Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College "Affiliated to
KBC North Maharashtra University, Jalgaon

KNOWLEDGE IS POWER

ESTD. 1945

SYLLABUS

Chemistry

T.Y.B. Sc.

(Semester V &VI)

Under Choice Based Credit System (CBCS)

[w. e. f. Academic Year: 2021-22]

T. Y. B.Sc. Chemistry (CBCS pattern)

Program Specific Outcomes (PSO):

- T.Y. B.Sc. (Chemistry) graduates will have sound knowledge about various terms, facts, concepts, processes, techniques and principles of subjects and applied knowledge of Chemistry.
- They can further continue their education as PG and then Ph.D.
- After successful completion of the program, students will acquire laboratory and transferable skills which will help them to boost their career.
- The student will understand the interdisciplinary nature of chemistry and to integrate knowledge of mathematics, physics and other disciplines to a wide variety of chemical problems
- To develop ability to apply the knowledge of chemistry at academic, Industrial and at daily life for welfare of society

Learning Objectives:

- To expose the students to various emerging new areas of Chemistry and apprise them with their prevalent in their future studies and their applications in various spheres of Chemical Sciences.
- To articulate foundation and pillar level knowledge of Chemistry for the beneficiaries to apply them for advanced studies in the subject.
- To develop practical skills with a sound theoretical background.
- To apply the knowledge gained for higher education, research and profession of their choice.
- To analyse their interests among the various disciplines and implement them in their professional endeavors.

Exam Pattern:

- Each theory and practical course will be of 50 marks comprising 10 marks internal and 40 marks external examination.

External Theory Examination (40 marks):

- External examination will be of two hours duration for each theory course. There shall be 4 questions each carrying equal marks (10 marks each) while the tentative pattern of question papers shall be as follows:
    - Q1 (A), Q2 (A) and Q3 (A), each will be of 6 marks (attempt any 2 out of 3 sub-questions).
    - Q1 (B), Q2 (B) and Q3 (B), each will be of 4 marks (attempt any 1 out of 2 sub-questions).
    - Q4 will be of 10 marks (attempt any 2 out of 3 sub-questions).

External Practical Examination (40 marks):

- Practical examination shall be conducted by the respective department at the end of the semester. Practical examination will be of minimum 3 hours duration and shall be conducted as per schedule. There shall be 05 marks for journal, 10 marks for viva-voce. Certified Journal is compulsory to appear for practical examination.

Internal Theory/ Practical Examination (10 marks):

- Internal theory assessment of the student by respective teacher will be comprehensive and continuous, based on written test/ assignment. The written test may comprise of both objective and subjective type questions.
- Internal practical examination should be conducted by respective department as per schedule given. For internal practical examination student should perform at least one major and/or one minor experiment and should have completed journal.

Structure of TYBSc (Chemistry) Curriculum Semester V

Discipline	Course Type	Course Code	Course Title	Credits	Hours/ Week (Clock Hours)	Total Teaching hours	Marks	
							Int	Ext
DSC	Core I	CH-351	Physical Chemistry-IV	3	3	45	10	40
	Core II	CH-352	Inorganic Chemistry-III	3	3	45	10	40
	Core III	CH-353	Organic Reaction Mechanism	3	3	45	10	40
	Core IV	CH-354	Analytical Chemistry-I	3	3	45	10	40
	Core V	CH-355	Green Methods in Chemistry	3	3	45	10	40
	Core VI	CH-356A	Polymer Chemistry OR Biochemistry	3	3	45	10	40
		CH-356B						
SEC	Skill Based	CH-350	Instrumental methods of Analysis-I	2	2	30	10	40
DSC	Core (Practical)	CH-357	Physical Chemistry Practical-I	2	4 / batch	60	10	40
		CH-358	Inorganic Chemistry Practical-I	2	4 / batch	60	10	40
		CH-359	Organic Chemistry Practical-I	2	4 / batch	60	10	40

Structure of TYBSc (Chemistry) Curriculum Semester VI

Discipline	Course Type	Course Code	Course Title	Credits	Hours/ Week (Clock Hours)	Total Teaching hours	Marks	
							Int	Ext
DSC	Core I	CH-361	Physical Chemistry-V	3	3	45	10	40
	Core II	CH-362	Inorganic Chemistry-IV	3	3	45	10	40
	Core III	CH-363	Organic Spectroscopy	3	3	45	10	40
	Core IV	CH-364	Analytical Chemistry-II	3	3	45	10	40
	Core V	CH-365	Industrial Chemistry	3	3	45	10	40
	Core VI	CH-366A	Pharmaceutical Chemistry OR Research Methodology	3	3	45	10	40
		CH-366B						
SEC	Skill Based	CH-360	Instrumental Methods of Analysis-II	2	2	30	10	40
DSC	Core (Practical)	CH-367	Physical Chemistry Practical-II	2	4 / batch	60	10	40
		CH-368	Inorganic Chemistry Practical-II	2	4 / batch	60	10	40
		CH-369	Organic Chemistry Practical-II	2	4 / batch	60	10	40

DSC: Discipline Specific Core Courses/Core Practical; **SEC:** Skill Enhancement Course; **Int.:** Internal examination; **Ext:** External examination

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH–351: Physical Chemistry–IV

Total Hours: 45 **Credits: 3**

Course objectives:
The course is fundamental, still it is helpful to develop experimental skills in the laboratories and useful to pursue research in chemistry. The course is aimed at

- To orient and acquaint the UG students towards the fundamental aspects of quantum chemistry
- To acquire knowledge about chemical kinetics, rate of reaction and rate laws
- To learn and understand the significance of the phase equilibria and phase rule
- To evoke the fundamental concepts of electrochemistry and understand the advanced concept involved in it

Course outcomes:
Students will be able to:

- Understand the black body radiation and quantum theory, photoelectric effect: Wave-Particle duality of radiation, Quantum theory and atomic spectra
- Understand core study of chemical kinetics
- Understand the importance of phase rule and its applications
- different types of reversible electrodes, determination of ΔH^0, ΔG^0 and ΔS^0 of a cell reaction, electromotive force and equilibrium constant of cell reaction

Unit-I: Quantum Chemistry **(12 h)**

Introduction, Black body radiation and quantum theory, Distribution of energy in black body radiation, Photoelectric effect: Wave-particle duality of radiation, Quantum theory and atomic spectra, Bohr model, Wave-particle duality of material particles and de Broglie's hypothesis, Uncertainty principle, Operators: Algebra of operators, Linear operator, Commutator operator, Eigen values and Eigen functions, related numericals.

Unit-II: Chemical Kinetics **(13 h)**

Introduction, Rate of reaction and factors affecting on it, Rate law, Rate constant, Molecularity and order of a reaction, Concept of zero, first, second and third order of reaction with suitable examples, Pseudo-order reactions and examples of it, Derivation of integrated rate equations for zero, first and second order reaction (both for equal and unequal initial concentrations of reactants) and third order reaction, Different methods to determine the order of a reaction (integrated rate equations, graphical, half-life and differential method), Effect of temperature on reaction rate: Arrhenius equation, related numericals.

Unit-III: Phase Equilibria **(10 h)**

Introduction, Concept of phase, component and degrees of freedom of a system with suitable examples, Derivation of phase rule, One component system, Phase diagrams of one-component system: Water system and Sulphur system, Two component systems involving simple eutectic systems: Silver-Lead and zinc-cadmium system, related numericals.

Unit-IV: Electrochemistry-I **(10 h)**

Galvanic cells, Common types of reversible electrodes: Metal-metal ion electrodes, Gas electrodes (Hydrogen electrode, Chlorine electrode, Oxygen electrode), Metal-insoluble metal salt electrodes, Oxidation-reduction electrodes, Electrical energy in a Galvanic cell: Electrical energy and free energy change of the cell reaction, Relation between electrical energy and enthalpy of a cell reaction, Determination of ΔH, ΔG and ΔS and ΔH^0, ΔG^0 and ΔS^0 of a cell reaction, Electromotive force and equilibrium constant of cell reaction, Standard electromotive force and equilibrium constant, related numericals.

Reference Books:

- Prasad, R. K., (2000), Quantum Chemistry, Second Edition, New Age International (P) Limited, Publishers, New Delhi.
- Chandra, A. K., (1979), Introductory to Quantum Chemistry, Tata McGraw Hill., New Delhi.
- Levine, I. N., (2014) Quantum Chemistry, Seventh Edition, Peasrson, New York.
- McQuarie, D. A., (2008) Quantum Chemistry, Second Edition, University Science Books, Herndon, USA.
- Hanna, M. W, (1966), Quantum Mechanics in Chemistry, A. A. Benjamin, Inc., New York.
- Agrawal, G. L., (1990), Basic Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
- Laidler, K. J., Chemical Kinetics, McGraw-Hill Book Company, Inc., New York, 1950.
- Frost, A. A., Pearson, R. G., (1961), Kinetics and Mechanism a Study of Homogeneous Chemical Reactions, Second Edition, John Wiley and Sons, USA.
- Bahl, B. S., Bahl, A., Tuli, G. D., S., (2005), Essentials of Physical Chemistry, Chand and Co Ltd., New Delhi.
- Puri, B. R., Sharma, L. R., Pathania, (2007), Principles of Physical Chemistry (42nd Edition), M. S., Vishal Publishing Co., Jalandhar.
- Maron, S. H., Prutton C. F., (2012), Principles of Physical Chemistry (4th Edition), Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Atkins, P., J. de Paula, (2002) ATKINS' Physical Chemistry, Seventh Edition, Oxford University Press, New York.
- Barrow, G. M., (2003), Physical Chemistry, International Student Edition, McGraw-Hill Book Company, New York.
- McQuarrie, D. A., Simon, J. D., (2006), Physical Chemistry- A Molecular Approach, Viva Books Pvt. Ltd., New Delhi.
- Glasstone, S., (1942), An Introduction to Electrochemistry, D. Van Nostrand Company, Inc., Princeton, N. J.
- Robinson, R. A. and Stokes, R. H., (1959), Butterworths, Electrolytic Solutions, London.

Methods of teaching:

- Lecture method, discussion and problem solving, question answer method, brainstorming method, assignment method. ICT enabled teaching, video clips/movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-352: Inorganic Chemistry-III

Total Hours: 45 **Credits: 3**

Course Objectives:

- To understand the structure and reactivity of molecules.
- To study of bonding in simple molecules by Valence Shell Electron Pair Repulsion theory (VSEPRT).
- To acquire the knowledge of modern theories of coordination chemistry like Crystal Field Theory (CFT) and Molecular Orbital Theory (MOT).
- It is helpful to study reaction mechanism of coordination compounds.

Course Outcomes:

Students will be able to:

- Know structure and reactivity of molecules.
- Understand bonding in simple molecules by Valence Shell Electron Pair Repulsion theory (VSEPRT).
- Understand modern theories of coordination chemistry and its applications.
- Understand reaction mechanism of coordination compounds.

Unit-I: Structures and reactivity of molecules (10 h)

An overview of chemical reactivity, Sidgwick-Powell theory, Valence Shell Electron Pair Repulsion theory (VSEPRT), assumption of VSEPRT, Geometry and Shapes of molecules, effect of lone pairs and electronegativity on bond angle, isoelectronic principle.

