B.Sc. Chemistry Program
(w.e.f. Session 2023-2024)
Scheme

3/4-Year Degree Program as per NEP-2020

DEPARTMENT OF CHEMISTRY

J. C. Bose University of Science and Technology, YMCA, Faridabad

NH-2, Sector-6, Haryana Pin-121006

Semester Wise Credits Distribution									
	Discipline Specific Major	**Minor/DSE**	**Multidisciplinary**	**Ability Enhancement Courses**	**Skill Enhancement Courses**	**Value Added Courses**	**Internship**	**Research Project/ Dissertation**	**Total Credits**
I	8	4	3	2	3	2	-	-	22
II	8	4	3	2	3	2	-	-	22
*A Student exiting the program after securing 48 credits will be awarded **UG Certificate in Chemistry** provided he/she secures 4 credits in work-based vocational courses offered during the summer term or an internship in Industry / University. **Exit Criteria 44+4=48 credits**									
III	12	4	3	2	2	2	-	-	25
IV	12	6	-	2	2	3	-	-	25
A Student exiting the program after securing 97 credits will be awarded UG Diploma in Chemistry provided he/she secures additional 4 credits in a skill-based Summer Internship in Industry/ University during the first-year or second-year summer term. **Exit Criteria 94+4=98 Credits**									
V	12	6	-	-	4	-	4	-	26
VI	12	6	-	-	4	-	-	-	22
A Student who wants to undertake a 3-year UG program will be awarded BSc Chemistry upon securing 142 credits. **Exit Criteria 142 Credits** **Students who secured 75 % and above marks till VI semester shall be eligible to opt for 'BSc Chemistry Hons with Research' Programme**									
VII	18/12	4	-	-	-	-	-	0/6	22
VIII	18/12	4	-	-	-	-	-	0/6	22
Total	**101/89**	**38**	**8**	**8**	**16**	**9**	**4**	**0/12**	**186**
A Student will be awarded UG Degree BSc Chemistry (Hons) / BSc Chemistry (Hons with Research) upon securing 186 credits.									

Semester - 1										
Sr. No.	**Category**	**Course Code**	**Course Title**	**Hours per week**			**Credits**	**Marks for Sessional**	**Marks for End Term Examination**	**Total**
				L	**T**	**P**				
1.	DSC-A1 / Major	BCHT-DS-101	Physical Chemistry - I	4	0	0	4	25	75	100
2.	DSC-A2-1/ Major	BCHP-DS-102	Inorganic Chemistry Lab – I	0	0	4	2	15	35	50
3.	DSC-A2-2/ Major	BCHP-DS-103	Physical Chemistry Lab - I	0	0	4	2	15	35	50
4.	MIC1-1 / Minor	BCHT-MI-104	Inorganic Chemistry - I	4	0	0	4	25	75	100
5.	MDC-1/ Multidisciplinary	BCHT-MD-105/ BCHT-MD-106/ BCHT-MD-107	Mathematics-I/Biology-I/Computer-I	3	0	0	3	25	75	100
6.	AEC1/ Ability Enhancement	AEC-101-N1	Writing Skills and the Art of Rhetoric (WSAAR)	2	0	0	2	25	75	100
7.	SEC1-1/ Skill Enhancement	BCHT-SE-108	Instrumentation Skills-I	2	0	0	2	25	75	100
8.	SEC1-2/ Skill Enhancement	BCHP-SE-109	Instrumentation Skills Lab-I	0	0	2	1	15	35	50
9.	VAC1/ Value Added Courses	VAC-101-N1	Environmental Studies – I (EVS-I)	2	0	0	2	25	75	100
	**** To be taken from other depts.**		**Total**	**17**	**0**	**10**	**22**	**195**	**555**	**750**

