Kavayitri Bahinabai Chaudhari

North Maharashtra University, Jalgaon

Syllabus

T.Y.B.Sc.

Subject: Chemistry

Choice Based Credit System

With Effect from June -2020

As Per U.G.C. Guidelines

Prepared By

Board of Studies

Chemistry,

Kavayitri Bahinabai Chaudhari

North Maharashtra University, Jalgaon

Syllabus

Class- T.Y.B.Sc. Subject- Chemistry

Choice Based Credit System (CBCS) (60-40) Pattern

with effect from June-2020

Structure of Curriculum of T.Y.B.Sc. (Chemistry)

Semester – V

Course Type	Course code	Course Title	Credits	Hours per week	Teaching Hours
Core I	CH – 501	Principles of Physical Chemistry-I	3	3	45
Core II	CH – 502	Inorganic Chemistry	3	3	45
Core III	CH – 503	Organic Reaction Mechanism	3	3	45
Core IV	CH – 504	Industrial Chemistry	3	3	45
Skill Enhancement (SEC)	CH – 505	Analytical Instrumentation	3	3	45
Elective **(Any One)**	CH – 506 (A)	Biochemistry	3	3	45
	CH – 506 (B)	Green Chemistry	3	3	45
Core course **(Practical)**	CH – 507	Physical Chemistry Practical	2	4 (Per Batch)	60
	CH – 508	Inorganic Chemistry Practical	2	4 (Per Batch)	60
	CH – 509	Organic Chemistry Practical	2	4 (Per Batch)	60
Non-Credit Audit Course **(Any One)**	AC-510	NSS	No Credit	2- Batches	60
	AC-511	NCC		2- Batches	60
	AC-512	Sports		2- Batches	60

Note:

1. Each lecture is of one hour (60 Minutes) duration.
2. Each theory paper has three lectures per week.
3. Each practical course has four lectures per week.
4. An industrial study tour is compulsory for the T.Y.B.Sc. Students. The students should submit their tour reports at the time of practical examination of VIth Semester.

5. Use of Chart/Text book/Hand book of practical is allowed during examination.
6. Scientific calculator (non-programmable) is allowed during theory and practical examination.
7. All units should be in SI unit.

Semester VI

Course Type	Course code	Course Title	Credits	Hours per week	Teaching Hours
Core I	CH – 601	Principles of Physical Chemistry-II	3	3	45
Core II	CH – 602	Chemistry of Inorganic Solids	3	3	45
Core III	CH – 603	Spectroscopic Methods of Structure Determination	3	3	45
Core IV	CH – 604	Chemistry of Industrially Important Products	3	3	45
Skill Enhancement	CH – 605	Analytical Techniques	3	3	45
Elective **(Any One)**	CH – 606 (A)	Polymer Chemistry	3	3	45
	CH – 606 (B)	Research Methodology for Chemistry	3	3	45
Core course **(Practical)**	CH – 607	Physical Chemistry Practical	2	4 (Per Batch)	60
	CH – 608	Inorganic Chemistry Practical	2	4 (Per Batch)	60
	CH – 609	Organic Chemistry Practical	2	4 (Per Batch)	60
Non-Credit Audit Course **(Any One)**	AC-610	Soft Skill	No Credit	2- Batches	60
	AC-611	Yoga		2- Batches	60
	AC-612	Practicing Cleanliness		2- Batches	60

Note:

1. Each lecture is of one hour (60 Minutes) duration.
2. Each theory paper has three lectures per week.
3. Each practical course has four lectures per week.

4. An industrial study tour is compulsory for the T.Y.B.Sc. Students. The students should submit their tour reports at the time of practical examination of VI Semester.
5. Use of Chart/Text book/Hand book of practical is allowed during examination.
6. Scientific calculator (non-programmable) is allowed during theory and practical examination.
7. Values required for spectral problems should be provided in the question paper.
8. All units should be in SI unit.

Chairman B.O.S. **Dean Science Faculty**

Aims and Objectives

To enable the students-

- To promote understanding of basic facts and concepts in Chemistry while retaining the excitement of Chemistry.
- To make students capable of studying Chemistry in academic and Industrial courses.
- 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 develop problem solving skills in students.
- To expose the students to different processes used in Industries and their applications.
- To develop ability and to acquire the knowledge of terms, facts, concepts, processes, techniques and principles of subjects,
- To develop ability to apply the knowledge of contents of principles of chemistry.
- To inquire of new knowledge of chemistry and developments therein.
- To expose and to develop interest in the fields of chemistry
- To develop proper aptitude towards the subjects.
- To develop the power of appreciations, the achievements in Chemistry and role in nature and society.
- To develop skills required in chemistry such as the proper handling of apparatus and chemicals.

NOTE:

1. There are in all Six theory courses (4 Core courses, 1 Skill Enhancement course, 1 Elective) and Three practical (Core course practical) courses for each semester.
2. Each theory paper carry 100 Marks out of which 40 Marks are allotted for internal assessment and 60 Marks for external assessment.

3. As per the directions given by University, at the end of each semester internal examination will be conducted for 40 marks and University Examination will be conducted for 60 Marks.
4. The student has a right to choose any one of the optional paper for V^{th} semester either CH-506 (A) OR CH-506 (B), Similarly The students has a right to choose any one of the optional paper for VI^{th} semester either CH – 606 (A) OR CH – 606 (B).
5. A student is expected to submit a journal certified by the Head of the Department/Head of the Institution for each semester.
6. A student will not be permitted to appear for the practical examination unless he/she produce a certified journal. If the journal is lost, the student should produce a certificate from Head of the department / Head of the Institution stating that he/she has satisfactorily completed the practical work.
7. Industrial tour is compulsory for all the students.

