-Indian Knowledge System Or VAC-Culture, traditions and moral values		1	2	-
Total			9	17	3

B.Sc. Second Year (IV Semester)
DSC (Major)-V
Chemistry (Theory)
Paper Name: Coordination Chemistry, States of Matter and Chemical Kinetics

Credits: 04
Theory: 60 Hours
Section A: Inorganic Chemistry

Unit I. Transition Elements (3dseries) (8 Hours)

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 (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit II. Coordination Chemistry (7 Hours)

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

Unit III. Crystal Field Theory (10 Hours)

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

Section B: Physical Chemistry

Unit IV. Kinetic Theory of Gases (10 Hours)

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

Unit V. Liquids (5 Hours)

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

Unit VI. Solids (10 Hours)

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law.

Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Unit VII. Chemical Kinetics (10 Hours)

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Reference Books:

• Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
• Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
• Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India P vt. Ltd., New Delhi (2009).
• Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
• Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
• Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry,* Wiley.
• Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
• Wulfsberg, G. *Inorganic Chemistry,* Viva Books Pvt. Ltd.
• Rodgers, G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd. ,2008.

B.Sc. Second Year (III Semester)
DSC (Major)-V
Chemistry (Practical)
Paper Name: Practical - Coordination Chemistry, States of Matter and Chemical Kinetics

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Note: The practical of the DSC (Major)-V Chemistry Practical course is Skill-based.

Credits: 01

Theory: 30 Hours

Section A: Inorganic Chemistry

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+}, Cr^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+.

Anions: CO_3^{2-}, S^{2-}, SO_3^{2-}, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, SO_4^{2-}

(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as Bis-(dimethylglyoximato) nickel (II) or aluminium as oximate in a given solution gravimetrically.
2. Draw calibration curve (absorbance at λ max vs. concentration) for various concentrations of a given-coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.
3. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
5. Estimation of total hardness of a given sample of water by complexometric titration.

Section B: Physical Chemistry

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

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

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

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

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

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

(III) Chemical Kinetics

Study the kinetics of the following reactions.

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Reference Books:

• Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
• Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
• Khosla, B.D.; *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

B.Sc. Second Year (IV Semester)
DSC (Minor)-IV
Chemistry (Theory)
Paper Name: Coordination Chemistry, Kinetics of Gases and Chemical Kinetics

Credits: 03
Theory: 45 Hours
Section A: Inorganic Chemistry

Unit I. Transition Elements (3dseries) (8 Hours)

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 (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit II. Coordination Chemistry (7 Hours)

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

Unit III. Crystal Field Theory (10 Hours)

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

Section B: Physical Chemistry

Unit IV. Kinetic Theory of Gases (10 Hours)

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

Unit V. Chemical Kinetics (10 Hours)

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Reference Books:

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• Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
• Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India P vt. Ltd., New Delhi (2009).
• Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
• Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
• Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry,* Wiley.
• Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
• Wulfsberg, G. *Inorganic Chemistry,* Viva Books Pvt. Ltd.
• Rodgers, G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd. ,2008.

B.Sc. Second Year (IV Semester)
DSC (Minor)-IV
Chemistry (Practical)
Paper Name: Practical - Coordination Chemistry, Kinetics of Gases and Chemical Kinetics

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Note: The practical of the DSC (Minor)-IV Chemistry Practical course is Skill-based.

Credits: 01

Theory: 30 Hours

Section A: Inorganic Chemistry

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+}, Cr^3 $Co^{2+,+}$, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+.

Anions: CO_3^{2-}, S^{2-}, SO_3^{2--}, NO_2^-, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, SO_4^{2-},

(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as Bis (dimethylglyoximato) nickel (II) or aluminium as oximate in a given solution gravimetrically.
2. Draw calibration curve (absorbance at λ max vs. concentration) for various concentrations of a given-coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.
4. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.
5. Estimation of total hardness of a given sample of water by complexometric titration.

Section B: Physical Chemistry

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

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

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

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

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

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

(III) Chemical Kinetics

Study the kinetics of the following reactions.

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate.

c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

Reference Books:

• Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.

• Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

• Khosla, B.D.; *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

B.Sc. Second Year (IV Semester)
Chemistry (SEC (Major)-VI, Theory)
Paper Name: Drugs, Dyes, and Cosmetics

Note: The Chemistry (SEC (Major)-VI, Theory); Drugs, Dyes, and Cosmetics course is Skill-based.