Some examples using VSEPRT; simple molecules containing bond pairs of electrons only; Methane (CH_4), Beryllium fluoride (BeF_2), Phosphorus pentachloride (PCl_5).

Molecules and ions containing lone and bond pairs of electrons: Ammonia (NH_3), Water (H_2O), Sulphur tetrafluoride (SF_4), Bromine trifluoride (BrF_3), Dichloroiodate (I) anion (ICl_2^-), Pentaflurotellurate (IV) anion (TeF_5^-), Tetrachloroiodate (I) anion (ICl_4^-), Phosphorus trihalides (PX_3), Carbonyl Fluorides (OCF_2), Summary of VSEPRT, Drawbacks of VSEPRT.

Unit-II: Valance Bond Theory (VBT) and Crystal Field Theory (CFT) (Part-A) (10 h)

Valance Bond Theory (VBT), assumptions of VBT, shortcoming of VBT, Examples of square planar, tetrahedral and octahedral complexes: tetracyanonickelate (II) ion, $[Ni(CN)_4)]^{2-}$, tetrachloronickelate (II) ion $[NiCl_4]^{2-}$, Tetrammine copper (II) ion $[Co(NH_3)_4)]^{3+}$ and cobalt(III) hexaamminecobalt(III) ion, $[Co(NH_3)_6)]^{3+}$. Inner and outer d-orbital octahedral complexes.

Crystal Field Theory (CFT), assumptions of CFT, orientation of d orbitals and CFT of energy levels, Crystal Field Stabilization Energy (CFSE), crystal field splitting in octahedral complexes, crystal field splitting in tetrahedral complexes, crystal field splitting in tetragonal and square planar complexes. Magnetic properties of complexes and CFT. Factor affecting the magnitude of crystal field splitting, weak and strong ligand field splitting, spectrochemical series and its characteristics.

Unit-III: Crystal Field Theory (CFT) (Part-B) (10 h)

Characteristics and calculation of Crystal Field Stabilization Energy (CFSE), Crystal field effect on ionic radii, lattice energies, and hydration energies of first row

transition series, Crystal field effect on geometry of coordination complexes, factors affecting magnitude of Crystal field splitting. CFT and magnetic properties. distribution of electrons in d orbital. Problems related to calculation of spin only magnetic moment for square planer, tetrahedral and octahedral complexes (for high spin and low spin complexes). limitations and advantages of CFT, Jahn-Teller effect.

Unit-IV: (A) Molecular Orbital Theory (MOT)
(B) Reaction mechanism of Coordination compounds **(15 h)**

(A) Molecular Orbital Theory (MOT):

Molecular Orbital Theory (MOT) and its assumptions, Sigma bonding in tetrahedral and octahedral complexes, pi bonding in tetrahedral and octahedral complexes, sigma and pi bonding in square planar complexes, charge transfer spectra, advantages of Molecular Orbital Theory (MOT), comparison of VBT and CFT, comparison of CFT and MOT, comparison of VBT and Molecular Orbital Theory (MOT).

(B) Reaction mechanism of Coordination compounds:

Substitution reactions in octahedral complexes: Unimolecular Nucleophilic Substitution (S_N^1) and Bimolecular Nucleophilic Substitution (S_N^2) reactions, Types of intermediates formed during S_N^1 and S_N^2 reactions, lability and inertness of octahedral complexes. Acid hydrolysis of octahedral complexes, base hydrolysis of octahedral complexes, substitution reactions of square planar complexes. Oxidation-Reduction reactions. Two electron transfer reactions.

References:

- Puri, B. R., Sharma, L. R., Kalia, K. C., (2006), Principle of Inorganic Chemistry, thirtieth edition, Milestone Publisher, Delhi.
- Lee, J. D., (1991), Concise Inorganic Chemistry, Fourth edition, Chapman and Hall, London.
- Huheey, J. E., Keiter, E. A., Keitler R. L., (1993), Inorganic Chemistry Principles of Structure and Reactivity, fourth Edition, Harper Collins Publisher, New York.
- Atkins, P., Overton T., Rourke J., Weller M., Armstrong F., (2009), Shriver and Atkins' Inorganic Chemistry, fifth edition, Oxford University Press, W. H. Freeman and Company, New York.
- Pfennig, B. W., (2015), Principles of Inorganic Chemistry, John Wiley & Sons, Inc., Hoboken, New Jersey.

Methods of teaching:

- Classroom teaching method, discussion, question answer method, brainstorming method, assignment method. ICT enabled teaching, video clips/ movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-353: Organic Reaction Mechanism

Total Hours: 45 **Credits: 3**

Course Objectives:

- To study different types of organic reactions.
- To understand the mechanisms of different types of reactions.
- To distinguish between types of substrates and types of reagents.
- To understand ways of attack of reagent, breaking and formation of bonds in different reaction mechanisms.
- To study kinetics, evidences and factors affecting different types of reactions.
- To study stereochemistry of different reactions.
- To understand role of different reagents in different reactions.

Course Outcomes:

Students will be able to:

- understand the reaction pathway in organic transformation
- Improve the skill of proposing mechanism for particular reaction
- propose the expected product based on the mechanism
- explain the selectivity in the organic reactions

Unit-I: Nucleophilic Substitution at Saturated Carbon (12 h)

Introduction, Nucleophiles and Leaving groups, Mechanism of Nucleophilic substitution reaction, S_N^1, S_N^2 and S_N^ireactions, Mechanism, energy profile diagram and stereochemistry, regioselectivity and stereo specificity of substitution reaction. Scope at saturated carbon, allylic carbon and vinylic carbon. Factors affecting rate of S_N^1, S_N^2 and S_N^ireactions (Effect of nature of substrate, nucleophile, leaving group and solvent). Comparison of S_N^1& S_N^2. Neighboring group participation (norbornyl & norbornenyl systems), non-classical carbocations.

Unit-II: Reactions of Carbon Carbon Double Bond and Triple Bond (11 h)

Introduction, Addition to Carbon- Carbon double bond with examples, Mechanism and evidence of mechanism of electrophilic addition to C=C bond, Hydrohalogenation: orientation and reactivity , Rearrangement(support for formation of carbocation), Markownikoff's and Anti Markownikoff's addition (peroxide effect), stereochemistry, Halogenation: Mechanism and evidences for mechanism, addition of hypohalous acids (HOX)Halohydrin formation: Mechanism and examples, Oxymercuration-demercuration, Hydroxylation: Formation of 1,2 diols, cis and trans hydroxylation, Hydroboration- Oxidation (Formation of alcohol), Hydrogenation (Formation of alkane), Ozonolysis (formation of aldehydes & ketones).

Reactions of Carbon-Carbon triple bond: Addition of hydrogen, halogens, halogen acids and water.

Unit-III: Reactions of Carbon-Oxygen double bond (11 h)

Introduction, Structure of carbonyl group, reactivity of carbonyl group, Addition of Hydrogen cyanide, alcohols, thiols, water, ammonia derivatives.

Aldol and Cannizzaro Reaction, Perkin reaction, Wittig reaction, Reformatsky reactions, Reduction reactions using $NaBH_4$, $LiAlH_4$ with mechanism.

Unit-IV: Aromatic Substitution Reactions **(11 h)**

Introduction, arenium ion mechanism, Effect of substituent group (Orientation, o/p directing and meta directing groups). Classification of substituent groups (activating and deactivating groups) Mechanism of: Nitration, Sulfonation, Halogenation, Friedal-Crafts reactions (alkylation and acylation), Diazo Coupling reactions, Ipso-substitution.

Nucleophilic substitution

Addition- elimination (SNAr), Elimination-addition (Benzyne) mechanism with evidences, Chichibabin reaction

References:

- Clayden J., Greeves N. & Warren S. and Wothers P, (2012), Organic Chemistry, 2nd Edition, Oxford, England
- Smith Michael B., March Jerry, (2000), Advanced Organic Chemistry-Reactions, Mechanisms and Structure, 5th Edition, Wiley-VCH, Weinheim.
- Carey A. and Sundberg R. J. (1990), Advanced Organic Chemistry Part A- Structure and Mechanisms, 3rd Edition, Springer US, NY
- Morrison R. T., Boyd R. N. Bhattacharjee S. K. (2010), Organic Chemistry, 7th Edition, Pearson, India.
- Web- Organic Chemistry Portal
- March, J. (2008), Advanced Organic Chemistry, 4th Edition, Wiley Eastern Limited, New Delhi
- Bahl. B.S. and Bahl A., (2011), A Text book of Organic Chemistry, S. Chand & company Ltd., New Delhi.

Methods of teaching:

- Classroom teaching methods, discussion and problem solving, problem solving method, question answer method, brain storming method, assignment method. ICT enabled teaching, video clips/ movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-354: Analytical Chemistry- I

Total Hours: 45 **Credits: 3**

Course Objectives:

- To get the knowledge of basic concept of analytical Chemistry.
- To learn the statistical analysis methods in analytical chemistry.
- To study the electrochromatography.
- To learn the methods of solvent extraction.
- To understand, water pollution and its analyzing methods.
- To get the knowledge of laws governing water pollution.

Course Outcomes:

Students will be able to:

- Understand basic concept of analytical Chemistry.
- Understand method involving Electrophoresis and electrochromatography.
- Gain knowledge of solvent extraction.
- Know various methods involved in analysis of water pollution.

Unit-I: Data handling and spreadsheets in Analytical chemistry (13 h)

Errors in chemical analysis. Classification of errors systematic and random, additive and proportional, absolute and relative. Accuracy and precision. Mean, median, average deviation and standard deviation. Significant figures and rules to determine significant figures. Rounding off. Use of spreadsheets in Analytical chemistry.

Comparison of methods: F-test and T-test. Rejection of data based on Q-test. Using spreadsheets for plotting calibration curve. Slope, intercept and coefficient of determination. Detection limits. Statistics of sampling.

Unit-II: Electrophoresis and Electrochromatography (12 h)

Definition. Types of electrophoretic methods: Free solution electrophoresis. The Tiselius method, moving boundary electrophoresis, Density gradient electrophoresis, Zone electrophoresis or electrochromatography. Types of supporting or stabilizing medium. Paper electrophoresis, paper used, electrode, source of current, location of components, requirements of electrophoretic chambers. Problems in electrophoresis. Applications of electrochromatography.

Unit-III: Solvent Extraction (10 h)

The Distribution Co-efficient, The Distribution Ratio, Percent Extracted, Solvent Extraction of Metals - Ion Association Complex and Metal Chelates, The Extraction Process, The Separation Efficiency of Metal Chelates (without derivation), Analytical Separations, Multiple Batch Extractions, Countercurrent Distribution (Craig's apparatus), Simple numerical problems on Percent Extracted and Multiple Extraction, Problems

Unit-IV: Analysis of Water pollution (10 h)

Pollution. Water pollution. Water pollutants. Origin of waste water. Effects of water pollutants.

Sources of water pollution. Types of water pollution. Water Analysis: Colour, Turbidity, Total dissolved solids, hardness of water, Biochemical oxygen demand

(BOD), Chemical oxygen demand (COD), Test of BOD, Test of COD. Water pollution laws. Water Quality. Water standards.