Rules for Personal Safety in Chemistry Laboratory:

- A long sleeved, knee length laboratory coat/ apron is recommended. Long pants and closed toed shoes must be worn for individual safety. Loose clothing, open style shoes and sandals are prohibited. Long hair must be tied up. Each student will have to get his / her own necessary protection items.
- For eye protection, safety goggles must be worn in the laboratory whenever necessary. If the student wears contact lenses, full protection goggles, which provide total seal around eyes, must be worn. All students are expected to wear safety goggles.
- Prior to the practical examination, the teacher-in-charge will check all protective equipment to ensure that they are in order.
- Pipetting by mouth should be avoided. Use of pro-pipette bulbs is recommended.
    - All laboratories should be equipped with safety chart, adequate first aid requirements and fire extinguishers.

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North Maharashtra University, Jalgaon

T.Y.B.Sc Chemistry Syllabus

(CBCS) Pattern

Semester V **Core Course I**

CH-501

Subject- Principles of Physical Chemistry-I

(Theory: Lectures = 45 hrs. Marks 60) **(Credits: 03)**

Course objectives

- To orient and acquaint the students towards the basic concepts of Quantum Chemistry
- To acquire knowledge about rates of chemical reactions and distinguishing the reaction of different order and their characteristics.
- To understand the basic principles of phase rules and phase diagrams.
- To learn the underlying principles of electrode reactions, electrochemical cells and applications of EMF.

Learning outcomes

After successful completion of this course, students are expected to:

- Understand the significance of wave function and postulates of quantum mechanics.
- Deduce rate equations and half-life equations for first and second order reactions
- Draw and explain the one and two component system phase diagrams.
- Explain the principles of electrode processes and apply them during Practicals.

UNIT-1. Basic Quantum Chemistry **(L-11, M-15)**

Failures of Classical Mechanics, Origin of quantum mechanics, Particle aspect of radiation: Blackbody radiation, Photoelectric effect, Compton Effect, de Broglie's hypothesis: Matter waves, Heisenberg uncertainty principle, Application of Heisenberg's principle,

Interpretation of wave function, Significance of ψ and ψ^2, Normalization of wave function Operators and operator algebra, Eigen functions and Eigen values, various operators in quantum mechanics: Linear momentum, Kinetic energy and Total energy operator (only equations no derivations), Postulates of quantum mechanics.

Ref. 1: 3, 5-10, 12, 13, 30, 31, 36, 37, 79-84, 115-121

Ref. 2: 3-9, 18, 27-29, 36-39, 43-48

Ref. 4: 21, 24, 32-36, 38-44

UNIT-2. Chemical Kinetics (L-11, M-15)

The concept of reaction rates. Effect of temperature, Pressure, Catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal initial concentrations of reactants) Half–life of a reaction, Pseudo order reactions, General methods for determination of order of a reaction. Effect of temperature on reaction rate, Arrhenius equation (exponential and integrated form), Collision theory, Concept of activation energy and its calculation from Arrhenius equation, Related numerical.

Ref. 3: 732, 734-744, 751-759

Ref. 4: 970-971, 975-978, 984, 988-990, 992, 993

UNIT-3. Phase Equilibrium (L-11, M-15)

Phases, Components and Degrees of freedom of a system, Criteria of phase equilibrium. Gibbs Phase rule and its thermodynamic derivation. Derivation of Clausius –Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, Congruent and Incongruent melting points (lead-silver, $FeCl_3$-H_2O only), Related Numerical.

Ref. 3: 697-714, 719-721

Ref. 4: 605-607, 609-614, 616, 617, 623, 626, 627, 631, 632

UNIT- 4. Electrochemical Cell (L-12, M-15)

Introduction, overview of electrode processes, Faradaic and Non-Faradaic Processes, Introduction to electrical double layer, Factors affecting electrode reaction rate and current.

Classification of electrochemical cell, EMF expression for chemical cell with and without transference, Liquid junction potential, Types of liquid junction potential, Minimization of liquid junction potential.

Application of EMF measurement for pH using Hydrogen gas electrode, Quinhydrone electrode and Glass electrode, Related numerical.

Ref. 5: 1-4, 9, 10, 12-14, 23, 24, 64, 72, 73, 74

Ref. 4: 807, 808, 811, 812, 816-818

References and Suggested Readings

1. *Quantum Chemistry, Donald A. McQuarie, , Viva student edition, Viva Books*
2. *Quantum Chemistry, 4th edition, R. K. Prasad, New Age international Publishers.*
3. *Essentials of Physical Chemistry, Arun Bahl, B. S. Bahl, G. D. Tuli, S., Multicolor edition, S. Chand Publication.*
4. *Principles of Physical Chemistry, 44th edition, Puri, Sharma and Pathaniya, Vishal Publishing Co.*
5. *Electrochemical Methods Fundamentals and Applications, 2nd edition, Allen J. Bard and Larry R. Faulkner, John Wiley & Sons.*
6. *Chemical Kinetics, 2nd edition, K. J. Laidler,*
7. *An Introduction to Electrochemistry, S. Glasstone, East-West Press.*

Semester VI **Core Course I**

CH-601

Subject- Principles of Physical Chemistry-II

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Course objectives

- To learn the basics of molecular spectroscopy and rotational spectra.
- To understand the basic principles and applications of nuclear chemistry.
- To learn the consequences of light absorption by atoms and molecules and photochemical reactions.
- To learn the laws of crystallography and basics of crystal structure.