Semester - 2										
Sr. No.	**Category**	**Course Code**	**Course Title**	**Hours per week**			**Credits**	**Marks for Sessional**	**Marks for End Term Examination**	**Total**
				L	**T**	**P**				
1.	DSC-A3 / Major	BCHT-DS-201	Organic Chemistry - I	4	0	0	4	25	75	100
2.	DSC-A4-1 / Major	BCHP-DS-202	Organic Chemistry Lab - I	0	0	4	2	15	35	50
3.	DSC-A4-2 / Major	BCHP-DS-203	Physical Chemistry Lab – II	0	0	4	2	15	35	50
4.	MIC2-1 / Minor	BCHT-MI-204	Physical Chemistry - II	4	0	0	4	25	75	100
5.	MDC-2/ Multidisciplinary	BCHT-MD-205/ BCHT-MD-206/ BCHT-MD-207	Mathematics-II/Biology-II/Computer-II	3	0	0	3	25	75	100
6.	AEC2/ Ability Enhancement	AEC-102-N1	Communication, Meditation, and Resolution (CMR)	2	0	0	2	25	75	100
7.	SEC2-1/ Skill Enhancement	BCHT-SE-208	Instrumentation Skills-II	2	0	0	2	25	75	100
8.	SEC2-2/ Skill Enhancement	BCHP-SE-209	Instrumentation Skills Lab-II	0	0	2	1	15	35	50
9.	VAC2/ Value Added Courses	VAC-103-N1	Yoga and Meditation	2	0	0	2	25	75	100
	**** To be taken from other depts.**		**Total**	**17**	**0**	**10**	**22**	**195**	**555**	**750**
10.	Internship in Industry / University			0	0	8	4	-	-	-

Semester-I

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-DS-101	**Inorganic Chemistry - I**	**25 + 75 = 100**	**4**	**4**
		L – 4	**T - 0**	**P - 0**

Course Objectives:

- Learn basic concept of atom and its structure in detail.
- Arrangement of electrons in atom.
- Concept of s, p, d and f orbitals and their shape using.
- Understand nature of chemical bonding and concept of molecular orbitals

Learning Outcomes:

- The objective of the course is to make the students understand the basic concept of atom and atomic structure, periodic properties of elements and chemical bonding.

Course Content:

Unit-I **Atomic Structure: (15 Hrs)**

Atomic Structure: Recapitulation of Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance; Schrödinger's wave equation, the significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals; Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, aufbau principle and its limitations.

Unit-II **Periodicity of Elements (15 Hrs)**

Brief discussion of the following properties of the elements, with reference to *s* & *p*-block and the trends shown. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. Atomic and ionic radii. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization enthalpy and trends in groups and periods. Electron gain entahlpy and trends in groups and periods. Electronegativity, Pauling's/ Allred Rochow's scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

Unit-III **Chemical Bonding-I (15 Hrs)**

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy; Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of the following simple molecules and ions containing lone pairs and bond pairs of electrons: H_2O, NH_3, PCl_3, PCl_5, SF_6, ClF_3, I_3^-, BrF_2^+, PCl_6^-, $ICl_2^-ICl_4^-$ and SO_4^{2-}, Multiple bonding and bond lengths.

Unit-IV **Chemical Bonding-I (15 Hrs)**

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interaction. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment). Effects of weak chemical forces, melting and boiling points, solubility, energetics of dissolution process.

Suggested Books/Reading:

1. Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010
2. Huheey, J.E., Keiter, E.A., Keiter, R. L., Medhi, O.K. Inorganic Chemistry, Principles of Structure and Reactivity, Pearson Education 2006.
3. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
4. Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.
5. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

Semester-I

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-DS-102	**Physical Chemistry - I**	**25 + 75 = 100**	**4**	**4**
		L – 4	**T - 0**	**P - 0**

Course Objectives:

The objective of the course is to make the students understand the different states of matter and various laws governing the properties of solid, liquid and gaseous state. Emphasis will also be on the basic concept of ionic equilibrium and its applications.

Learning Outcomes:

- Learn the states of matter in detail.
- Laws governing the solid, liquid and gaseous state.
- Have a deep-understanding methods to study the solid, liquid and gaseous state.
- Concept of ionic equilibria and its applications.

