1. **Structure of the Programme:**

Curriculum Framework Syllabus
B.Sc. (Chemistry) 2023-24
L-6 (III Semester)

Level / Semester	Nature of Course	Courses Code	Course Title	MM	L	T	P	C
L-6 III Semester	Discipline Specific: Major	CHE-DSM-311	Physical and Organic Chemistry (Theory)	100	4	0	0	4
	Discipline Specific: Major	CHE-DSM-312	Physical and Organic Chemistry (Practical)	100	0	0	2	2
	Discipline Specific: Major	DSM-313	Other Department	100	6	0	0	6
	Multi Discipline Major	CHE-MDM-311	Chemistry of Biomolecules (Theory)	100	4	0	0	4
	Multi Discipline Major	CHE-MDM-312	Chemistry of Biomolecules (Practical)	100	0	0	2	2
	Ability Enhancement Course (AEC)	CHE-AEC-311	Basic Analytical Chemistry (Theory)	100	2	0	0	2
	Value Enhancement Course	VEC-311	Other Department					Qualifying
Total Credits								**20**

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Bachelor of Science – B.Sc.
Discipline Specific Major (DSM)
B.Sc. III Semester
CHE-DSM-311: Physical and Organic Chemistry (Theory)

Credit: 04	Time: 60 Hrs

Course Learning Objectives: Students will be empowered with basic to advance knowledge of Physical and Organic Chemistry.

Course Learning Outcomes: Upon successful learning, students will be able to

Unit I: Understand the chemistry and properties of liquid, solid and liquid crystals.

Unit II: Understand about electrochemistry, different types of cells, concept of standard electrode potential, EMF.

Unit III: Understand qualitative aspect of acid-base and redox processes and explore basic chemistry of alkyl and aryl halides, their preparation, and reactions.

Unit IV: Understand and explore the chemistry of alcohols and phenols, their synthesis, and reactions.

Unit V: Learn about the chemistry of ethers and carbonyl compounds, their synthesis and chemical reactions.

Unit I	**Liquid and Solid States** **Liquid state**: structure, and properties of liquids (a qualitative description). 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). Liquid crystals: classification and structure. **Solid State**: Nature of solid state, 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.	12
Unit II	**Electrochemistry:** 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: ΔG, ΔH and ΔS 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.	12
Unit III	**Potentiometric titrations:** Qualitative treatment (acid-base and oxidation-reduction only). **Alkyl Halides** (Up to 5 Carbons): Types of Nucleophilic Substitution (S_N1, S_N2 and SNi) reactions, effect of solvents etc. nucleophilic substitution vs elimination. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. **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 $NaNH_2/NH_3$). Relative reactivity of alkyl,	12

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	allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.	
Unit IV	**Alcohols (Up to 5 Carbons)** Preparation: Preparation of 1°, 2°and 3°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 diazoniumsalts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction, dihydric phenols.	12
Unit V	**Ethers** (aliphatic and aromatic): Williamson's ether synthesis, Cleavage of ethers with HI. **Aldehydes and ketones (aliphatic and aromatic):** (Formaldehye, acetaldehyde, acetoneand 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 (MPV) reduction.	12

Reference books:

1. P.W. Atkins, J.D. Paula, Elements of Physical Chemistry, Seventh Edition, Oxford University Press.
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004
3. G. M. Barrow, Physical Chemistry, 5th Edition, Tata McGraw Hill (2007).
4. K.L. Kapoor, A Textbook of Physical Chemistry, Vol. 3, 3rd Edition, McMillan.
5. R.A. Alberty, Physical Chemistry, 4th Edition, John-Wiley & Sons.
6. C.N.R Rao, University General Chemistry, 1st Edition, MacMillan India Ltd- New Delhi.
7. T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
10. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman
11. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

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Bachelor of Science – B.Sc.
Discipline Specific Major (DSM)
B.Sc. III Semester
CHE-DSM-312: Physical and Organic Chemistry (Practical)

Credit: 02	Time: 30 Hrs

Course Learning Objectives: To impart practical knowledge including procedure and applications of experimental Physical and Organic chemistry.

Course Learning Outcomes: Upon successful learning, students will be able to

- Understand the determination of specific rotation of optically active substance
- Learn the determination of kinetics of chemical reactions.
- Understand the phase equilibrium in study of binary system and to construct phase diagram.
- Learn the electrochemical investigation of ionizable compounds in solution.
- Understand the determination of solubility and thermodynamic parameters.
- Learn the qualitative analysis of monofunctional organic compounds and preparation of derivatives.
- Learn the practical synthesis, purification of some organic compounds, determinations of melting points and chemical yields.