References:

- Christian Gary D. (2015), Analytical Chemistry 6th edition, Wiley publication, Satyam enterprises, Delhi
- Sharma B. K., (2012), Instrumental methods of chemical analysis 28th edition, GOEL publishing house, Krishna Prakashan media Ltd., Meerut, India
- Willard, H. H., (1986), Instrumental Methods of Analysis, CBS Publishers, New Delhi
- Skoog D. A., West D. M. and Holler F. J., (1992), Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth,Texas
- Gupta Alka L., (2017), Analytical chemistry 8th edition, Pragati Prakashan, Meerut
- Dean, J. A., (1992) Analytical Chemistry Notebook, McGraw Hill, New York
- Vogel, A. I., (1996), Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, NewYork

Methods of teaching:

- Classroom teaching method, discussion and problem-solving method, question answer method, brain storming method, assignment method, ICT enabled teaching, animated videos and video clips/ movies, online quiz., Group discussion, Presentation contest, seminar competition.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-355: Green Methods in Chemistry

Total Hours: 45 **Credits: 3**

Course Objectives:

- To familiarize with serious issues about pollution, depleting resources, climate change, ozone depletion, legislation which is getting stringent with strict environmental laws, rising cost of waste deposits, health concern and so on.
- To minimize challenges and obstacles during sustainable development on becoming more environmentally conscious.
- To aware about importance of regular practices in Green chemistry.
- To innovative applications of green chemistry in various sectors like education, industries, societies, economical fields for development of nation and world.

Course Outcomes:

Students will be able to:

- Learn Principles of Green chemistry, basic understanding of toxicity, hazards and risk of chemical substances and reactions, stoichiometric calculations, and atom economy.
- Understand Design and use of less toxic and safer chemicals, products, processes. Students will learn to develop innovative solutions to environmental problems.
- Know use of modern and efficient green techniques such as use of microwave and ultrasound irradiation in chemical reactions.
- Know role and importance of solvent, reagents and catalysis in green chemistry. Students will understand a future trend in Green Chemistry.

Unit-I: Introduction to Green Chemistry **(8 h)**

Definition of Green Chemistry, Drawbacks of conventional chemistry, Need of Green Chemistry, Minamata Disease, and Goals of Green Chemistry. Twelve principles of Green Chemistry, role of Paul T. Anastas, importance of green chemistry with examples: Prevention of waste/by-products, Atom economy, Prevention or Minimization of hazardous products.

Unit-II: Designing Chemical Synthesis **(8 h)**

Designing safer chemicals, Energy requirements for synthesis, Selection of suitable solvents, Selection of starting materials, Use of protecting groups, Use of catalysts, Designing of biodegradable products, Prevention of chemical accidents, Strengthening of analytical techniques, and industrial safety.

Unit-III: Some Green Chemistry Techniques **(12 h)**

A. Microwave assisted synthesis-Introduction and importance, Applications-Esterification, Fries rearrangement, Ortho-ester Claisen Rearrangement, Diels-Alder Reaction, and Hofmann Elimination.
B. Ultrasound assisted reactions-Introduction and importance, Application-Esterification, saponification, aromatic substitution reactions, alkylation, oxidation, and reduction.

Unit-IV: Solvents, Reagents and Catalysts in Green Chemistry **(17 h)**

A. Solvents-Introduction and Importance, Examples-Michael Addition in water, Bis-indolyl methane in ionic liquid, and tetrazole synthesis in deep eutectic solvent.

B. Reagents-Introduction and Importance, Examples-Alkylation using dimethyl carbonate, and Solid phase peptide synthesis using Merrifield reagent.

C. Catalysts-Introduction and Importance, Examples-Reduction of carbonyl group using Baker's yeast, Esterification using Lipase enzyme, Zeolite clay and Cyclodextrin.

D. Future Trends in Green Chemistry: Biomimetic, Photochemical reactions, Multifunctional Reagents, and Green Chemistry in sustainable development.

Reference Books:

- Ahluwalia V. K., and Kidwai M. R., (2005), New Trends in Green Chemistry, Anamaya Publishers, New Delhi.
- Anastas P. T., and Warner J. K., (1998), Green Chemistry-Theory and Practice, Oxford University Press, New York.
- Matlack A. S., (2001), Introduction to Green Chemistry, Marcel Dekker, New York.
- Cann M. C. and Connely M. E., (2000), Real-World Cases in Green Chemistry, American Chemical Society, Washington.
- Ryan M. A. and Tinnesand M., (2002), Introduction to Green Chemistry, American Chemical Society, Washington.
- Manahan Stanley E., (2006), Green Chemistry, 2nd Edition., Chem Char Research Inc, Columbia, Missouri.

Methods of teaching:

- Classroom teaching methods, discussion and question answer method, brain storming method, assignment method. ICT enabled teaching, video clips/ movies, online quiz etc.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-356 (A): Polymer Chemistry

Total Hours: 45 **Credits: 3**

Course Objectives:

- The course offers the basic concepts of polymer, polymerization, classes of polymers, important properties, and poly (lactic acid) as a biodegradable polymer.
- The course also offers to study preparation, properties, and applications of industrially important selected polymers.
- The course will give chance to study various mechanisms of polymerization and learn different techniques of polymerization.
- The student will be able to understand glass transition temperature and factors affecting on it and various ways to express molecular weight of polymers.

Course Outcomes:

Students will be able to:

- Define terms like monomer, polymer, polymerization, polydispersity index, etc., classify polymers based on their origin, native backbone chain, and thermal response.
- Know glass transition temperature and its determination, various ways to express molecular weights of polymers and polydispersity index.
- Identify different mechanisms of polymerizations *viz*. free radical, ionic, and condensation polymerizations.
- Distinguish techniques of polymerization based on physical conditions required for the preparation of polymers in laboratory or industry.
- Familiar with preparation, properties, and applications of industrially important selected polymers.

Unit-I: Basic Concepts of Polymers **(12 h)**

Introduction, brief history, monomers and polymers, degree of polymerization, functionality, linear, branched and cross-linked polymers, homo polymers, Types of copolymers: -random, alternate, block and graft copolymers, Tacticity(stereochemistry)of polymers: isotactic, syndiotactic and atactic polymers. Classification of polymers: -based on a) origin-natural and synthetic polymers b) native back bone chain –organic and inorganic polymers c) thermal response– thermoplastic and thermosetting polymers d) ultimate form and use–plastic, elastomer, fibre and liquid resin, Degradation of polymers: -types of degradation: chain end and random degradations.

Unit-II: Chemistry of Polymerization **(12 h)**

Introduction, chain growth polymerization (initiation, propagation, termination, and kinetics): free radical polymerization, ionic (cationic and anionic) polymerizations, step growth polymerization (mechanism and kinetics), ring opening polymerization.

Unit-III: Polymerization Techniques &Polymer Processing Techniques **(9 h)**

Polymerization techniques: - Bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, interfacial condensation polymerization. Polymer processing techniques: -Calendaring, diecasting, filmcasting, and compression moulding.

Unit-IV: Study of Some Important Polymers **(12 h)**

Preparation, properties and applications of-Polyethylene [PE], Polypropylene [PP], Poly (vinyl chloride) [PVC], Polystyrene [PS], Polyacrylonitrile [PAN], Polycarbonates [PC], Phenol-formaldehyde resins [PF], Epoxy resins, Polyester-Polyethylene terephthalate [PET], Polyamides (Nylon-6andNylon-6,6), Poly (vinyl alcohol) [PVA], Poly (lactic acid) [PLA], Polyaniline and Polybutadiene.

References:

- Govarikar V.R., Viswanathan, N. V., Jayadev Sreedhar, (1997), Polymer Science, New Age International (P) Ltd. New Delhi, India.
- Billmeyer, F. W. (1984). Textbook of polymer science. John Wiley & Sons, Canada.
- Seymour, F. B. (Ed.). (2012), Pioneers in polymer science (Vol. 10). Springer Science & Business Media, USA.
- Odian, G. (2004). Principles of polymerization. John Wiley & Sons, Canada.
- Ghosh, P. (1990). Polymer science and technology. Tata McGraw-Hill Education, Kolkata, India.
- Lenz, R. W. (1967). Organic chemistry of synthetic high polymers, USA.

Methods of teaching:

- Classroom teaching methods, assignment method. ICT enabled teaching, video clips/ movies, online quiz etc.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-356 (B): Biochemistry

Total Hours: 45 **Credits: 3**

Course Objectives:

- To study different types of biomolecules.
- To study structure of biomolecules.
- To study classification of each type of biomolecules.
- To Study of metabolism and thus, study of metabolic processes and reactions involved.

Course Outcomes:

Students will be able to:

- Learn biomolecules like carbohydrates, amino acids, proteins, enzymes, lipids and nucleic acids.
- Understand definitions, classifications and examples of these biomolecules.
- Learn the detailed structure of these biomolecules along with types of bonds or linkages present in their molecules.
- Learn the chemical properties of these biomolecules and the action of some reagents on the min the form of reactions or graphical presentation.

Unit-I: Carbohydrates **(12 h)**

a) **Introduction**, definition, classification.
b) **Monosaccharaides:** structure of glucose (open chain and ring structures) Kiliani Fischer synthesis of D-glucose. Reactions of glucose: oxidation with bromine water and nitric acid, reduction, acetylation, addition of HCN, NH2OH and phenyl hydrazine, mutarotation.
c) **Disaccharides:** structure of sucrose, lactose and maltose.
d) **Polysaccharides:** storage polysaccharides, structure of starch, Structural polysaccharides, structure of cellulose.

Unit-II: Amino Acids and Proteins **(12 h)**

a) **Amino acids:** Introduction, structure of ammino acids, classification of amino acids, amphoteric nature of amino acids, reactions of amino acids with FDNB and Dansyl chloride, formation of peptide bond
b) **Proteins:** Introduction, classification of proteins: based on functions and based on shape, structure of proteins: primary, secondary, tertiary and quaternary structure). Study of some proteins: keratins and hemoglobin. Separation of amino acids and proteins by paper electrophoresis and dialysis

Unit-III: Enzyme sand Lipids **(9 h)**

a) **Enzymes:** Introduction, specificity of enzymes, classification, role of enzymes in biochemical reactions, Michaelis Menten equation (no derivation). Effect of substrate concentration, pH and temperature on enzyme catalyzed reactions. Enzyme inhibitors: introduction and types.
b) **Lipids:** Introduction, classification of lipids, fatty acids, nomenclature of fatty acids, triacyl glycerol, hydrogenation of oils, Saponification value and iodine value of oils, phosphor lipid sand waxes.

Unit-IV: Nucleic Acids and Energy Rich Compounds **(12 h)**

a) **Nucleic acids**: Introduction, Components of nucleic acids: sugars, bases, nucleosides and nucleotides. Watson and Crick model of DNA, types of RNA (structure not expected)

b) **Energy rich compounds**: Introduction, Pyrophosphates, acyl phosphates, enolic phosphates, thiol esters (structure, hydrolytic reaction and energetics). Energy carriers in biological redox systems: NAD^+ and FAD

References:

- Conn E.E. and Stumpf P. K. (1976), 4th Edition, Outlines of Biochemistry, Wiley, Canada.
- Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). Lehninger principles of biochemistry. Macmillan, USA.
- Talwar, G. P., & Srivastava, L. M. (2002). Textbook of biochemistry and human biology. PHI Learning Pvt. Ltd, New Delhi.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2006) Biochemistry. VIth Edition. W.H. Freeman and Co, Canada.
- Devlin, T. M. (Ed.). (2006). Textbook of biochemistry: with clinical correlations, USA.