Course Content:

Unit-I **Gaseous state (18 Hrs)**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of ζ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities; Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure and temperature for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour, calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit-II **Liquid state (6 Hrs)**

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Unit-III **Solid state (16 Hrs)**

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

Unit-IV **Ionic equilibria (20 Hrs)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Suggested Books/Reading:

1.	Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
2.	Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3.	Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4.	Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

Semester-I

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-DS-103	**Inorganic Chemistry Lab-I**	**15 + 35 = 50**	**4**	**2**
		L – 0	**T - 0**	**P - 4**

Course Objectives:

- To teach skills of preparation of solutions and basics of Tritimetry and Acid Base analysis.

Learning Outcomes:

- Student will be able to prepare different molar/normal solutions, understanding of estimation methods and their applicability for laboratory handling.

Course Content:

Unit-I **Titrimetric Analysis**

Calibration and use of apparatus
(i) Preparation of solutions of titrants of different Molarity/Normality

Unit-II **Acid-Base Titrations**

Principles of acid-base titrations to be discussed.
(i) Estimation of sodium carbonate using standardized HCl solution.
(ii) Estimation of carbonate and hydroxide present in a solution together in a mixture.
(iii) Estimation of carbonate and bicarbonate present in a solution together in a mixture.
(iv) Estimation of free alkali present in different soaps/detergents

Unit-III **Oxidation-Reduction Titrimetry**

Principles of oxidation-reduction titrations (electrode potentials) to be discussed.
(i) Estimation of Fe(II) and oxalic acid present in a solution using standardized $KMnO_4$ solution
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal indicator (diphenylamine, N-phenylanthranilic acid) and discussion of external indicator present in a solution.

Suggested Books/Reading:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS

Semester-I

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-DS-103	**Physical Chemistry Lab-I**	**15 + 35 = 50**	**4**	**2**
		L – 0	**T - 0**	**P - 4**

Course Objectives:

- To invoke physical property analysis and teach handling of glass apparatus for physical parameter measurements.
- To understand signatures of crystalline system and get practical understanding
- To imbibe Acid-Base handlining and their key aspect of acid-base analysis.

Learning Outcomes:

- Student will be able to characterize liquid properties, crystalline system and acid/bases

Course Content:

Unit-I	**Surface tension and Viscosity measurement**

1. Determine the surface tension by (i) drop number (ii) drop weight method in a solution.
2. Study the variation of surface tension with different concentration of detergent solutions. Determine CMC.
3. Determination of co-efficient of viscosity of an unknown aqueous solution.
4. Study the variation of co-efficient of viscosity with different concentration of Poly Vinyl Alcohol (PVA) and determine molar of PVA.
5. Study the variation of viscosity with different concentration of sugar solution.

Unit-II	**Solid State**

a. Indexing of a given powder diffraction pattern of a cubic crystalline system.

Unit-III	**pH metry**

a. Study the effect of addition of HCl/NaOH on pH to the solutions of acetic acid, sodium acetate and their mixtures.
b. Preparation of buffer solutions of different pH values: (i) Sodium acetate-acetic acid, (ii) Ammonium chloride-ammonium hydroxide
c. pH metric titration of (i) strong acid with strong base, (ii) weak acid with strong base.
d. Determination of dissociation constant of a weak acid.
Any other experiment carried out in the class.

Suggested Books/Reading:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.;McGraw-Hill: New York (2003).

Semester-I

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-SE-108	Instrumentation Skills-I	15 + 35 = 50	2	2
		L – 2	T - 0	P - 0

Course Objectives:

- To revise error estimation, qualitative and quantitative aspects of analysis.
- To study aspect of chemical system and solvent extraction.
- To learn theory and practice of chromatography.

Learning Outcomes:

- Ability to derive physical chemistry laws & functions and learning of solving physical chemistry numerical.
- Apply equilibrium aspects to deduce effects of chemical reaction parameters and estimation of molecular mass of solute.

Course Content:

Unit-I **Chemical Preparations (7 Hrs)**

SI Units and Derived units of Mass, Length, Time, Temperature, Amount of substance, Electrical current and Luminous intensity), Conversion between units, Significant figures, Concentration Terms, and their applicability
Qualitative and quantitative aspects of analysis:

Unit-II **Analytical Approach (8 hrs)**

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, methods for determination of uncertainty, normal law of distribution in indeterminate errors, Statistical treatment of measurement data by means of different hypothesis testing (for example Q test, t-tests, F-tests and ANOVA) and linear regression statistical test of data and confidence intervals.