Laboratory course

Physical Chemistry Laboratory

1. Determination of Specific Rotation of Cane Sugar.
2. Study the kinetics of the following reactions acid hydrolysis of methyl acetate or ethyl acetate
3. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
4. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
5. To perform the following conductometric titrations: Strong acid vs. strong base; Weak acid vs. strong base.
6. Study of the solubility of benzoic acid in water and determination of ΔH.

Organic Chemistry Laboratory

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements) by using zinc and sodium carbonate instead of metallic sodium.
2. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, nitro, amines, amide, anilides) and preparation of one derivative.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done. a) Acetylation of phenol/aniline. b) Benzoylation of amines/phenols.
   c) Oxime and 2,4dinitrophenylhydrazone of aldehyde/ketone.

Reference Books:

1. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.
2. J. N. Gurtu, Amit Gurtu, Advanced Physical Chemistry Experiments, Pragati Prakashan.
3. A. M. Halpern, & G.C. McBane, Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

4. V.D. Athawale and P. Mathur, Experimental Physical Chemistry, New Age International
5. A.I. Vogel, Textbook of Practical Organic Chemistry, Prentice Hall, 5thEdn.
6. A.I. Vogel, Text Books of Qualitative Organic Analysis, Pearson India; 2nd edition (1 January 2010)
7. A.I. Vogel: Text Book of Elementary Practical Organic Chemistry: Small Scale Preparation, Pearson India; 2nd edition (1 January 2010)
8. F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
9. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
10. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.
11. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Course In Practical Chemistry, New Central Book Agency Pv. Ltd.

Bachelor of Science – B.Sc.
Multidisciplinary Major (MDM)
B.Sc. III Semester
CHE-MDM-311: Chemistry of Biomolecules (Theory)

Credit: 04	Time: 60 Hrs

Course Learning Objectives: Students will be empowered with basic knowledge on chemistry of biomolecules and their importance.

Course Learning Outcomes: Upon successful learning, students will be able to

Unit I: Learn about the chemistry of amino acids, their structures, properties, chemical synthesis, and reactions.

Unit II: Understand the chemistry of peptides and proteins, their structures, properties, and synthesis.

Unit III: Learn about the chemistry of carbohydrates, their structures, properties, synthesis and chemical reactions.

Unit IV: Understand the basic chemistry of lipids and enzymes, their structures, properties, chemical and biochemical reactions and importance.

Unit V: Learn about the basic chemistry, structure of vitamins, nucleotides and nucleic acids.

Unit I	**Amino Acids** Structure and properties of amino acids. Zwitterion, Isoelectric point and Electrophoresis. Preparation of Amino Acids: Strecker synthesis, using Gabriel's phthalimide synthesis. Reactions of Amino acids: esterification of –COOH group, acetylation of $-NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test etc.	12
Unit II	**Peptides and 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 (up to dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) C-protecting & C-activating groups and Merrifield solid-phase synthesis. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins.	12
Unit III	**Carbohydrates:** 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 disacharrides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.	12
Unit IV	**Lipids:** Introduction to lipids, classification. oils and fats: common fatty acids present in oils and fats, omega fatty acids, trans fats, hydrogenation of unsaturated oils, saponification value, acid value, iodine number. reversion and rancidity. Biological importance of lipids. **Enzymes:** Nomenclature, classification, mechanism of enzyme action, coenzymes, cofactors, enzyme inhibitors and their importance.	12
Unit V	**Vitamins:** Introduction of vitamins. classification, Function, Deficiency of vitamins Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of Nucleic acids, Nucleosides, and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA, Biological roles of DNA and RNA.	12

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Reference books:

1. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
2. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
3. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
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 7th Ed., W. H. Freeman.

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Bachelor of Science – B.Sc.
Multidisciplinary Major (MDM)
B.Sc. III Semester
CHE-MDM-312: Chemistry of Biomolecules (Practical)

Credit: 02	Time: 30 Hrs

Course Learning Objectives: To provide basic concept on experimental methodologies of Chemistry of Biomolecules.