Methods of teaching:

- Classroom teaching methods, discussion and problem solving, question answer method, brain storming method, assignment method, ICT enabled teaching, video clips/ movies, online quiz.

T.Y.B.Sc. (Chemistry): Semester-V
Skill Enhancement Course (SEC)
CH-350: Instrumental methods of Analysis-I

Total Hours: 30 **Credits: 2**

Course Objectives:

- To develop an understanding of the range and uses of analytical methods in chemistry.
- To understand and establish the role of chemistry in qualitative and quantitative analysis.
- To enhance the Analytical instrumental skill of the students.
- To learn about the pHmetry and potentiometry.

Course Outcomes:

Students will be able to:

- Understand the fundamentals of analytical methods and instruments for qualitative and quantitative Analysis.
- Learn the role of analytical chemistry in science.
- Know their role as a member of an interdisciplinary problem-solving team member.

Unit-I: pH and its determination **(18 h)**

Cell and battery. Galvanic cell. Daniel cell. Electrochemical cell. Reversible and irreversible cells. Reversible electrodes. EMF and its measurement. Standard cell. Cell reaction and EMF. Standard electrode potentials. Mechanism of electrode potential- Nernst theory of solution pressure. Nernst's expression for electrode potential or difference of potential at a junction metal/salt solution. Reference electrodes. Methods of determining the pH. Potentiometric determination of pH.

pH indicating electrodes: Advantages of Hydrogen electrode. Disadvantages of Hydrogen electrode. Uses. Advantages of Quinhydrone electrode. Disadvantages of Quinhydrone electrode. Uses. Factors affecting pH measurements with the glass electrode. Advantages of Glass electrode. Disadvantage of Glass electrode. Advantages of Antimony electrode. Disadvantages of Antimony electrode. pH meters.

Unit-II: Potentiometry **(12 h)**

Potentiometer, The Cell for Potential Measurements, Combination Electrode, Theory of Glass Membrane Potential, The Alkaline Error, The Acid Error, Standard Buffers, Ion- selective Electrodes - Glass Membrane Electrodes, Precipitate Electrodes, Solid-State Electrodes, Liquid-Liquid Electrodes, Plastic Membrane/Ionophore Electrodes, Coated Wire electrodes, Enzyme Electrodes. Potentiometric titration.

References:

- Sharma B. K., (2012), Instrumental methods of chemical analysis 28th edition, GOEL publishing house, Krishna Prakashan media Ltd., Meerut, India
- Willard, H. H., (1986), Instrumental Methods of Analysis 6th edition, CBS Publishers, New Delhi
- Christian Gary D., (2015), Analytical Chemistry 6th edition, Wiley publication., Satyam enterprises, Delhi
- Skoog D. A., West D. M. and Holler F. J., (1992), Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth, Texas

- Willard H. H., Merrit L. L., Dean J. D., Settle S. A., (1984). Instrumental Methods of Chemical Analysis. 6th Ed, CBS publishers, New Delhi
- Braun R. D. (2016). Introduction to Instrumental Analysis- Pharmamed press, Hyderabad-2nd edition
- GrinbergNelu, RodriguezSonia.(2019). Ewing's Analytical Instrumentation handbook-4th edition. CRC Press, New Delhi
- Chatwal G.& Anand S. (2019). Instrumental Methods of Chemical Analysis. Himalaya publications-5th edition, Mumbai

Methods of teaching:

- Classroom teaching method, discussion and problem solving, laboratory method, problem solving method, question answer method, brain storming method, assignment method, ICT enabled teaching, video clips/ movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-357: Physical Chemistry Practical–I

Total Hours: 60 **Credits: 2**

Course Objectives:

- To develop the experimental skills required in physical chemistry
- To expose the students to an extent of experimental techniques using modern instrumentation

Course Outcomes:

Students will be able to:

- Perform preparation for each experiment by studying lab handouts and links therein
- Understand safety requirements and lab skills to perform physico-chemical experiments
- Know how to keep records of instruments, parameters, and experimental observations reporting of experimental result
- Understand an appreciation for modern problems and scientific controversies in physical chemistry

Sr. No.	Topic particular	Hours
	Conductometry:	
1	To determine the concentration of hydrochloric acid and acetic acid in a given mixture by titrating it with a standard solution of sodium hydroxide conductometrically.	04
2	To determine the hydrolysis constant of sodium acetate conductometrically.	04
3	To determine the second order velocity constant for the hydrolysis of ethyl acetate by sodium hydroxide conductometrically.	04
	Potentiometry:	
4	To determine Ecal (oxid) and hence pH of given buffer solutions using quinhydrone electrode.	04
5	To determine the dissociation constant of acetic acid by potentiometric titration.	04
	pH-metry:	
6	To determine the pH values of various mixtures of sodium acetate and acetic acid in aqueous solutions and find out the dissociation constant of the acid.	04
7	To determine the dissociation constant of acetic acid pH-metrically	04
	Colorimetry / Spectrophotometry:	
8	To test the validity of Beer's-Lambert's law and hence determine the concentration of given unknown Cu^{++} solution colorimetrically/spectrophotometrically.	04
	Polarimetry:	
9	To study the kinetics of inversion of cane sugar using polarimeter.	04
	Refractometry:	
10	To determine the specific and molar refractivities of the given liquids A, B, C and D.	04

	Chemical Kinetics:	
11	To investigate the kinetics of a reaction between potassium persulphate and potassium iodide.	04
12	To determine the energy of activation of the reaction between persulphate and potassium iodide.	04
13	To investigate the kinetics of iodination of acetone (zero order reaction).	04
	Non-Instrumental:	
14	To determine the radius of glycerol molecule by viscosity measurement.	04
	Application of Microsoft Excel:	
15	Calculations for the given data using Microsoft excel.	04

References:

- Jeffery, G. H., Bassett, J., Mendham, J., Dennet, R. C., (1989), VOGEL's Textbook of Quantitative Chemical Analysis, Fifth Edition, Longman Scientific and Technical, England.
- Rose, J., (1964), Advanced Physico-Chemical Experiments- A Text Book of Practical Physical Chemistry and Calculations, Sir Isaac Pitman and Sons Ltd., London.
- Garland, C. W., Nibler, J. W., D. P. Shoemaker, (2003), Experiments in Physical Chemistry, Eighth Edition, McGraw-Hill Companies, Inc., New York.
- Yadav, J. B., (2008) Advanced Practical Physical Chemistry, Twenty Sixth Edition, Goel Publishing House- A Unit of Krishna Prakashan Media (P) Ltd., Meerut.
- Rajbhoj, S. W., Chondhekar, T. K., (2000), Systematic Experimental Physical Chemistry, Second Edition, Anjali Publication, Aurangabad.

Methods of teaching:

- Lecture method, discussion and problem solving, laboratory method, problem solving method, question answer method, brainstorming method, assignment method.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-358: Inorganic Chemistry Practical-I

Total Hours: 60 **Credits: 2**

Course Objectives:

- To acquire practical knowledge and analyses inorganic mixtures.
- To understand the determination of metal from ore and alloy analysis.
- To get the knowledge of metal determination by colorimetric analysis.

Course Outcomes:

Students will be able to:

- Understand determination cation and anion from inorganic mixtures by using inorganic qualitative analysis.
- Determine metal from ore and analyse the alloy
- Carry determination by colorimetric analysis.

Sr. No.	Topic Particular	Hours
	Inorganic Qualitative Analysis: (Minimum seven)	
1 to 7	Binary mixtures containing common anions.	4 X 7 = **28**
	Ore Analysis: (Any two)	
8	Hematite ore - Estimation of Iron volumetrically	**04**
9	Pyrolusite ore- Estimation of Manganese volumetrically	**04**
10	Hematite ore - Estimation of Iron volumetrically	**04**
	Alloy Analysis: (Any two)	
11	Estimation of Zn from Brass alloy.	**04**
12	Estimation of Tin gravimetrically as SnO_2 from solder alloy.	**04**
13	Estimation of Copper iodometrically from nichrome alloy.	**04**
14	Determination of iron gravimetrically from stainless steel.	**04**
	Colorimetric Analysis (Any one)	
15	Colorimetric titration of Cu(II) against EDTA method .	**04**
16	Estimation of Titanium using hydrogen peroxide.	**04**

References:

- Mendham, J., (2009) Vogel's Quantitative Chemical Analysis ,6th Edition, Pearson, Germany.
- Svehla, G., Shivshankar B., (2012), Vogel's Qualitative Inorganic Analysis, Pearson Education India.
- Christian, G. D., (2006), Analytical chemistry, 6th Edition, Wiley-India.
- Mendham, J., Denny R. C.,Barnes J. D., Thomas M.,Sivasankar B., (2009), Quantitative Chemical Analysis.,6th Edition, Pearson, Germany.
- Jeffrey, H., Bassett J., Mendham, J., Denney R. C., (1989), Vogel's Textbook of Quantitative Inorganic Analysis, 5th Edition, Longman Scientific and Technical, England co published with John willey and Sons, New York.
- Patel, H. N., Turakhia, S. P., Kelker, S. S., Puniyani, S.R., (2010), College Practical Chemistry, Himalaya Publishing House, Mumbai.

Methods of teaching:

- Laboratory method, discussion and problem solving method, question answer method, Heuristic method, ICT enabled teaching, video clips/ movies.

T.Y. B.Sc. (Chemistry): Semester V
Discipline Specific Core (DSC) Course
CH-359: Organic Chemistry Practical-I

Total Hours: 60 **Credits: 2**

Course Objectives:

- To develop skills required in chemistry such as the appropriate handling of apparatus and chemicals.
- The student will learn the laboratory skills needed to design, safely conduct and interpret chemical research.
- To expose the students to an extent of experimental techniques using modern instrumentation.
- The student will develop the ability to effectively communicate scientific information and research results in written and oral formats.