Learning outcomes

After successful completion of this course, students are expected to:

- Analyze the rotational spectra of diatomic molecules and determine the bond length.
- Explain and apply the radioactivity principles for various chemical and biological investigations.
- Describe the mechanism of fluorescence, phosphorescence and photochemical reactions.
- Analyze the given crystal structure and determine the indices of planes, inter-planer distances and type of crystal structure.

UNIT-1. Investigation of Molecular Structure **(L-11, M-15)**

Introduction, Dipole Moment, Induced dipole moment, Electrical polarization of molecules. Orientation of dipole in an electric field, Debye equation. Method of determination of dipole moment, Vapour temperature method, Molecular structure and dipole moment

Interaction of electromagnetic radiation with molecules, Various types of spectra Rotational, Vibration and Electronic energy levels; with principle and example of each type.

Rotational spectroscopy: Rigid and non-rigid rotor diatomic molecule-Moment of inertia, Energy Levels, Selection rule, Intensities of spectral lines, Determination of bond lengths of diatomic and linear triatomic molecules, Isotopic substitution. Related numerical

Ref. 1: 253-257, 259-261

Ref. 3: 5-9, 33-46

UNIT-2. Nuclear Chemistry (L-12, M-15)

Introduction, Radioactive elements, Types of radioactive decay, Decay schemes, General characteristic of radioactive decay, Decay kinetics, Decay constant, Half-life period, Mean life, Units of radioactivity.

Application of radioactivity – Radiochemical principle of tracer technique; Application of tracer technique – Chemical investigation reaction mechanism- esterification, hydrolysis, Oxidation - Oxidation of CO, Structure determination - PCl_5 molecules, Thiosulphate ion, C-14 dating and tritium dating, Medical applications- Thyroditis, Bone fracture Healing, Brain tumor location, Defects in Blood Circulation.

Nuclear Fusion / Fission as source of energy with example

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management with case study. Related numerical

Ref. 4: 118-125, 225, 247, 248, 373-378, 402, 403, 407-411

Ref. 1: 103-105, 108-110, 113-115, 120-122, 136-138

Ref 6: 87-94, 108-112

UNIT-3. Photochemistry (L-11, M-15)

Laws of photochemistry, Quantum yield, Examples of low and high quantum yields, Consequence of light absorption by atoms and molecules, Jablonski diagram, Fluorescence, Phosphorescence, Quenching. Experimental setup for determination of quantum yield with actinometer as detector

Photochemical gas reactions, Photolysis of ammonia, Combination of H_2 and Cl_2 reaction, Reaction between H_2 and Br_2, Photosensitized gas reaction, H_2 and O_2, H_2 and CO, Chemiluminescence, Related numerical.

Ref. 1: 1045-1055

Ref. 2: 1044, 1045, 1048, 1049, 1054, 1055, 1059-1061

UNIT-4. Crystal Structure (L-11, M-15)

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law and Bragg's method. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects

in crystals: Shottkey and Frenkel defects. Liquid Crystal, Types and Applications. Related numerical

Ref. 1: 449-454, 456-463, 472-474

Ref. 2: 1085-1087, 1099, 1100, 1104-1107, 1123, 1130, 1131

References and Suggested Readings

1. *Essentials of Physical Chemistry, Arun Bahl, B. S. Bahl, G. D. Tuli, S. Multicolor edition, S. Chand Publication.*
2. *Principles of Physical Chemistry, 44th edition, Puri, Sharma and Pathaniya, Vishal Publishing Co.*
3. *Fundamentals of Molecular Spectroscopy, 4th Edition, C. N. Banwell and E. M. McCash, Tata McGraw-Hill: New Delhi*
4. *Essentials of Nuclear Chemistry, Revised 4th Edition, H. J. Arnikar, New Age International Publishers.*
5. *Advance Physical Chemistry, Gurtu and Gurtu, Pragati Publication.*
6. *Environmental Pollution and Health, V. K. Ahluwalia, The Energy and Resources Institute (TERI), 2005.*

Semester V **Core Course II**

CH-502

Subject-Inorganic Chemistry

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Course objectives:

- To describe the VSEPR theory to predict shape of molecules from electron pairs.
- To describe the bonding in simple compounds using VBT.
- To describe the principles of VBT to predict hybridization of orbitals.
- To understand how CFT explains electronic structure, colour and magnetic properties of co-ordination compounds.
- To introduce the basic principles of MOT and electronic geometry of molecules.

Learning outcomes:

- Learn about the VSEPR theory and how it can be used to explain molecular shapes.
- Learn about the VBT to describe the formation of covalent bonds in terms of atomic orbital overlap.
- Learn about stability of complexes using CFSE.
- Learn about MOT to draw energy diagrams and to predict bond order.

UNIT-1: Structure and Reactivity of Molecules **(L-09, M-12)**

Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, prediction of shapes of irregular molecules and ions like - Sulphur tetra fluoride, Bromine trifluoride, Dichloroiodate (I) anion, Penta fluoro telluurate (IV) anion, Tetrachloroiodate (III) anion, Nitrogen dioxide, Phosphorus trihalides, Carbonyl fluoride, Summary of VSEPR rules Drawbacks of VSEPR theory.

Ref.1: 206-207

Ref. 3: Relevant pages.