Unit-III **Solvent extraction (7 hrs)**

A. Solvent extraction: Distribution law, determination of distribution ratio, Mechanism of extraction: extraction by solvation and chelation, Techniques of extraction: batch extraction, continuous extraction, discontinuous extraction, counter current batch, continuous and counter-current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Unit-IV **Chromatography (8 hrs)**

Theory and practice: Introduction, chromatography (elution time and volume) capacity factor, column efficiency and resolution, sample preparation; Techniques of paper chromatography: Experimental modifications, various modes of development, nature of paper, detections of spots, retardation factors, factors that affect the reproducibility of Rf values (due to paper, solvent system, sample, development procedures), selection of solvent, quantitative analysis, and applications; Thin layer chromatography: Stationary phase, adsorbents, liquid phase support, plate preparation, mobile phase, sample application, development, saturation of chamber, detection of spot, Rf values (effect of adsorbent, solvent, solute, development process), quantitative analysis, applications.

Suggested Books/Reading:

1. D. A. McQuarrie and J. D. Simon, "Physical Chemistry. A Molecular Approach" University Science Books, Sausalito 1997.
2. Ira N. Levine, "Physical Chemistry" Tata McGraw-Hill Education, 2011.
3. P.W. Atkins and Julio de Paula, "Physical Chemistry", 8th Ed., W. H. Freeman Publication, 2006.
4. G.M. Barrow, "Physical Chemistry" Tata McGraw-Hill Education, 2008.
5. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).

Semester-I

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-SE-109	Instrumentation Skills Lab-I	10 + 20 = 30	2	1
		L – 0	T - 0	P - 2

Course Objectives:

- To give hands-on training and practice chemical laboratory analytical tools.
- To learn handling of spectrophotometers and basics of its sample preparations and analysis.

Learning Outcomes:

- Student will be acquainted with separation methods and characterization of liquid samples/food samples.

Course Content:

Unit-I **Apparatus and Chemical Sstandards (15 Hrs)**

1. Use and calibration of volumetric glass apparatus (volumetric flasks, pipettes and burettes).
2. Preparing solutions: standard solutions, primary standards, secondary standards.
3. Handling of Vacuum Pump and filtration procedures

Unit-II **Chromatography (15 Hrs)**

1. Separation and identification of monosaccharides present in a given mixture by radial paper.
2. Separation of ortho-nitrophenol and para-nitrophenol by thin layer chromatography.
3. Separation of constituents of leaf pigments by thin layer chromatography.
4. Use of pH meter: determination of pH of given dilute solutions of shampoos and soaps
5. Determine the pH of the given aerated drinks fruit juices, shampoos, and soaps.
6. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
7. Separation of a mixture of two sugars by ascending paper chromatography
8. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Suggested Books/Reading:

1. Higson, S. P.J. (2003), Analytical Chemistry, Oxford University Press.
2. Skoog, D.A.; West, D.M. (2003), Fundamentals of Analytical Chemistry, Brooks/Cole.
3. Christian, G.D.(2004), Analytical Chemistry, 6th Edition, John Wiley & Sons, New York.
4. Fifield,F.W.; Kealey, D. (2000), Principles and Practice of Analytical Chemistry, Wiley.
5. Harris, D. C. (2007), Exploring Chemical Analysis, W.H. Freeman and Co.

SEMESTER II

Semester-II				
Course	**Name of Courses**	**Max Marks**	**Hrs. Per Week**	**Credit**
BCH-DS-201	**Organic Chemistry - I**	**25 + 75 = 100**	**4**	**4**
		L – 4	**T - 0**	**P - 0**

Course Objectives:

The objective of the course is to have an understanding the structure and bonding in organic chemistry, electronic displacements, stereochemistry and chemistry of aliphatic and aromatic hydrocarbons.