Course Outcomes:

Students will be able to:

- Carry out Qualitative analysis of Organic Compound
- Identify Organic Compound
- Separate and analyze binary water insoluble mixture
- Understand the purification technique used in organic chemistry
- To carry out estimations of organic compounds

Sr. No.	Topic Particular	Hours
	Separation of organic Binary Mixtures and Qualitative Analysis (Minimum six mixtures).	
1 to 6	Separation of organic mixture containing two components, identification of the components and preparation of suitable derivative if any. Note: • Students are expected to determine type of the mixture and to separate the mixture. • Separation of the Mixture should be done by chemical method only. • It is expected to perform preliminary tests, physical constants, detection of elements and determination of functional groups of separated compounds. • On the basis of above tests, students are expected to determine structure of compounds. • The separated compounds should be purified and then melting point of purified compound should be determined. The purified samples of the separated components should be submitted. • Separation and qualitative analysis of the binary Mixtures should be carried out on micro scale as far as possible.	4 X 6 = **24**
	Organic Estimations (Any three)	
7 to 10	1) Determination of Eq. Wt. of the given Organic Acid 2) Determination of Eq. Wt. of an ester by saponification. 3) Estimation of amount of amide in the given solution 4) To estimate amount of glucose in the given solution 5) To estimate the amount of carboxylic acid in the given solution.	4 X 3 = **12**

Preparation of derivatives (Any three)

11	Oxime derivative of aldehydes or Ketones	**04**
12	Aryloxy acetic acid derivative of Phenol	**04**
13	2, 4 DNP derivative of aldehydes or Ketones	**04**
14	Anilide derivative of acid	**04**
15	Bromo Derivative of Aniline	**04**
16	Benzoyl Derivative of Aniline	**04**

References:

- Vogel A. I., (2005), Practical Organic Chemistry, 5th Edition Pearson. New York
- Agarwal O. P., (2014), Practical Organic Chemistry, Krishna Prakashan Media (P) Ltd, Meerut, India
- Kamboj P. C., (2013,) University Practical Chemistry, 1st (Reprint) Edition, Vishal Publishing Co. Jalandhar, India
- Ahluwalia V. K. and Aggarwal Renu, (2016), Comprehensive Practical Organic Chemistry-Qualitative Analysis Universities Press, Hyderabad, India
- Woodward R.B. and Baer H., J. Am. Chem. Soc. 1948, 70, 1161.
- Rideout D. C. and Breslow R., J. Am. Chem. Soc. 1980, 102, 7816.
- Anastas, P.T and Warner, J.C (1998), Green Chemistry: Theory and Practice, J.C. Oxford University Press. New York
- Monograph on Green Chemistry Laboratory Experiments, Green Chemistry Task Force Committee, DST Page 69 of 70, India

Methods of teaching:

- Laboratory method, discussion and problem solving method, question answer method, Heuristic method, ICT enabled teaching, video clips/ movies.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH–361: Physical Chemistry–V

Total Hours: 45 **Credits: 3**

Course objectives:
The course is fundamental, still it is helpful to develop experimental skill in the laboratories and useful to pursue research in chemistry. The course is aimed at

- To understand fundamental and advanced concepts nuclear chemistry
- To enrich the understanding of solid state chemistry and its utility.
- To learn about photochemistry
- To evoke the fundamental concepts of electrochemistry and understand the advanced concept involved in it.

Course outcomes:
Students will be able to:

- Understand the concept of radioactivity and radioactive decay, calculation of half-life of a radioactive isotope, nuclear reactions
- Learn Bragg's equation, classification of crystals and crystal defects
- Learn photochemical processes, laws of photochemistry and significance of quantum yield
- Understand concentration cells and its types, liquid junction potential and fuel cells

Unit-I: Nuclear Chemistry **(12 h)**

Introduction, Radioactivity and its unit, Types of radioactive radiations (alpha, beta and gamma rays) and their properties, Types of radioactive decay: alpha and beta decay, Rate of radioactive decay, Half-life of a radioactive isotope, Activity of a radioactive substance, Calculation of Half-life of a radioactive isotope, Calculation of sample left after time t, Average life, Nuclear reactions, Nuclear Fission and Fusion reactions, related numericals.

Unit-II: Solid State Chemistry **(13 h)**

Introduction, Types of solids (Crystalline and amorphous), Isotropy and Anisotropy, Crystal structure, Cubic unit cells and its types (simple, body-centred and face-centred cubic unit cell), X-ray crystallography, Bragg's equation, Classification of crystals on the basis of bonds (Ionic, Molecular, Network covalent and Metallic crystals), Structure of metal crystals, Types of close-packed metallic crystals: Hexagonal and cubic close-packed, Crystal defects, Schottky defect, Frenkel defect, related numericals.

Unit-III: Photochemistry **(10 h)**

Introduction, Differences between thermal and photochemical processes, Laws of photochemistry: Grothus-Draper law and Stark-Einstein law of photochemical equivalence, Primary and secondary reactions, Quantum yield, Cause of high and low quantum yield, Examples of high and low quantum yield, Calculation of quantum yield, Photosensitized reactions, photophysical processes: Fluorescence and Phosphorescence, Jablonski diagram, Chemiluminescence, related numericals.

Unit-IV: Electrochemistry-II **(10 h)**

Concentration cells, types of concentration cells: Electrode-concentration cells and Electrolyte-concentration cells, Types of electrolyte-concentration cells: Concentration cells without transference and Concentration cells with transference, Liquid junction potential, Fuel cells: Hydrogen-Oxygen fuel cells, related numericals.

References:

- Arnikar, H. J., (1995), Essentials of Nuclear Chemistry, New Age International (P) Limited Publishers, New Delhi.
- Rohatgi-Mukherjee, (1986), Fundamentals of Photochemistry, Revised Edition, New Age International (P) Limited Publishers, New Delhi.
- Bahl, B. S., Bahl, A., Tuli, G. D., S., (2005), Essentials of Physical Chemistry, Chand and Co Ltd., New Delhi.
- Puri, B. R., Sharma, L. R., Pathania, (2007), Principles of Physical Chemistry (42nd Edition), M. S., Vishal Publishing Co., Jalandhar.
- Azaroff, L. V., (1977), Introduction of Solid, Tata McGraw Hill, New Delhi.
- West, A. R., (1999), Basic Solid State Chemistry, John Wiley and Sons Ltd., USA.
- Maron, S. H., Prutton C. F., (2012), Principles of Physical Chemistry (4th Edition), Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Atkins, P., J. de Paula, (2002) ATKINS' Physical Chemistry, Seventh Edition, Oxford University Press, New York.
- Barrow, G. M., (2003), Physical Chemistry, International Student Edition, McGraw-Hill Book Company, New York.
- McQuarrie, D. A., imon, J. D., (2006), Physical Chemistry- A Molecular Approach, Viva Books Pvt. Ltd., New Delhi.

Methods of teaching:

- Lecture method, discussion and problem solving method, question answer method, brainstorming method, assignment method. ICT enabled teaching, video clips/movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-362: Inorganic Chemistry-IV

Total Hours: 45 **Credits: 3**

Course Objectives:

- To acquire the knowledge of organometallic compounds.
- To introduce bioinorganic chemistry.
- To study inorganic polymers
- To study and apply the knowledge of inorganic chemistry in the field of environmental chemistry and in medicine.

Course Outcomes:

Students will be able to:

- Draw structure and reactions of organometallic compounds.
- Understand elements involved in the biological system through bioinorganic chemistry.
- Understand different types of useful inorganic polymers
- Understand elements from environmental chemistry and in medicine

Unit-I: Organometallic compounds **(10 h)**

Organometallic compounds an introduction, classification of organometallic compounds based on nature of metal-carbon bond: 1) Ionic organometallic compounds 2) Compounds containing metal-sigma bond, 3) Ylids 4) Organometallic compounds with multicentre bonds 5) Organometallic compounds with pi bonded ligands. Bonding in pi-metal organometallic complexes, Ferrocene: aromatic character, preparation, and reactions (Nitration, halogenation, Vilsmeier and Mannich condensation reaction). Aromaticity of cyclic $C_nH_n$ligands. Ziegler-Natta catalyst. Inert gas rule.

Unit-II: Bioinorganic Chemistry **(10 h)**

Introduction of Bioinorganic Chemistry, role of myoglobin and hemoglobin in biological systems. Metallo-enzymes: carbonic anhydrase, carboxypeptidase, peroxidases, catalases, cytochrome P-450. Inhibition and poisoning of enzymes, role of alkali and alkaline earth metal ions in biological system, biological and toxicity of some elements, biological fixation of nitrogen.

Unit-III: Inorganic Polymers **(10 h)**

Inorganic polymers: an introduction, properties of inorganic chemistry, glass transition temperature. 1) Phosphorus-based polymers: a) Phosphorus-based chain polymers: Polyphosphazenes, Polyposphonitrilic chlorides, Polyphosphoryl Chlorides. b) Phosphorus-based network polymers: Polymeric phosphorus Pentoxide, Polyorthophosphates of boron, Polymeric silver phosphate, borophosphate glasses. 2) Sulphur-based polymers: Polymeric sulphur, polymeric sulphur nitride, chalcogenide glasses. 3) Boron-based polymers: Polyboranes, polymeric boron nitride 4) Silicon-based Polymers: organosilicones, silicone rubber, silicon resins. 5) Coordination polymers: natural and synthetic coordination polymers.

Unit-IV: (A) Environmental chemistry
(B) Chemistry of elements in medicine **(15 h)**

(A) Environmental chemistry:

Environment chemistry; an introduction. Air pollution: air pollutant (Carbon Monoxide, Carbon dioxide, Chlorine, Nitric acid rain, Sulphuric acid rain, Hydrogen sulphide, effect of nitrogen oxide and fluorocarbons on ozone layer. Particulates: sources of particulates, effect on visibility and materials, toxic effect of particulates on humans. Smog; Mechanism of the formation of photochemical smog.

Pesticides and their adverse side effects, Insecticides: stomach poisons, contact poisons, fumigants. Fungicides, herbicides, Rodenticides.

Various water pollutants: sewage and other oxygen-demanding wastes, plant nutrients, exotic organic chemicals, inorganic chemicals and minerals like Lead, Arsenic, Cadmium etc.

(B) Chemistry of elements in medicine:

Chelation therapy, Cancer treatment, Anti-arthritis drugs, Imaging agents. Role of Na, K, and Li in the biological system.

References:

- Puri, B. R., Sharma, L. R., Kalia, K. C., (2006), Principle of Inorganic Chemistry, thirtieth edition, Milestone Publisher, Delhi.
- Lee J. D., (1991), Concise Inorganic Chemistry, Fourth edition, Chapman and Hall, London.
- Huheey, J. E., Keiter, E. A., Keitler R. L., (1993), Inorganic Chemistry Principles of Structure and Reactivity, fourth Edition, Harper Collins Publisher, New York.
- Atkins, P., Overton T., Rourke J., Weller M., Armstrong F., (2009), Shriver and Atkins' Inorganic Chemistry, fifth edition, Oxford University Press. W. H. Freeman and Company, New York.
- Lekishvili N., Kopylov, V. and Zaikov G., (2010), Silicon-Organic Oligomers and Polymers with Inorganic and Organic-Inorganic Main Chains, Nova Science Publishers, Inc., New York (ISBN 978-1-62100-522-3).

Methods of teaching:

- Lecture method, discussion and problem solving method, question answer method, brainstorming method, assignment method. ICT enabled teaching, video clips/movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH- 363 Organic Spectroscopy

Total Hours: 45 **Credits: 3**

Course Objectives:

- Learn the principles of Molecular Spectroscopy to Organic Molecules
- Characterize the organic molecule using various spectroscopic technique
- Derive the structure of the molecule using the spectroscopic techniques

Course Outcomes:

Students will be able to:

- Understand the principle and applications of UV-Visible and IR spectroscopy
- Elucidate the structure of the unknown compounds using the provided UV Visible and IR spectroscopic data.
- Know the principle and applications of NMR spectroscopy
- Derive the structure of the unknown organic molecule using the provided spectroscopic data

Unit-I: Introduction to Spectroscopy **(7 h)**

Introduction, meaning of spectroscopy, nature of electromagnetic radiation, wave length, frequency, energy, amplitude, wave number, and their relationship, different units of measurement of wavelength and frequency, different regions of electromagnetic radiations. Interaction of radiation with matter. Excitation of molecules with different energy levels, such as rotational, vibrational and electronic level. Types of spectroscopy, advantages of spectroscopic methods

Unit-II: Ultra Violet Spectroscopy **(11 h)**

Introduction, nature of UV spectrum, Beer's law, absorption of UV radiation by organic molecule leading to different excitations. Terms used in UV Spectroscopy: Chromophore, Auxo chrome, Bathochromic shift (Red shift), hypsochromic shift (Blue shift), hyperchromic and hypochromic effect. Effect of conjugation on position of UV band. Calculation of λ-max by Woodward and Fisher rules: for dienes and enone system, Applications of UV Spectroscopy: Determination of structure, determination of stereo chemistry (cis and trans), problems.