UNIT 2: Modern Theories of Coordination Compound Part –A (L-09, M-12)

Assumptions, Werner theory and isomerism, EAN, Stability of complex ion, Factors affecting stability of complex ion, Irving William series, Stabilization of unstable oxidation state, Stereochemistry of coordination compound with C.N. 4 and 6, Isomerism in coordination compounds.

Ref. - 1: 735-737, 742-745, 748--757.

Ref. - 2: Relevant Pages.

UNIT 3: Modern Theories of Coordination Compound Part –B (L-09, M-12)

Assumptions of V.B.T., V.B. Theory as applied to structural and bonding in complexes of 3d series elements. Examples of square planar, Tetrahedral and Octahedral complexes, inner and outer orbital complexes, Magnetic properties of complexes of 3d series elements, limitations of V.B.T., Assumptions of CFT, Degeneracy of 'd' orbital's, Application of CFT to octahedral complexes, Weak and strong ligand field splitting, spectrochemical series.

Ref. 1: 759 - 766

Ref.2: Relevant Pages

UNIT 4: Modern Theories of Coordination Compound Part –C (L-09, M-12)

Definition of C.F.S.E., Calculation of C.F.S.E. in weak and strong field octahedral complexes, Evidences of C.F.S.E., Factor's affecting 10 Dq, CFT and magnetic properties, spin only magnetic moment equation, Electron occupancy in CFT, Application of CFT to tetrahedral a nd Calculation of C.F.S.E. in tetrahedral complexes. Tetragonal distortions from octahedral geometry, Jahn-Teller theorem Application of CFT to square planer complexes, Problems related to calculation of spin only magnetic moment for square planer, tetrahedral and octahedral complexes (for high spin and low spin complexes).

Ref.1: 766 -772,

Ref.2: Relevant pages

UNIT 5: Modern Theories of Coordination Compound Part –D (L-09, M-12)

Crystal field effects- Variation of lattice energies, enthalpies of hydration and crystal radii variations in halides of first and second row transition metal series and spinel structures, limitations of CFT, experimental evidences in support of metal ligand bond overlaps. ACFT,

Assumptions of Molecular orbital theory, composition of ligand group orbitals, Molecular orbital treatment (Qualitative) of octahedral complexes (strong & weak field), Effect of pi-bonding, Charge transfer spectra, Comparison of VBT, CFT and MOT.

Ref. 1: 794-796,774-778

Ref. 2: Relevant Pages

References:

1. *Principle of Inorganic Chemistry, B. R. Puri, L. R. Sharma, K. C. Kalia, Milestone Publisher and distributor.*
2. *Concise Inorganic Chemistry, 5th Edition, J. D. Lee.*
3. *Inorganic Chemistry Principles of Structure and Reactivity, 4th Edition, James E. Huheey,*
4. *Ellen A. Keiter. Richard L. Keitler.*

Semester VI **Core Course II**

CH-602

Subject- Chemistry of Inorganic Solids

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Course Objectives:

- To describe basic principles of nanomaterials.
- To describe basic synthesis of nanoparticles.
- To describe composition and technological importance of inorganic solids.
- To describe composition of cement, lime and alloys.
- To describe manufacture of fertilizers.

Learning Outcomes:

- Learn about basic principles and synthesis of nanomaterials.
- Learn about classification, composition and processing of cement.
- Learn about classification and composition of alloys.
- Learn about types manufacture and applications of fertilizers.

UNIT 1: Synthetic Methods of Nanomaterials (L-09, M-12)

Introduction to Nano science, nanostructure and nanotechnology (basic idea), Size dependent properties of nanomaterials (basic idea) a) Semiconducting nanoparticles b) Metallic nanoparticles. Synthesis routes of nanomaterials: a) Bottom up approaches i) Chemical vapor deposition (CVD) ii) Spray pyrolysis iii) Sol gel process b) Top down approaches: mechanical alloying, Role of surfactant in shape and size control of nanomaterials

Ref:1: 602-604, 624, 653-655.

Ref:2: 66-70,74-77, 79,85-87.

Ref.3: 656-658, 707-712,721-724

UNIT 2: Inorganic Solids of Technological Importance (L-09, M-12)

Inorganic pigments, Coloured solids**,** White and black pigments, Molecular materials and fullerides, Molecular material chemistry – One dimensional metals, Molecular magnets,

Inorganic liquid crystals, Solid electrolytes (a) solid cationic electrolytes (b) solid anionic electrolytes .

Ref:- 1: 607-609,642-644,647-650.

Ref.3: 661-664,696-699,703-707.

UNIT 3: Cement and Lime (L-09, M-12)

Classification of cement, Ingredients and their role, Manufacture of cement and the setting process, Quick setting cements. Manufacture of lime and applications

Ref.4: Relevant pages

Ref.5: Relevant pages

UNIT 4: **Fertilizers (L-09, M-12)**

Plant Nutrients, Different types of fertilizers, need for fertilizers, requisite qualities of fertilizers, symptom of deficiency, Manufacture of following fertilizers:- Urea, Ammonium nitrate, Calcium ammonium nitrate, Ammonium phosphate, Super phosphates, Compound and Mixed fertilizers, Potassium chloride and Potassium sulphate.