Credits: 03

Theory: 45 Hours

Unit I. Drugs **(15 Hours)**

Introduction to drugs and pharmaceuticals, sources of drugs (plant, microbial, synthetic), classification of drugs (analgesics, antipyretics, anti-inflammatory, antibiotics, antihistamines, antacids, tranquilizers, etc.), routes of drug administration and dosage forms, drug design and development, basic concepts of pharmacodynamics and pharmacokinetics, synthesis and uses of common drugs such as aspirin, paracetamol and antibiotics, drug metabolism and environmental aspects of drugs

Unit II. Dyes **(15 Hours)**

Definition and classification of dyes, colour and chemical constitution (chromophore and auxochrome), natural and synthetic dyes, classification based on application and chemical structure, synthesis of important dyes (azo dyes, triphenyl methane dyes, indigo, etc.), dye intermediates and unit processes (nitration, sulphonation, diazotization), pigments and their properties, dyes used in textiles, food and cosmetics, environmental impact of dyes and dyestuff industry

Unit III. Cosmetics **(15 Hours)**

Definition and classification of cosmetics, skin, hair and nail physiology, cosmetic ingredients (emollients, surfactants, preservatives, fragrances), formulation and preparation of products such as creams, lotions, shampoos, lipsticks, powders and perfumes, herbal cosmetics and essential oils, sunscreens and personal care products, safety evaluation and regulatory aspects of cosmetics.

Reference Books:

- Medicinal Chemistry – Ashutosh Kar (8th Edition, 2023)
- An Introduction to Medicinal Chemistry – Graham L. Patrick (7th Edition, 2023)
- Principles of Medicinal Chemistry – Foye, Lemke & Williams (7th Edition, 2013)
- Industrial Chemistry – B.K. Sharma (Latest Edition, 2013)
- Engineering Chemistry – P.C. Jain & Monica Jain (2017 Edition)
- Ullmann's Encyclopedia of Industrial Chemistry (7th Edition, 2011–2014)
- Harry's Cosmeticology (8th Edition, 2015)
- Cosmetics: Formulation, Manufacturing & Quality Control – P.P. Sharma (2nd Edition, 2013)
- Cosmetics: Science and Technology – Balsam & Sagarin (2nd Edition, 2008)

B.Sc. Second Year (IV Semester)
Chemistry (M.D/I.D. (M)-IV, Theory)
Environmental Chemistry
Paper Name: Basics of Waste Treatment and Environmental Monitoring

Credits: 03
Theory: 45 Hours

Unit I. Waste Treatment Technologies (10 Hours)

Physical methods of waste treatment (filtration, sedimentation, centrifugation, adsorption), Chemical methods of waste treatment (neutralization, precipitation, oxidation-reduction, coagulation), Biological treatment of waste treatment (activated sludge process, trickling filters), Anaerobic digestion and biogas production, Composting and vermicomposting, Incineration and thermal treatment, Landfill design and management, Bioremediation and phytoremediation, Advanced oxidation processes, Sludge treatment and disposal.

Unit II. Waste Management Strategies (08 Hours)

Waste minimization techniques, 3Rs (Reduce, Reuse, Recycle), Resource recovery and energy recovery, Recycling technologies, Zero-waste concept, Circular economy principles, Sustainable waste management, Integrated waste management systems, Policies and regulations, Public awareness and participation, Green chemistry approaches.

Unit III. Environmental Monitoring and Laws and Policies (15 Hours)

Air quality modelling (Gaussian plume model), Meteorological influences on pollutant dispersion, Surface water quality modelling (rivers, lakes), Groundwater contamination modelling, Introduction to Geographic Information Systems (GIS), Spatial data analysis and mapping, Remote sensing: principles and platforms, Satellite data applications in environmental monitoring, Use of models in decision-making and policy. Evolution of environmental legislation, Key national environmental laws (air, water, forest, wildlife protection), Institutional framework and regulatory bodies, Environmental clearance procedures, Environmental standards and guidelines, Economic instruments (taxes, subsidies, carbon pricing), International environmental governance, Detailed study of Kyoto Protocol mechanisms, Key features of Paris Agreement, Role of international organizations (UNEP, IPCC), Compliance, enforcement, and penalties, Environmental policy analysis and implementation challenges.

Unit IV. Energy Resources and Environmental Impact (12 Hours)

Conventional energy sources (coal, petroleum, natural gas), Combustion chemistry and emissions, Air pollution from fossil fuels, Renewable energy (solar, wind, hydropower, geothermal), Solar photovoltaic cells and thermal systems, Biomass energy and biofuels (biogas, biodiesel, ethanol), Hydrogen economy and hydrogen fuel, Fuel cells (types and working principles), Nuclear energy (fission, fusion, radiation hazards), Radioactive waste management, Carbon cycle and greenhouse gases, Carbon footprint and carbon sequestration, Climate change and global warming, Life Cycle Assessment (LCA).