Unit-III: Infra-red Spectroscopy **(11 h)**

Introduction, Principle of IR Spectroscopy, fundamental modes of vibrations (3N-6, 3N-5) Types of vibrations (Stretching and bending), Regions of IR Spectrum: functional group region, finger print region and aromatic region, Characteristic IR absorption of functional groups: Alkanes, alkenes, alkynes, alcohol, ethers, alkyl-halides, carbonyl compounds (- CHO, C=O, -COOR, -COOH), amines, amides and Aromatic Compounds and their substitution Patterns. Factors affecting IR absorption: Inductive effect, resonance effect, hydrogen bonding. Applications of IR Spectroscopy: determination of structure, chemical reaction and hydrogen bonding, Problems.

Unit-IV: **(16 h)**

A. **NMR Spectroscopy**
Introduction, Principles of NMR Spectroscopy, Magnetic and nonmagnetic nuclei, Precessional motion of nuclei without mathematical details, Nuclear resonance, chemical shift, shielding, & deshielding effect. Measurement of chemical shift, delta and Tau-scales.
TMS as reference and its advantages, peak area, integration, spin-spin coupling, coupling constants, *J*-value (Only first order coupling be discussed), problems.

B. **Combined Problems Based on UV, IR, NMR** Determination of structure of simple organic compounds on the basis of spectral data such as λ max values, IR frequencies, chemical shift (δ values), coupling constant, peak values provided to the students.

References:

- Williams D. H. & Fleming I., (2007), Spectroscopic Methods in Organic Chemistry, 6th Ed. McGraw-Hill Education, Europe, Middle East & Africa.
- Kalsi P. S., (2007), Spectroscopy of Organic Compounds, 6thEd, New Age Int. Pub. India
- Silverstein R. M. and Webster F. X., (2007) Spectrometric Identification of Organic Compounds, 7th Edition, John Wiley and Sons Inc, NJ.
- Pavia Donald L., Lampman Gary M., Kriz George S. and Vyvyan J. R., (2015), Introduction to Spectroscopy, 5th edition. Indian Edition. Cengage Learning, Australia, Brazil, Mexico, Singapore, United Kingdom, United States.
- Sharma Y. R. Elementary Organic Spectroscopy, (2013)5th Ed. S Chand & Company. New Delhi.
- Jag Mohan Organic Spectroscopy (2001), Narosa Publishing House, New Delhi

Methods of teaching:

- Classroom teaching methods, discussion and problem solving, hands on training on IR and UV instrumentation. problem solving method, question answer method, brain storming method, assignment method. ICT enabled teaching, video clips/ movies, online quiz

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-364: Analytical Chemistry-II

Total Hours: 45 **Credits: 3**

Course Objectives:

- To get the knowledge of basic concept of analytical Chemistry.
- To learn the sampling methods in analytical chemistry.
- To study the Gas chromatography.
- To learn the methods of Ion exchange chromatography.
- To understand, clinical chemistry and its analyzing methods.

Course Outcomes:

Students will be able to:

- Understand the basic concept of analytical Chemistry.
- Understand method involving Gas chromatography.
- Understand knowledge of Ion exchange chromatography
- Understand methods involving analysis of clinical chemistry.

Unit-I: Introduction to Analytical chemistry **(13 h)**

Role of Analytical chemistry. Types of analysis. Classification of Analytical methods. Selecting an analytical method. Factors affecting the analytical methods. Safety in the analytical laboratory. Laboratory operations and practices. Sampling technique. Sample preparation. Selecting and handling of reagents.
Qualitative and Quantitative analysis: What does each tell us? The Analytical process. Validation of a method. Range-What size sample? Some useful websites.

Unit-II: Gas Chromatography **(12 h)**

Introduction, Principles, Gas chromatography Columns, Gas Chromatography Detectors, Column Efficiency in Chromatography- Theoretical Plates, 1) Van Deemter Equation, 2) Capacity Factor and 3) Resolution, Problems

Unit-III: Ion Exchange Chromatography **(10 h)**

Introduction, Cation Exchange Resins, Anion Exchange Resins, Cross-linkage, Effect of pH Separation of Amino Acids, Effect of Complexing Agents-Separation of Metal ions on Anion Exchange Columns, Applications of Ion Exchange Chromatography

Unit-IV: Clinical Chemistry **(10 h)**

Composition of blood. Collection and preservation of samples. Storage of blood samples. Clinical analysis: Estimation of blood glucose, Estimation of blood urea, Estimation of total serum protein (Biuret method of Reinhold) Immunoassay.

References:

- Christian Gary D.(2015), Analytical Chemistry 6th edition, Wiley publication, Satyam enterprises, Delhi
- Sharma B. K., (2012), Instrumental methods of chemical analysis 28th edition, GOEL publishing house, Krishna Prakashan media Ltd., Meerut, India
- Willard, H. H., (1986), Instrumental Methods of Analysis, CBS Publishers, New Delhi

- Skoog D. A., West D. M. and Holler F. J., (1992), Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth,Texas
- Gupta Alka L., (2017), Analytical chemistry 8th edition, Pragati Prakashan, Meerut
- Dean, J. A., (1992) Analytical Chemistry Notebook, McGraw Hill, New York
- Vogel, A. I., (1996), Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, NewYork
- Chatwal G.& Anand S. (2019). Instrumental Methods of Chemical Analysis, 5th edition Himalaya publications, Mumbai

Methods of teaching:

- Classroom teaching method, discussion and problem solving, problem solving method, question answer method, brain storming method, assignment method, ICT enabled teaching, video clips/ movies, online quiz. Group discussion, Presentation contest, seminar competition.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-365: Industrial Chemistry

Total Hours: 45 **Credits: 3**

Course objectives:

- To make students capable of acquiring different skills and applied knowledge necessary for higher education, research and various industries by studying chemistry in academics.
- To make aware & expose the students to different Industrial processes and their applications.
- To make students familiar with industrial work culture, its importance and need and to develop the ability to apply the knowledge of the contents of principles of chemistry.
- To develop proficiency in the applications of current aspects of industrial chemistry.
- To develop the ability to describe various industrial products of important organic and inorganic compounds / chemicals.
- To equip students with advanced knowledge about various industrially important products.
- To make students aware of dyes, classification of dyes, needs and uses.
- To acquire knowledge and skill of preparation of Hair dye, shampoo, talcum powder, nails enamel, shaving creams etc.

Course outcomes:

Student will be able to:

- Understand importance of patent, trade-marks, copyright act in various industries.
- Know the manufacturing processes involved in Industrial Organic Synthesis such as Methanol, Isopropanol, Glycerol, with their uses.
- Understand basic requirements of chemical industries, chemical production, Quality control, research and development.
- Know importance of essential oils in cosmetic industries & perfumery with reference to Geraniol, Sandalwood oil, Eucalyptus, Rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone etc.
- Know importance, definition and meaning of the different terms involved in the Drugs and Pharmaceuticals Industry.
- Understand Synthesis, uses, properties and industrial manufacture of Paracetamol, Aspirin, Chloroquine.
- Know preparation of dyes, its structure and its application.
- Know preparation of Hair dye, shampoo, talcum powder, nails enamel, shaving creams etc.

Unit-I: Modern Aspect of Industrial Chemistry **(13 h)**

Introduction, basic requirements of chemical industries, chemical production, raw materials, unit process and unit operations, Quality control, quality assurance, process control, research and development, pollution control, human resource, safety measures, classification of chemical reactions, batch and continuous process, Conversion, selectivity and yield, copyright act, patent act, trademarks.

Unit-II: Chemistry of Pharmaceutical Industries **(7 h)**

A. Meaning of the terms: Prescriptions, doses, analgesic, antipyretic, diuretic, anesthetics, antibiotics, anti-inflammatory, anti-viral, tranquilizer, antiulcer,

antiallergic and bronchodilators, cardiovascular, cold preparations, anti-hypertensive, cough preparation, anti-neoplastic, sedative and hypnotics, steroidal, contraceptive, histamine and antihistamine.

B. Synthesis and uses: i) Paracetamol, ii) Aspirin, iii) Chloroquine.

Unit-III: Industrially Valuable Product **(15 h)**

A. **Organic Synthesis: -** Manufacture of methanol from synthesis gas, Isopropanol from propylene, Glycerol from propylene via allyl chloride, Acetone by catalytic dehydrogenation of isopropanol (with flow sheet), Unsaturated Hydrocarbon – preparation of Acetylene from Natural gas (with flow sheet), Aromatic hydrocarbon Preparation of toluene (with flow sheet).

B. **Dyes:** Introduction, properties of dyes, Otto Witts Theory, classification of dyes according to their mode of application and chemical constitution, synthesis and uses of dyes :Congo red, Methyl orange, Phenolphthalein.

Unit- IV: Perfume and Cosmetics Industrial Chemistry **(10 h)**

A. 1) Introduction of Essential oils

2) Properties, Uses and Importance of - essential oils in cosmetic industries with reference to --- i) Eugenol ii) Geraniol iii) Sandalwood oil iv) Eucalyptus v) Rose oil vi) 2-phenyl ethyl alcohol vii) Jasmone viii) Civetone ix) Muscone x) Antiperspirants and Artificial flavours.

B. Preparation and uses of Hair dye, shampoo, suntan lotions, lipsticks, talcum powder, nails enamel, creams (cold and shaving creams).

References:

- Sharma B. K., (2011), Industrial Chemistry, 16th Edition, Goel Publishing House, Meerut, (U.P.), India.
- Austin George T.,(1984), Shreve's Chemical Process Industries, 5th Edition, McGraw Hill, New York.
- Clausen III Chris A and Mattson Guy, (1978), Principles of Industrial Chemistry, John Wiley and Sons, Inc. Somerset, New York.
- More P.G., (2010), Comprehensive Industrial Chemistry, 1st Edition, Pragati Prakashan, Meerut (U.P.), India.
- Ali Mohammad Farhat, El Ali Bassam M., Speight James G., (2005), Handbook of Industrial Chemistry: Organic Chemicals, The McGraw-Hill Education, India.
- Kent Jems A., (1997), Riegel`s Handbook of Industrial Chemistry, 9th Edition, CBS Publishers and Distributors, Delhi.
- Das R.K., (1976), Industrial Chemistry ,2nd Edition, Asia Publishing Mumbai.
- Noble Elin, (1998), Dyes & Paints: A Hands-On Guide to Coloring Fabric, Fibre Studio Press, USA.

Methods of teaching:

- Classroom teaching methods, discussion method, question answer method, brain storming method, assignment method. ICT enabled teaching, video clips/ movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-366 (A): Pharmaceutical Chemistry

Total Hours: 45 **Credit: 03**

Course Objective:

- To study different natural sources as biologically active agent and their mode of action.
- To learn different classes of drugs and methods of drug synthesis.
- To study ingredients, formulation and design of drugs.
- To acquire the skill of identification of impurity in pharmaceutical product.