Ref.5: Relevant pages

Ref.6: Relevant pages

UNIT 5: **Alloys (L-09, M-12)**

Classification of alloys, Ferrous and Non-ferrous alloys, Specific properties of elements in alloys, Manufacture of steel, Removal of silicon, decarburization, demagnetization and desulphurization. Composition and properties of different types of steels

Ref.7: Relevant pages

Ref.8: Relevant pages

Reference:

1. *Inorganic Chemistry, 4^{th} /5^{th} edition, Shriver and Atkins*
2. *Textbook of Nano Science and technology, B. S. Murthy, P. Shankar, Badev Raj, B. B. Rath and James Murday, University Press III M, Metallurgy and Material Sciences.*
3. *Inorganic Chemistry, 6^{th} Edition, Weller, Overton, Rourke & Armstrong.*
4. *Shriver Chemical Process Industry, 5^{th} edition, George T. Austin.*
5. *Industrial Chemistry, 14^{th} edition, B. K. Sharma,2004.*
6. *Riegels Handbook of Industrial chemistry, 9^{th} Edition, James A. Kent, CBS Publishers and Distributors*

7. *Engineering Chemistry, S. S. Dara.*
8. *Engineering Chemistry, B. K. Sharma, Goel Publishing House, Meerut.*
9. *Engineering Chemistry, P. C. Jain and M. Jain Dhanpat Rai and Sons Delhi.*

Semester V **Core Course III**

CH-503
Subject- Organic Reaction Mechanism

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Learning 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 learn organic reactions like nucleophilic substitution, electrophilic substitution, nucleophilic addition, electrophilic addition and elimination.
- Students will be able to write/ explain mechanisms of those types of reactions.
- Students will understand how a reaction takes place in one or more steps.
- Students will understand the types of intermediates formed in different reactions.
- Students will learn how reagent attacks the substrate molecule and accordingly how bonds break and formed.
- Students will learn how change in structure of substrate, reagent and solvent changes the product formed and its stereochemistry.

- Students will be able to predict the products and to suggest the mechanisms.

UNIT 1. Nucleophilic Substitution at Saturated Carbon (9 L, 12M)

SN^1, SN^2 and SN^i reactions, Mechanism and stereochemistry, regioselectivity and stereo specificity of substitution reaction. Scope at saturated carbon, allylic carbon and vinylic carbon. Factors affecting rate of SN^1, SN^2 and SN^i reactions (Effect of nature of substrate, nucleophile, leaving group and solvent).Neighboring group participation (norbornyl & norbornenyl systems), Non-classical carbocation's.

Ref:- 1: 328-359, 931-937.

Ref:- 2: 293-369.

Ref: - 3: 257-328.

Ref: - 4: 179-200.

UNIT 2. Electrophilic Addition to C=C (9 L, 12M)

Introduction, Mechanism of electrophilic addition to C=C bond ($Ad_{2}{}_{E}$Mechanism)**,** addition of hydrogen halides, orientation of addition: Markownikoff's and Anti Markownikoff's addition (peroxide effect), stereochemistry, addition of halogens: experimental evidences for two step mechanism, mechanism of addition of bromine, factors affecting anti-stereoselectivity, effect of substituents on rate of addition, addition of hypohalous acids (HOX), Hydroxylation (Mechanism of formation of cis and trans 1,2-diols), Hydroboration- Oxidation (Formation of alcohol), Hydrogenation (Formation of alkane), Ozonolysis (formation of aldehydes & ketones).

Ref:- 1: 427-447.

Ref:- 2: 734-742, 783-788.

Ref: - 4: 323-360, 425-440

UNIT 3. Nucleophilic Addition to C=O (9 L, 12M)

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, Reformatski reactions,

Reduction reactions using $NaBH_4$, $LiAlH_4$ with mechanism.

Ref:- 1: 222-239.

Ref:- 2: 879-919.

UNIT 4. Aromatic Substitution Reactions **(09 L, 12M)**

Electrophilic substitution

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

Ref:- 1: 471-527.

Ref:- 2: 501-521, 641-653.

Ref: - 4: 517-545, 943-967.

UNIT 5. Elimination Reactions: **(9 L, 12M)**

Introduction, The reaction mechanisms: E1, E2, E1CB with evidences and factors affecting the reaction.E1 v/s E2 and Elimination v/s substitution. Anti and Syn elimination, Stereo electronic factors. Bredt's rule. Dehydrohalogenation, Dehalogenation, Dehydration, Hoffmann and Saytzeff's elimination, Pyrolytic elimination.

Ref:- 1: 382-406.

Ref:- 2 : 982-1010.

Ref: -4 : 273-310.

References

1. *Organic Chemistry, Second Edition. J. Clayden, N. Greeves & S. Warren and P. Wothers (Oxford).*
2. *Advanced Organic Chemistry-Reactions, Mechanisms and Structure, 5th Edition, Michael B. Smith, Jerry March.,Wiley-VCH, Weinheim, 2000,*
3. *Advanced Organic Chemistry Part A- Structure and Mechanisms, 3rd Edition, A. Carey and R.J. Sundberg. Springer US, Third Edition*
4. *Organic Chemistry, 6th Edition, R. T. Morrison and R. N. Boyd.*
5. *Web- Organic Chemistry Portal*

Semester VI **Core Course III**

CH-603

Subject- Spectroscopic Methods of Structure Determination

(Theory: Marks 60 Lectures = 45 hrs) **(Credits: 03)**

Course Objectives

- To study principle of spectroscopy and to understand wave parameters and terms involved in spectroscopy.
- To study different types of spectroscopy.
- To understand principle, concept and the terms used in each type of spectroscopy.
- Interpretation of UV, IR, NMR spectra.
- Use of spectral data for determination of structure of unknown organic compounds.
- To study different applications of each type of spectroscopy.