Course Learning Outcomes: Upon successful learning, students will be able to

- Understand the separation of organic compounds/biomolecules by chromatography
- Learn the qualitative tests of amino acids and sugars.
- Learn the quantitative estimation of amino acids and sugars.
- Determine the saponification value and iodine value of an oil/fat.
- Learn the quantitative estimation of Vitamin-C
- Understand the Extraction of DNA.

Laboratory course

1. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)
   a. Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine, or any other amino acid) by paper chromatography.
   b. Identify and separate the sugars present in the given mixture by paper chromatography.
2. Qualitative tests of amino acids and sugars.
3. Estimation of Amino acids by Titration methods.
4. Study of titration curve of glycine and determination of pKa of glycine.
5. Estimation of glucose/sucrose by titration using Fehling's solution.
6. Determination and differentiate between a reducing/ nonreducing sugars.
7. To determine the saponification value of an oil/fat.
8. To determine the iodine value of an oil/fat.
9. Vitamin-C/Ascorbic acid estimation by titration.
10. Extraction of DNA from onion/cauliflower.

Reference books:

1. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, ELBS.
2. Vogel, A. I. Vogel's Quantitative Chemical Analysis 6thEd., Prentice Hall.
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry,

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Universities Press.
4. K Wilson and J Walker, Principles and Techniques of Practical Biochemistry, 5th Ed. Oxford University Press, 2000.
5. S. Sadasivan and K Manikam, Biochemical Methods, 3rd Ed. New Age International (P) Ltd., 2007.
6. S. K. Sawhney and Randhir Singh, Introductory Practical Biochemistry, Narosa Publishing House.
7. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Course In Practical Chemistry, New Central Book Agency Pv. Ltd.

Bachelor of Science – B.Sc.
Ability Enhancement Course (AEC)
B.Sc. III Semester
CHE-AEC-311: Basic Analytical Chemistry (Theory)

Credit: 02 | Time: 30 Hrs

Course Objectives:
To inculcate the basic understanding of analytical chemistry and its interdisciplinary applications among the students.

Course learning outcomes: Upon successful learning, students will be able to
Unit I-Gather knowledge of basic and applied areas of Analytical Chemistry as well as how to present experimental data.
Unit-II- Measurement of important water quality parameters and adulterants in food items.
Unit-III- Understand the composition of soil and measurement of important parameters of soil.
Unit IV- To understand the basic concept of different types of chromatography and its applications.
Unit V-To develop concept about analysis of cosmetics and metal ions in various samples using classical and instrumental method of quantitative analysis.

Unit I	**Introduction:** Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.	06
Unit II	**Analysis of water:** Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. Determination of pH, acidity and alkalinity of a water sample. Determination of dissolved oxygen (DO) of a water sample. Analysis of food products: Nutritional value of foods, idea about food processing and food preservations and adulteration. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. Analysis of food preservatives and coloring matter.	06
Unit III	**Analysis of soil:** Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators, Determination of pH of soil samples. Estimation of Calcium and Magnesium ions by complexometric titration.	06
Unit IV	**Chromatography:** Definition, general introduction on principles of chromatography, paper chromatography TLC etc. Paper chromatographic separation of mixture of organic compounds and metal ions. To compare paint samples by TLC method. Column chromatography, ion- exchange chromatography. Gas Chromatography, Liquid Chromatography etc.	06
Unit V	**Analysis of cosmetics:** Major and minor constituents of cosmetics and their function. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration. **Suggested Applications (Any one):** a. To study the uses of phenolphthalein in trap cases.	06

	b. To analyze arson accelerants. c. To carry out analysis of gasoline. **Suggested Instrumental demonstrations:** a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry. b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets. c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.	

Reference Books:

1. Willard, H. H. Instrumental Methods of Analysis, CBS Publishers.
2. Skoog&Lerry. Instrumental Methods of Analysis, Saunders College Publications, New York.
3. Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth (1992).
4. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
5. Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
7. Freifelder, D. Physical Biochemistry 2ndEd., W.H. Freeman and Co., N.Y. USA (1982).
8. Cooper, T.G. The Tools of Biochemistry, John Wiley and Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7thEd., Prentice Hall.
10. Vogel, A. I. Vogel's Quantitative Chemical Analysis 6thEd., Prentice Hall.
11. Robinson, J.W. Undergraduate Instrumental Analysis 5thEd., Marcel Dekker, Inc., New York (1995).
12. Verma, R. M. Analytical Chemistry: Theory and Practice, Third Edition, CBS Publishers & Distributers.

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