Course Outcomes:

Student will be able to:

- Acquire the knowledge of some important natural compounds used in Pharmaceutical Chemistry.
- Understand the mechanism of drug synthesis.
- Understand the role of each constituent used in tooth powder/ toothpaste.
- Check the quality of pharmaceutical products and supervises the processes for quality assurance.
- Conduct qualitative and quantitative research of medicines and the substances used in pharmacy.

Unit-I: Introduction of Pharmaceuticals Chemistry and Drugs **(10 h)**

Important aspects of Pharmaceuticals Chemistry, Importance of Chemistry in Pharmacy, History of Pharmacopoeia, Classification of drugs, Theories of drug action: Nature of pharmacological action, Rate theory and induced fit theory, Natural product as potential new drug, Natural product for drug discovery, Natural product for Therapeutic biological effect, biologically active natural products.

Unit-II: Drugs and Pharmaceuticals **(15 h)**

Introduction of drug class and synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Ibuprofen, Celecoxib), antibiotics (Chloramphenicol), antibacterial and antifungal agents (Sulphonamides, Sulphanethoxazol, Sulphacetamide, Trimethoprim), antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), Antineoplastic agent (Carmustine).

Unit- III: Dentrifrices- Desensitizing Agent-Anticaries Agents **(10 h)**

Dentrifrices: Introduction, Classification, Tooth powder, Formulation of tooth powder, Abrasive and polishing material, Detergents and foaming additives, sweetening agent, Flavoring substances, Toothpaste, Desensitizing agent, Anticaries Agents.

Unit IV: Impurities in Pharmaceutical Substances **(10 h)**

Sources of impurities in pharmaceutical chemicals, Effect of impurities, Permissible impurities in pharmaceutical substances, Purification of pharmaceutical substances, Test of Purity, Limit Test-Arsenic, Lead, Sulphate, Iron and Heavy metals

Volumetric Estimation: Introduction to volumetric estimation, Condition, Requirement and Advantages of volumetric analysis, Primary standard and secondary standard, Methods of
expressing concentration of volumetric analysis, Titration methods: Types of titration methods, Acid-base titration, Non-aquious titration, Oxidation reduction titration, Precipitation titration, Complexometric titration.

References:

- Chatwal, G. R. (2006), Medicinal Chemistry (Organic pharmaceutical Chemistry) Himalaya Publishing House, Bombay.
- Kar, A. (2015), Medicinal Chemistry, New Age International Publisher, 6th edition, New Delhi.
- Lemke, T. L., William, D. A. (2006), Foey's Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi.
- Kar, A. (2008), Pharmaceutical Drug Analysis, New Age International Publisher, New Delhi.
- Patrick, G.L.(1995,) Introduction to Medicinal Chemistry, Oxford University Press, UK. 65
- Kapoor, H. V. K., (2004), Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.

Methods of Teaching:

- Classroom teaching method, discussion, question answer method, brain storming method, assignment method. ICT enabled teaching, video clips/ movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-366 (B): Research Methodology

Total Hours: 45 **Credit: 03**

Course Objectives:

- To familiarize students towards basics of research, process of research and methods.
- To enable the student in conducting research work and formulating research synopsis and report.
- To learn the analysis of primary research articles and peer review articles.
- Improve student understanding of how scientific questions are developed and posed through proposals and dissemination of research results.
- To learn the scientific method of collecting and analyzing information.

Course outcomes:
Student will be able to:

- Learn about what is research, research methods and impact of chemical research on society through pure and applied research.
- Learn how to analyze research in chemistry drawn from contemporary primary chemical literature.
- Develop problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- Communicate the results of scientific work in oral, written and electronic formats.

Unit-I: Introduction to Research **(12 h)**

Definition of Research, Objectives of Research, Importance, and need for Research in a related field. Motivation in Research Methods versus Methodology, Classification and types of Research, Pure and applied Research, Difference between Computational lab and wet lab research, theoretical and experimental models, Criteria of Good Research Application of the oretical knowledge in designing of experiments. Methods of Data Collection. List of National Importance Institutes and List of CSIR Laboratories.

Unit-II: Print Literature Resources **(12 h)**

Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index with examples.

Unit-III: Digital Literature Resources **(12 h)**

The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information. Web resources, E-journals, Journal access, TOC alerts, Citation index, Impact factor, H-index, UGC in fonet, E-books. The introduction of Search engines, Scirus, Google, Google Scholar, Chem Industry, Wiki-Databases, Chem Spider, American Chemical Society, Royal Society of Chemistry, Wiley-interscience, ScienceDirect, Springer, SciFinder, Scopus, C & EN News Reaxys.

Unit-IV: Writing Scientific Reports **(12 h)**

Writing Skills, Reporting practical and project work, Referencing, Organizing a poster display. Communication Skills, Body Language, Giving an oral presentation.

Content of Research Papers, How to down load Research Paper? How to Read Research Paper, Abstract and Summary. What are Paper, Patent and Review? Introduction of Plagiarism and self Plagiarism.

References:

- Kothari, C. R. (2004). Research methodology: Methods and techniques. New Age International, New Delhi.
- Dean, J. R. (2002). Practical skills in chemistry. Pearson Education, canada.
- Hill Jr, R. H., & Finster, D. C. (2016). Laboratory safety for chemistry students. John Wiley & Sons, Canada.
- De Levie, R. (2001). How to Use Excel® in Analytical Chemistry: And in General, Scientific Data Analysis. Cambridge University Press, United Kingdom.
- Cooper, C., & Purchase, R. (2017). Chemical Hazard Information for the Laboratory. In Organic Chemist's Desk Reference (pp. 171-196). CRC Press, USA.
- OSUSafetyManual1.01

Methods of teaching:

- Classroom teaching methods, discussion and problem solving, question answer method, brain storming method, assignment method, ICT enabled teaching, video clips/ movies, online quiz.

T.Y. B.Sc. (Biochemistry): Semester VI
Skill Enhancement Course (SEC)
CH-360: Instrumental methods of Analysis-II

Total Hours: 30 **Credits: 2**

Course Objectives:

- To develop an understanding of the range and uses of analytical methods in chemistry.
- To understand and establish the role of chemistry in quantitative analysis.
- To learn conductometry and thermo analytical methods of analysis.
- To enhance the Analytical instrumental skill of the students.

Course Outcomes:

Students will be able to learn:

- The fundamentals of analytical methods and instruments for qualitative and quantitative Analysis.
- The role of analytical chemistry in science.
- Their role as a member of an interdisciplinary problem-solving team member.

Unit-I: Conductometric titrations **(12 h)**

Introduction. Specific resistance. Equivalent conductance. Molecular conductance. Measurement of conductance. Effect of temperature and pressure on conductance. Effect of purity of solvent on conductance. Applications of conductance measurement. Conductometric titration apparatus. Automatic titration.

Unit-II: Thermoanalytical methods **(18 h)**

Introduction. Thermogravimetric analysis. Types of thermogravimetric analysis. Principle. Instrumentation for thermogravimetry, Applications of thermogravimetry
Differential Techniques- Differential Thermal Analysis (DTA) and Differential Scanning
Calorimetry (DSC), Principle and working. Instruments for DTA and DSC, Factors affecting results. Applications of DTA and DSC. Thermometric titrations: Apparatus, Applications: Acid- base titration, Precipitation titration, Complexation titration.

References:

- Sharma B. K., (2012), Instrumental methods of chemical analysis 28th edition, GOEL publishing house, Krishna Prakashan media Ltd., Meerut, India
- Willard, H. H., (1986), Instrumental Methods of Analysis 6th edition, CBS Publishers, New Delhi
- Christian Gary D.,(2015), Analytical Chemistry 6th edition, Wiley publication., Satyam enterprises, Delhi
- Skoog D. A., West D. M. and Holler F. J., (1992), Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth, Texas
- Willard H. H., Merrit L. L., Dean J. D., Settle S. A., (1984). Instrumental Methods of Chemical Analysis. 6th Ed, CBS publishers, New Delhi
- Braun R. D. (2016). Introduction to Instrumental Analysis- Pharmamed press, Hyderabad-2nd edition
- Grinberg Nelu, Rodriguez Sonia, (2019). Ewing's Analytical Instrumentation handbook-4th edition. CRC Press, New Delhi

- Chatwal G.& Anand S. (2019). Instrumental Methods of Chemical Analysis. Himalaya publications-5th edition, Mumbai

Methods of teaching:

- Classroom teaching method, discussion and problem solving, laboratory, question answer method, brain storming method, assignment method, ICT enabled teaching, video clips/ movies, online quiz. Zoom classroom. Google classroom, Group discussion, Presentation contest, seminar competition

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-367: Physical Chemistry Practical–II

Total Hours: 60 **Credits: 2**

Course Objectives:

- To develop the experimental skills required in physical chemistry
- To expose the students to an extent of experimental techniques using modern instrumentation

Course Outcomes:

Students will be able to:

- Perform preparation for each experiment by studying lab handouts and links therein
- Understand safety requirements and lab skills to perform physico-chemical experiments
- Know how to keep records of instruments, parameters, and experimental observations reporting of experimental result
- Understand an appreciation for modern problems and scientific controversies in physical chemistry

Sr. No.	Particular Topic	Hours
	Conductometry:	
1	To investigate the conductometric titration of oxalic acid with sodium hydroxide.	04
2	To determine the hydrolysis constant of the aniline hydrochloride conductometrically.	04
	Potentiometry:	
3	To determine the strength of hydrochloric acid by titrating it with a standard solution of sodium hydroxide potentiometrically.	04
4	To determine the dissociation constant of chloroacetic acid by potentiometric titration	04
	pH-metry:	
5	To determine the hydrolysis constant of aniline hydrochloride pH-metrically.	04
6	To determine the dissociation constant of chloroacetic acid by pH-metric titration.	04
	Colorimetry / Spectrophotometry:	
7	To test the validity of Beer's-Lambert's law and hence determine the concentration of given unknown $KMnO_4$ solution colorimetrically/spectrophotometrically.	04
	Polarimetry:	
8	To determine the concentration of given solution of an optically active substance (cane sugar) by polarimetric measurement.	04
	Refractometry:	
9	To determine the molar refractive indices of series of KCl solution and hence unknown concentration of given KCl solution.	04
	Chemical Kinetics:	
10	To determine the order of reaction between potassium persulphate and potassium iodide by fractional change method.	04
11	To study the hydrolysis of methyl acetate in presence of hydrochloric acid.	04

12	To investigate the reaction between H2O2 and KI by gas burette method.	04
	Non-Instrumental:	
13	To determine the molecular weight of a given polymer by viscometry method.	04
	Application of Microsoft Excel:	
14-15	Draw the two graphs of the given data using Microsoft excel.	04

References:

- Jeffery, G. H., Bassett, J., Mendham, J., Dennet, R. C., (1989), VOGEL's Textbook of Quantitative Chemical Analysis, Fifth Edition, Longman Scientific and Technical, England.
- Rose, J., (1964), Advanced Physico-Chemical Experiments- A Text Book of Practical Physical Chemistry and Calculations, Sir Isaac Pitman and Sons Ltd., London.
- Garland, C. W., Nibler, J. W., D. P. Shoemaker, (2003), Experiments in Physical Chemistry, Eighth Edition, McGraw-Hill Companies, Inc., New York.
- Yadav, J. B., (2008) Advanced Practical Physical Chemistry, Twenty Sixth Edition, Goel Publishing House- A Unit of Krishna Prakashan Media (P) Ltd., Meerut.
- Rajbhoj, S. W., Chondhekar, T. K., (2000), Systematic Experimental Physical Chemistry, Second Edition, Anjali Publication, Aurangabad.