Learning Outcomes

- Students will learn interaction of radiations with matter. They will understand different regions of electromagnetic radiations. They will know different wave parameters.
- Students will learn principle of mass spectroscopy, its instrumentation and nature of mass spectrum.
- Students will understand principle of UV spectroscopy and nature of UV spectrum. They will learn types of electronic excitations.
- Students will be able to calculate maximum wavelength for any conjugated system. And from the value of λ-max they will be able to find out extent of conjugation in the compound.
- Students will understand principle of IR spectroscopy, types of vibrations and the nature of IR spectrum.

- From IR spectrum, they will be able to find out IR frequencies of different functional groups. And thus, they will be able to find out functional groups present in the compound.
- Students will understand principle of NMR spectroscopy and will understand various terms used in NMR spectroscopy. They will learn measurement of chemical shift and coupling constants.
- Students will be able to interpret the NMR data and they will be able to use it for determination of structure of organic compound.
- Students will be able to determine structure of simple organic compounds on the basis of spectral data such as λ max values, IR frequencies, chemical shift (δ values).

UNIT 1. A) Introduction to Spectroscopy (9L, 12M)

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

Ref:- 2: 1-19.

Ref:- 4 : 13-19.

B) Mass spectroscopy

Basic theory, Nature of mass spectrum, Importance of molecular ion peak, isotopic peaks, base peak, nitrogen rule, rule of 13 for determination of empirical formula and molecular formula.

Ref:- 1: 170-186.

Ref:- 2: 415-424.

Ref:- 3 : 2-15.

Ref:- 4 : 401-417.

UNIT 2. Ultra Violet Spectroscopy (9L, 12M)

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,

Auxochrome, 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.

Ref:- 1: 1-27.

Ref:- 2: 9-53.

Ref:- 4: 367-398.

UNIT 3. Infra-red Spectroscopy (9 L, 12M)

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.

Ref:- 1 : 28-57.

Ref:- 2 : 65-154.

Ref:- 3 : 71-109.

Ref:- 4 : 26-93.

UNIT 4. NMR Spectroscopy (9L,12M)

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.

Ref:- 1: 63-145.
Ref:- 2 : 185-356.
Ref:- 3 : 144-216.
Ref:-4 : 108-160.

UNIT 5. Combined Problems Based on UV, IR, NMR & Mass (9 L, 12M)

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.

Reference Books:

1. *Spectroscopic Methods in Organic Chemistry, D. H. Williams & I. Fleming, 5th Ed.*
2. *Spectroscopy of Organic Compounds, P. S. Kalsi, New Age Int. Pub., 6th Ed., 2007*
3. *Spectrometric Identification of Organic Compounds, R. M. Silverstein and F. X. Webster , John Wiley and Sons Inc, 7th Edition.*
4. *Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz and J. R. Vyvyan. Indian Edition. Cengage Learning; 5th edition (2015)*

Semester V **Core Course IV**

CH-504

Subject- Industrial Chemistry

(Theory: Lectures 45 hrs, Marks 60) **(Credits: 03)**

Course objectives

- To produce graduates with enhanced skills, applied knowledge, aptitude to carry out higher studies or research and development in the various industrial areas.
- To make the student cognizant about important aspects of Chemical Industries, Industrial work culture and environment.
- To prepare the students for immediate entry to the workplace with sound theoretical knowledge and some basic experimental concepts in the area of various industries viz. Sugar Industry, Fermentation Industry, Petroleum and Petrochemicals.
- To offers the synergism between basic concepts of Chemistry with Industrial applications.
- To equip the students with knowledge of some industrial organic synthesis as requirement of diverse chemical industries.
- Empower the students to understand the concepts in chemical processing, engineering and industrial development.

Learning outcomes

From the course CH: 504 Industrial Chemistry**,** the student will be able to understand….

- Basic requirements of Chemical Industry, different terms, operations and processes involved in chemical Industry.
- Describe Copy Right Act, Patent Act and Trade Marks, Bureau of Indian Standards (BIS) and International Organization for Standardization (ISO).

- Basic requirements, raw materials, different processes and operations involved in Sugar Industry and also different grades of sugar and uses of by-products of sugar industry.
- Importance of fermented products, basic requirements, theory and process of alcohol making, fractional distillation and various terms involved in Fermentation Industry.
- Understand Occurrence of Petroleum, theories of formation of Petroleum and different terms Viz. Knocking, Anti-Knock Compounds, Octane number, Cetane number, Gasohol and Power alcohol etc.
- Manufacturing processes involved in Industrial Organic Synthesis such as Methanol, Isopropanol, Glycerol, Acetylene and Aromatic hydrocarbon i.e. Toluene from petroleum with their uses.

UNIT 1: General Aspects of Industrial Chemistry (L-9, M-12)

Introduction, Basic Requirements of Industrial Chemistry, 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, Yield, Copy Right Act, Patent Act and Trade Marks. Bureau of Indian Standards (BIS), International Organization for Standardization (ISO)

Ref.1: Chapter 2(26, 27, 31 to 36)

Ref.4: Chapter 1 and 2 (Relevant Pages)

Ref.6: Chapter 1, 2 and 3 (Relevant Pages)

Ref: Websites and Web Pages

www.wikipedia.org/wiki/patentact , www.wikipedia.org/wiki/trademarks, www.wikipedia.org/wiki/trademarks,www.wikipedia.org/wiki/bis www.wikipedia.org/wiki/iso

UNIT 2: Sugar Industry (L-9, M-12)

Introduction, Sugar Industry in Maharashtra and India, Manufacture of Cane Sugar- [Refining (with flow sheet)], General Idea of Sulphitation and Carbonation, Concentration /Evaporation, Crystallization Separation of crystals. Grades, Baggase, Cellotex

Ref.3: Chapter 38 1208 to 1218 (Relevant Points Only)

UNIT 3: Fermentation Industry **(L-9, M-12)**

Introduction, Alcohol fermentation, Uses of alcohol, Theory underlying process of making alcohols beverages, Manufacture of Beer, Manufacture of Spirit, Alcohol from Cane Sugar Molasses, Theory of fractional distillation – Coffey'still, Rectified spirit, Absolute alcohol, Fusel oil, Proof spirit, Denatured alcohol.