Learning Outcomes:

- Know the basic concepts of organic chemistry.
- Understand the basics of reaction mechanism.
- Stereochemistry and optical isomerism in organic compounds.
- Understand the chemistry of aliphatic and aromatic hydrocarbons

Course Content:

Unit-I **Recapitulation of basics of Organic Chemistry (9 Hrs)**

Hybridization, Shapes of molecules Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation Dipole moment; Hydrogen bonding (Applications to be discussed with relevant topics)
Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Types, shape and relative stability of Carbocations, Carbanions, Free radicals and Carbenes.
Introduction to types of organic reactions: Addition, Elimination and Substitution reactions.

Unit-II **Stereochemistry (15 Hrs)**

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

Unit-III **Chemistry of Aliphatic Hydrocarbons (18 Hrs)**

A. Carbon-Carbon sigma bonds
General methods of preparation, physical and chemical properties of alkanes: Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.
B. Carbon-Carbon pi-bonds:
General methods of preparation, physical and chemical properties of alkenes and alkynes, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroboration- oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation(oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.
Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes

Unit-IV **Conformational Analysis and Aromatic Hydrocarbons (18 Hrs)**

Conformational analysis of alkanes: Relative stability and Energy diagrams. Types of cycloalkanes and their relative stability, Baeyer strain theory Chair, Boat and Twist boat forms of cyclohexane with energy diagrams; Relative stability of mono substituted cycloalkanes.
Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Suggested Books/Reading:

1.	Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2.	Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994
3.	Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4.	Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005
5.	Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Semester-II

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-DS-202	**Physical Chemistry - II**	25 + 75 = 100	4	4
		L – 4	T - 0	P - 0

Course Objectives:

The objective of the course is to have an understanding concept of thermodynamics in chemistry, system of variable composition, chemical equilibrium, solutions and colligative properties

Learning Outcomes:

- Understand the basic concept of chemical thermodynamics and the laws governing.
- Learn the basics of systems of variable compositions.
- Learn the concept of chemical equilibrium.
- Learn solution and colligative properties.

Course Content:

Unit-I **Chemical Thermodynamics (36 Hrs)**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of ζ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure and temperature for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour, calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit-II **Systems of Variable Composition (8 Hrs)**

Qualitative treatment of the structure of the liquid state; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Unit-III **Chemical Equilibrium (8 Hrs)**

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

Unit-IV **Solutions and Colligative Properties (8 Hrs)**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Suggested Books/Reading:

1. Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Rastogi, R.P and Mishra, R.R. An introduction to chemical Thermodynamics,1995.
4. Kapoor, K.L., A text book of physical chemistry, vol 2, McGraw Hill education

Semester-II

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-DS-204	**Organic Chemistry Lab-I**	**15 + 35 = 50**	**4**	**2**
		L – 0	**T - 0**	**P - 4**

Course Objectives:

- The objective of the course is to have an understanding concept of fundamental lab practices of organic compounds, Organic Preparations and separations of organic compounds

Learning Outcomes:

- Student will be able to get acquainted with organic synthesis, crystallization of organic compounds and their identification

Course Content:

Unit-I **Basic Organic Lab Practices and Preparations (15 hrs)**

- Checking the calibration of the thermometer
- Purification of organic compounds by crystallization using the following solvents: a.Water b.Alcohol c.Alcohol-Water
- Determination of the melting points of unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
- Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
- Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
- Detection of extra elements

Unit-II **Organic Preparations and functional groups detection (15 hrs)**

- Organic Preparations
  - Bromination of acetanilide / aniline / phenol
  - Nitration of nitrobenzene / toluene.
- Detection of Nitrogen-containing functional groups – Amine, Nitro, purines, and amides.

Suggested Books/Reading:

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

Semester-II

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-DS-205	**Physical Chemistry Lab-II**	**15 + 35 = 50**	**4**	**2**
		L – 0	**T - 0**	**P - 4**

Course Objectives:

- The objective of the course is to have an understanding concept of Calorimetry and concept of thermodynamics from lab experiments.

Learning Outcomes:

- Student will understand electromagnetic spectrum and atomic/group signatures of wavelength.