Methods of teaching:

- Lecture method, discussion, laboratory method, problem solving method, question answer method, brain storming method, assignment method. ICT enabled teaching, video clips/movies, online quiz.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-368: Inorganic Chemistry Practical-II

Total Hours: 60 **Credits: 3**

Course Objectives:

- To acquire practical knowledge and analyse the inorganic mixtures.
- To understand the determination of metal from ore and alloy analysis.
- To get the knowledge of metal determination by colorimetric analysis.

Course Outcomes:

Students will be able to:

- Determine cation and anion from inorganic mixtures by using inorganic qualitative analysis.
- Determine metal from ore and alloy analysis.
- Carry out colorimetric analysis.

Sr. No.	Particular Topic	Hours
	Gravimetric Estimations: (any two)	
1	Fe as Fe_2O_3	04
2	Zn as $Zn_2P_2O_7$	04
3	Pb as lead chromate	04
4	Al as Al_2O_3	04
	Volumetric Analysis: (Minimum two)	
5	Manganese by Volhard's method.	04
6	Estimation of Nickel by EDTA method	04
7	Determination of strength of NaOH and Na_2CO_3 in a given solution.	04
8	Estimation of ferrous and ferric by dichromate method.	04
	Inorganic Preparations: (Minimum five)	
9	Bis (ethylenediamine) copper (II) sulphate.	04
10	Potassium trioxalato chromate (III).	04
11	Tris (acetylacetonato) Iron (III).	04
12	Hexaaquanickel (II) chloride.	04
13	Potassium tris oxalatoaluminate (III)trihydrate.	04
14	ZnO nanoparticles using Zinc acetate dihydrate.	04
	Colorimetric Analysis: (any one)	
15	Estimation of iron using thiocynate method.	04
16	To determine the concentration of cobalt in the given solution using R-nitroso salt by colourimetry	04
	Paper Chromatography: (any Two mixtures)	
17	Separation and identification of binary mixture of cations (Fe^{3+},Ni^{2+}, Cu^{2+},Co^{2+}, Mn^{2+}, Zn^{2+}).	04

References:

- Mendham, J., (2009) Vogel's Quantitative Chemical Analysis ,6th Edition, Pearson, Germany.
- Svehla, G., Shivshankar B., (2012), Vogel's Qualitative Inorganic Analysis, Pearson Education India.
- Christian, G. D., (2006), Analytical chemistry, 6th Edition, Wiley-India.

- Mendham, J., Denny R. C.,Barnes J. D., Thomas M.,Sivasankar B., (2009), Quantitative Chemical Analysis.,6th Edition, Pearson, Germany.
- Jeffrey, H., Bassett J., Mendham, J., Denney R. C., (1989), Vogel's Textbook of Quantitative Inorganic Analysis, 5th Edition, Longman Scientific and Technical, England co published with John willey and Sons, New York.
- Nemade, A. M., Rajput, A. P., Zope, V. S., Gujrathi, R. B., (2013), A Textbook of Practical Chemistry, Prashant Publications., Jalgaon.
- Patel, H. N., Turakhia, S. P., Kelker, S. S., Puniyani, S.R., (2010), College Practical Chemistry, Himalaya Publishing House, Mumbai.

Methods of teaching:

- Laboratory method, discussion and problem solving method, question answer method, Heuristic method. ICT enabled teaching, video clips/ movies.

T.Y. B.Sc. (Chemistry): Semester VI
Discipline Specific Core (DSC) Course
CH-369: Organic Chemistry Practical-II

Total Hours: 60 **Credits: 2**

Course Objectives:

- To develop skills required in chemistry such as the appropriate handling of apparatus and chemicals.
- To learn the laboratory skills needed to design, safely conduct and interpret chemical research.
- To expose the students to an extent of experimental techniques using modern instrumentation.
- To develop the ability to effectively communicate scientific information and research results in written and oral formats.

Course Outcomes:

Students will be able to:

- Develop skill to carry out chemical reaction on laboratory scale
- Understand mechanism involved in Chemical Reaction.
- Understand various purification techniques.
- Carry out synthesis of various organic compounds through greener alternatives.

Sr. No.	Particular Topic	Hours
	Single Stage Preparations (Minimum four)	
1	p-nitro acetanilide from Acetanilide (Nitration)	04
2	Benzoic acid from benzamide by Hydrolysis method	04
3	Benzoic acid from benzaldehyde by Oxidation method (Oxidation method).	04
4	Benzoquinone from Hydroquinone (Oxidation by $KBrO_3$ or $K_2Cr_2O_7$)	04
5	Hippuric acid from Glycine (Benzoylation)	04
6	p-Iodonitrobenzene from p-Nitroaniline (Sandmeyer Reaction)	04
7	m- Nitro aniline from m-Dinitrobenzene (Reduction)	04
8	Benzoic acid from Ethyl benzoate (Ester hydrolysis)	04
9	m-dinitrobenzene from nitrobenzene by Nitration	04
10	Iodoform from ethanol by Halogenation.	04
	Organic Estimations (Minimum three)	
11	To determine saponification value of given oil sample	04
12	To estimate basicity of given acid sample	04
13	To determine the amount of glycine present in the given unknown solution.	04
14	To estimate amount of glucose in the given solution.	04
15	To estimate the amount of Nitro group in the given organic compound	04
16	Estimation of the amino group in given liquid.	04
	Green Chemistry Preparation (Any four)	
17	Synthesis of acetanilide from aniline by using Zn dust / acetic acid.	04
18	Synthesis of dibenzalpropanone from benzaldehyde and acetone. using $LiOH.H_2O$/NaOH.	04
19	Synthesis of p- bromo acetanilide from acetanilide by using KBr.	04

20	Synthesis of dihydropyrimidinone from ethyl ace to acetate, benzaldehyde and urea.	04
21	Diels-Alder reaction between furan and maleic acid [4+2] Cycloaddition Reaction.	04
22	Any Latest Green Chemistry Synthesis.	04
	Purification techniques (Any one)	
23	Crystallization & Distillation	04
24	Solvent extraction using separating funnel	04
25	Preparative TLC	04

References:

- Vogel A. I., (2005), Practical Organic Chemistry, 5th Edition Pearson. New York
- Agarwal O. P., (2014), Practical Organic Chemistry, Krishna Prakashan Media (P) Ltd, Meerut, India
- Kamboj P. C., (2013,) University Practical Chemistry, 1st (Reprint) Edition, Vishal Publishing Co. Jalandhar, India
- Ahluwalia V. K. and Aggarwal Renu, (2016), Comprehensive Practical Organic Chemistry-Qualitative Analysis Universities Press, Hyderabad, India
- Woodward R.B. and Baer H., J. Am. Chem. Soc. 1948, 70, 1161.
- Rideout D. C. and Breslow R., J. Am. Chem. Soc. 1980, 102, 7816.
- Anastas, P.T and Warner, J.C (1998), Green Chemistry: Theory and Practice, J.C. Oxford University Press. New York
- Monograph on Green Chemistry Laboratory Experiments, Green Chemistry Task Force Committee, DST Page 69 of 70, India

Methods of teaching:

- Laboratory method, Virtual Laboratory, problem solving method, Predicting Mechanism involved, ICT enabled teaching, video clips, Project.

Skills acquired and Job prospects for the Chemistry students

Chemistry is, with no doubt, one of the core subjects and also serves as central science through which other sciences such as physics, biology and geology connect to each other. A significant attraction of the course is the ability to combine in-depth scientific knowledge with practical laboratory skills and the career opportunities in all sectors.

After successful completion of three years degree course in Chemistry, student will be well versed with laboratory skills and transferable skills.

Development of Student Skills in a Chemistry Curriculum:

Problem-Solving Skills: Chemistry education provides students with the tools to solve problems. This means that students should be able to apply the scientific method: define a problem clearly, develop testable hypotheses, design and execute experiments, analyze data using appropriate statistical methods, and draw appropriate conclusions. Students should be able to integrate knowledge across chemical subdisciplines and apply this knowledge to solve problems. In the laboratory, in addition to the characteristics described above, students should understand the fundamental uncertainties in experimental measurements. Open-ended laboratory experiences provide excellent opportunities for the development and assessment of these skills.

Chemical Literature Skills: Students should be able to retrieve specific information from the chemical literature, critically evaluate technical articles, and manage many types of chemical information. Students should develop proficiency with electronic searching of appropriate technical databases, including structure-based searching.

Laboratory Safety Skills: Program will promote a safety-conscious culture in which students demonstrate and apply their understanding of the concepts of safe laboratory practices. A high degree of safety awareness will begin with the first laboratory course and continue throughout a student's college career. This includes understanding safety and dress rules; knowing when to use fume hoods; knowing when and how to use of safety/emergency equipment; handling, storage, and disposal of chemical waste; understanding and use of safety data sheets; and, in general, knowing how to effectively handle laboratory emergencies.

Communication Skills: Written and oral communication skills are very important for chemistry graduates' students. They will be able to synthesize information from a variety of sources in a clear and organized manner using a scientifically appropriate style. Equally important is the opportunity to orally present material. For the most effective experiences, students should receive critical feedback on their oral or written communications. Students should be able to use communication technology such as computerized presentations as well as software for word processing, chemical-structure drawing, and poster preparation.

Team Skills: Solving scientific problems often involves working in disciplinary and multidisciplinary teams. Students should learn to work productively with a diverse group of peers in classroom and laboratory activities.

Ethics: Chemistry, like any discipline, has a social structure with a code of practices that govern acceptable/unacceptable behaviors. Progress in chemistry, as in all sciences, relies on the chemist's complete honesty, openness, and trustworthiness, and on reproducibility of experimental results. The course will in cult professional ethics in students.

Job Opportunities:

After successful completion of B.Sc. in Chemistry, student may continue further studies like M. Sc.in Chemistry and then Ph.D. in Chemistry and make career in research field. Students have opportunities in private as well as public (Government) sectors.

Chemist: Chemists analyze compounds, refine substances, and test chemical products. Their role is to improve the quality of products and methods while ensuring safety.

Pharmacy Assistant: Dispenses prescriptions and other medical products to patients. They can work at hospitals or also under the direction of a licensed pharmacist.

Lab Assistant: They are highly-analytical experts skilled in basic lab techniques and equipment. Their duties include processing samples, classifying results, and noting findings.

Toxicologist: Toxicologists study the safety and biological effects of drugs, chemicals, agents, and other substances on living organisms.

Biochemist: They analyze enzymes, DNA, and other molecules to research the effects of drugs and food on biological processes.

Academics: As High School, Junior College Teacher after B.Ed. Undergraduate/Postgraduate Teacher after M.Sc. and Ph.D.

Researcher: After M.Sc. in Chemistry, Student can pursue Ph.D. or can work as Researcher at Government or Private Research Laboratories as Project Assistant.

Few other jobs that can also be scored are Cytologist, Technical Writer, Research Analyst, Forensic chemist etc.

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