Ref.2:578-596.

Ref.3: Chapter 36, 1175-1190 (Relevant Points Only)

UNIT4: Petroleum Industry. **(L-9, M-12)**

Occurrence, Petroleum producer countries in the world, Exploration Methods, Composition of Petroleum, Refining or Distillation of Petroleum, Anti-Knock Compounds, Octane number, Cetane number, Petrohol (their definitions only), Manufacture of Petrol or Gasoline by Bergius Method, Cracking process- Thermal, Catalytic, Hydro cracking.

Ref.1: 340 to 352, 356 to358 and 363 to 368.

Ref.3: Chapter 4, 217 to 311 and Chapter 5, 312 to 342 (Relevant Points only)

UNIT 5: Industrial Organic Synthesis **(L-9, M-12)**

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

Ref.3: Chapter 11, 439 to 451 and Chapter 14, 493 to 522 (Relevant Points Only).

References:

1. *Principles of Industrial Chemistry, Chris A Clausen III and Guy Mattson, John Wiley and Sons, Inc. Somerset, 1978, New York.*
2. *Shreve's Chemical Process Industries, George T. Austin, 5 th Edition, The McGraw-Hill, 1984, New York.*
3. *Industrial Chemistry, B. K. Sharma, 16th Edition, Goel Publishing House, Meerut,(U.P.) 2011, India.*
4. *Comprehensive Industrial Chemistry, P.G. More, 1st Edition, Pragati Prakashan, Meerut, (U.P.) 2010, India.*

5. *Chemistry and Technology of the Cosmetics and Toiletries Industry, D.F. Williams and W.H. Schmitt Blackie Academic & Professional First edition 1992 Second edition 1996 © Chapman & Hall ISBN-13 :978-94-0 10-7194-9 e-ISBN-13:978-94-009-1555-8*
6. *Handbook of Industrial Chemistry Organic Chemicals, Mohammad Farhat AIi, Bassam M. El AIi, James G. Speight, The McGraw-Hill Companies, 2005, ISBN 0-07-141037-6*

Semester VI **Core Course IV**

CH-604

Subject- Chemistry of Industrially Important Products

(Theory: Lectures 45 hrs, Marks 60) **(Credits: 03)**

Course objectives

- To make student perceptive about various commodity industries viz. Cosmetics and Perfumes, Dyes and Pharmaceuticals, Pesticides, Soaps and Detergents, related diversified and multidisciplinary fields of chemical industry.
- To produce graduates with enhanced skills, knowledge and research aptitude to carry out higher studies or research and development in the various industrial areas.
- To equip students with advance knowledge about various industrially important products.
- To makes students ready for immediate entry to the workplace with sound theoretical and basic experimental knowledge in the areas of various industries.
- To engender the substantial interest in the students to understand the concepts in chemical processing, engineering and industrial development of present era viz. Cosmetics and Perfumes Industry, Dyes and Pharmaceuticals, Pesticides, Soaps and Detergents, related multidisciplinary and diversified fields of chemical industry.
- To describe the industrial production of a number of important organic and inorganic compounds / chemicals and products of end use.
- To gain comprehensive knowledge of cutting-edge developments in a field of different chemical industries by discussions and exchange of experiences and knowledge.
- To develop proficiency in application of current aspects of industrial chemistry.

Learning Outcomes

On successful completion of the course **CH: 604 Chemistry of Industrially Important Products**, the student will be able to understand….

- Describe the industrial production of a number of important organic and inorganic compounds / chemicals and products of end use.
- Gain comprehensive knowledge of cutting-edge developments in a field of different chemical industries.
- Importance of Cosmetics Industry and a general study including preparation and uses of the Hair dye, hair spray, shampoo, suntan lotions, lipsticks, talcum powder, nail enamel, creams (cold, and shaving creams).
- Perfumes and identify the distinguishing features of its components and also an essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone etc.
- Know about pesticides both natural and synthetic, benefits and adverse effects of it, also synthesis, manufacture and uses of pesticides viz. Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Anilides (Alachlor and Butachlor).
- Definition, classification, raw material used in soaps and detergents, reaction involved in it, Manufacture of Soaps and cleansing action of soaps and detergents.
- Definition, properties of good dyes, relation between colour and constitution, classification of dyes according to their mode of application and chemical constitution.
- Importance's, definition and meaning of the different terms involved in Drugs and Pharmaceuticals Industry and also synthesis, uses, properties and industrial manufacture of Paracetamol, Aspirin, and Chloramphenicol.

UNIT 1: Chemistry of Cosmetics (L-9, M-12)

Introduction, Raw materials and general study including preparation and uses of the following: Hair dye, shampoo, suntan lotions, lipsticks, talcum powder, nails enamel, creams (cold and shaving creams).