Course Content:

Unit-I **Principle, working and applications of some basic instruments (7 hrs)**

Principle, construction, working and applications of some basic instruments/equipment's used in chemistry: Conductivity meter, Polarimeter, colorimeter and refractometer

Unit-II **Calorimetry (23 hrs)**

- Determination of heat capacity of a calorimeter for different volumes using (i) change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution of sulphuric acid or enthalpy of neutralization), and heat gained equal to heat lost by cold water and hot water respectively.
    - Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
    - Determination of the enthalpy of ionization of ethanoic acid.
    - Determination of integral enthalpy (endothermic and exothermic) solution of salts.
    - Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
- Determination of enthalpy of hydration of salt.
- Study of the solubility of benzoic acid in water and determination of ΔH.
- Any other experiment carried out in the class.

Suggested Books/Reading:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi (2001)

Semester-II				
Course	**Name of Courses**	**Max Marks**	**Hrs. Per Week**	**Credit**
BCH-SE-208	**Instrumentation Skills-II**	**15 + 35 = 50**	**2**	**2**
		L – 2	**T - 0**	**P - 0**

Course Objectives:

- To invoke optical methods and their application for photophysical characteristics of compounds.
- To teach spectroscopy of simple organic compound to understand UV-IR signatures.

Learning Outcomes:

- Student will be acquainted with UV-IR Spectroscopy method and characterization of optical active compounds using Optical Analytical Methods

Course Content:

Unit-I	**Optical Analytical Methods and Applications (6 Hrs)**
Origin of spectra, the interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. General principles Introduction to absorption and emission spectroscopy.	
Unit-II	**UV Spectroscopy and applications (8 hrs)**
Introduction: Electromagnetic radiations, regions of spectrum, basic features of spectroscopy, statement of Born-Oppenheimer approximation. Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption distinction between cis and trans isomers.	
Unit-III	**IR Spectroscopy and applications (10 hrs)**
IR Spectroscopy: Fundamental and non-fundamental molecular, vibrations degrees of freedom, vibrational frequencies of functional group, IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.	
Unit-IV	**Redox and Coulometric Titration (6 Hrs)**
Redox Principle, Redox Titration, Moisture Content Determination using Karl Fischer Titration, Principle, coulometric or volumetric, Classification of Karl Fischer Titration, Types of reagents, Karl Fischer Titrator, Instrumentation, Applications	

Suggested Books/Reading:

1.	Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York,
2.	Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
3.	Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International

Semester-II

Course	Name of Courses	Max Marks	Hrs. Per Week	Credit
BCH-SE-209	Instrumentation Skills Lab-II	10 + 20 = 30	2	1
		L – 0	T - 0	P - 2

Course Objectives:

- To give hands-on training and practice chemical laboratory analytical tools and plotting of data.
- To learn handling of spectrophotometers and basics of its sample preparations and analysis.

Learning Outcomes:

- Student will be able to handle spectrophotometer and will be able to understand significance of precision and its applications.

Course Content:

Unit-I **Apparatus and Chemical standards (15 Hrs)**

1. Plotting tools using MS Excel
2. Regression analysis and slope, intercept analysis of given data.
3. Background correction and its significance in analysis
4. Use of electronic balances and handling basics
5. Redox Principle, Moisture Content Determination using Karl Fischer Titration, Principle, Types of reagents, Karl Fischer Titrator, Instrumentation, Applications

Unit-II **UV-Visible Spectroscopy (15 Hrs)**

1. Determine the concentration of an unknown sample by using UV-Visible spectrophotometry.
2. To evaluate, λmax of the organic molecules in different solvents.
3. To understand the solvatochromism by UV-Visible spectroscopy.
4. To understand the effect of conjugation on the UV-Visible spectra of organic molecules.
5. Structural characterization of compounds by infrared spectroscopy.

Suggested Books/Reading:

1. Day. R. A.; Underwood, A. L. (1991), Quantitative Analysis, Prentice Hall of India.
2. Gordus, A. A. (1985), Outline of Analytical Chemistry, Tala McGraw-Hill.
3. Dean J. A. (1997), Analytical Chemistry Handbook, McGraw Hill.
4. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (1989), Vogel's Textbook of
5. Quantitative Chemical Analysis, John Wiley and Sons.