Reference Books:

- Mihelcic & Zimmerman – Environmental Engineering: Fundamentals, Sustainability, Design (3rd Edition, 2023)
- Masters & Ela – Introduction to Environmental Engineering and Science (3rd Edition, 2022)
- Metcalf & Eddy – Wastewater Engineering: Treatment and Resource Recovery (5th Edition, 2014 / latest reprints 2025–26)
- Mackenzie Davis – Principles of Environmental Engineering and Science (3rd Edition, 2022)
- Nazaroff & Alvarez-Cohen – Environmental Engineering Science (2024 Edition)
- B.K. Sharma – Industrial Chemistry (Latest commonly used edition, 2013 print)
- P.C. Jain & Monica Jain – Engineering Chemistry (2017 Edition)
- Ullmann's Encyclopedia of Industrial Chemistry (7th Edition, 2011–2014)
- Twidell & Weir – Renewable Energy Resources (3rd Edition, 2015)
- Ristinen & Kraushaar – Energy and Environment (2nd Edition, 2017)
- Divan & Rosencranz – Environmental Law and Policy in India (3rd Edition, 2017)
- Philippe Sands & Jacqueline Peel – International Environmental Law (4th Edition, 2018)

B.Sc. Second Year (IV Semester)
Chemistry (M.D/I.D. (M)-IV, Practical)
Environmental Chemistry
Paper Name: Practical-Environmental Chemistry-IV

Note: The practical of the Chemistry (M.D./I.D., Practical) of Environmental Chemistry course is Skill-based.

Credits: 01

Theory: 30 Hours

Perform some of the experiments from the given list. Additional relevant practicals may also be performed depending on the resources available in the institution.

1. Determine the pH of different water samples (tap water, river water, wastewater) using pH paper or a pH meter and compare their acidity/alkalinity.
2. Test hardness of water using soap solution and compare lather formation in different samples.
3. Determine total dissolved solids (TDS) in water using evaporation method and residue measurement.
4. Perform filtration of turbid water using sand and filter paper and study the reduction in suspended impurities.
5. Analyze corrosion rate of iron nails in different environments (salt water, distilled water, acidic water).
6. Study sedimentation by allowing muddy water to settle and measuring clarity improvement over time.
7. Demonstrate adsorption of dye from water using activated charcoal and observe color removal efficiency.
8. Perform coagulation using alum and determine its effectiveness in removing turbidity from water.
9. Carry out neutralization of acidic and alkaline solutions and observe pH changes using indicators.
10. Perform precipitation reaction (e.g., mixing salt solutions) to observe solid formation as a pollutant removal analogy.
11. Study oxidation–reduction reaction using simple reagents like potassium permanganate for color change observation.
12. Demonstrate biological treatment using a small model of activated sludge or aerated wastewater.
13. Study trickling filter principle using a bio-media column and observe microbial growth.
14. Study effect of detergents on water by comparing foam formation and persistence in different samples.
15. Prepare a simple buffer solution and test its resistance to pH change after adding acid/base.
16. Demonstrate CO_2 generation using acid and carbonate reaction and test gas using limewater.
17. Study biodegradation by comparing decomposition of organic waste and plastic under similar conditions.

18. Perform a simple life cycle analysis (LCA) of a plastic bottle or paper product using step-by-step observation from production to disposal.

Reference Books:

- Clair N. Sawyer, Perry L. McCarty & Gene F. Parkin, Chemistry for Environmental Engineering and Science 5th Edition, 2003.
- Metcalf & Eddy (Inc.), Wastewater Engineering: Treatment and Resource Recovery, 5th Edition, 2014.
- American Public Health Association (APHA), AWWA, WEF. Standard Methods for the Examination of Water and Wastewater, 23rd Edition, 2017.
- Mackenzie L. Davis, Principles of Environmental Engineering and Science, 3rd Edition, 2022.
- H.S. Peavy, D.R. Rowe & G. Tchobanoglous. Environmental Engineering, Reprint Edition, 2017.
- S.K. Garg. Environmental Engineering (Vol. I & II), Latest Edition, 2021.
- R. Gopalan, Laboratory Manual for Environmental Chemistry, 1st Edition, 2018.
- Sawyer, McCarty & Parkin (Alternate reference edition), Chemistry for Environmental Engineering, 4th Edition, 1994.