Ref.: 6 Chapter -1, 1 to 34, Chapter -2, 36 to 100, Chapter -3, 104 to 145, Chapter - 4 149 to 181 and Chapter- 9, 290 to 309. Relevant Points Only

UNIT 2: Chemistry of Perfumes (L-9, M-12)

Essential oils A general study including properties, uses and importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone and antiperspirants and artificial flavours.

Ref. 3: Chapter 53, 1520 to1544 Relevant Points Only.

Ref.6: Chapter 8, 272 to 289, Chapter 10, 310 to 344, Relevant Points Only.

UNIT 3: Pesticide Chemistry (L-9, M-12)

General introduction to pesticides and their changing concepts (natural and synthetic), benefits and adverse effects of pesticides, structure activity relationship, synthesis and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Anilides (Alachlor and Butachlor).

Ref.3: Chapter 41, 1280 to1318 Relevant Points Only.

Ref.7: Chapter 11, 381 to 426 Relevant Points Only.

UNIT 4: Soap and Detergents (L-9, M-12)

Soaps, Surfactants and its Importance, Raw Materials used in Soap Manufacture, Manufacture of Soaps (Continuous Process), Cleansing action of Soap, Classification of Soaps, Detergents, Principal group of Synthetic Detergents, Detergents builders and Additives, Comparison between Soap Detergent.

Ref.3: Chapter 39, 1219 to1251 and Chapter 40,1252 to1279 Relevant Points Only.

Ref. 6: Chapter- 5, 123 to160 Relevant Points Only.

UNIT 5: Dyes, Drugs and Pharmaceuticals. (L-9, M-12)

(a) Dyes: Introduction, properties of dyes, Otto Witts theory only, Classification of dyes according to their mode of application and Chemical Constitution.

Ref.3: Chapter 54, 1545 to1608 Relevant Points Only.

Ref.6: Chapter 8, 259 to 288 Relevant Points Only.

(b) Drugs and Pharmaceuticals: Introduction, Importance, Qualities of good drugs, Functional and chemotherapeutic drugs, Meaning of the terms: Prescriptions, Doses, Analgesic, Antipyretics, Antibiotics, Anti-inflammatory, Anti-viral, Cardiovascular, Cough and Cold Preparations, Sedatives and Hypnotics, contraceptives. Synthesis, uses, manufacture and properties of Paracetamol, Aspirin, Chloramphenicol

Ref.4: Chapter 8, 144 to194 Relevant Points Only.

Ref.6: Chapter 10, 331 to 379 Relevant Points Only.

References:

1. *Principles of Industrial Chemistry, Chris A Clausen III and Guy Mattson, John Wiley and Sons, Inc. Somerset, 1978, New York.*
2. *Shreve's Chemical Process Industries, George T. Austin, 5 th Edition, The McGraw-Hill, 1984, New York.*
3. *Industrial Chemistry, B. K. Sharma, 16th Edition, Goel Publishing House, Meerut,(U.P.) 2011, India.*
4. *Comprehensive Industrial Chemistry, P.G. More, 1stEdition, Pragati Prakashan, Meerut,(U.P.) 2010, India.*
5. *Chemistry and Technology of the Cosmetics and Toiletries Industry, D.F. Williams and W.H. Schmitt Blackie Academic &. Professional First edition 1992 Second edition 1996 © Chapman & Hall ISBN-13 :978-94-0 10-7194-9 e-ISBN-13:978-94-009-1555-8*
6. *Handbook of Industrial Chemistry Organic Chemicals, Mohammad Farhat AIi, Bassam M. El AIi, James G. Speight, The McGraw-Hill Companies, 2005, ISBN 0-07-141037-6*

Semester V **Skill Enhancement Course**

CH-505

Subject- Analytical Instrumentation

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

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 enhance the Analytical instrumental skill of the students.

Learning Outcomes

- Explain the fundamentals of analytical methods and instruments for qualitative and quantitative Analysis.
- Express the role of analytical chemistry in science.
- Students will be able to function as a member of an interdisciplinary problem solving team.

UNIT 1:-Spectrometry **(9L, 12M)**

Origin of spectra Interaction of electro-magnetic radiation with matter, Electro-magnetic Spectrum, The Absorption of Radiation, Solvents for Spectrometry, Quantitative Calculations, Beer's Law, Principles of instruments - Sources, Monochromators (prism, diffraction gratings, Optical filters), Cells, detectors, Slits Width, Single Beam Spectrometer, Spectrometric Errors, Deviation from Beer's Law - Chemical deviation, Instrumental deviation, Problems.

Ref.-1:- 398-401, 410-411, 413--435, 439-443.

Ref. 2 -6:-Relevant Pages

UNIT 2: Infrared Spectrometry **(9L, 12M)**

Infra red Spectrometry – Principles, Theory, Instrumentation, Source, monochromator, detectors, Single beam, Double beam, Types, Sampling Technique, Solvents, Spectrometric error, FTIR introduction, General applications.

Ref.-2: 447 – 458

Ref.-4: 527-576

Ref. 2-6: Relevant Pages

UNIT 3. A: Emission Spectrometry (9L, 12M)

Flame Emission Spectroscopy – Principles, Theory, Instrumentation, Experimental techniques, Interferences and applications , Advantages and disadvantage, Plasma Emission Spectrometry – Principles, Plasma as excitation source, inductively coupled Plasma source, ICP-AES Instrumentation, Applications.

Ref.-1: 462 - 467

Ref. 2-6: Relevant Pages

B:-Atomic Absorption Spectrophotometry

Introduction, Principles, Advantages over FES, Instrumentation – Sources, Burners, Flames, Interferences – Spectral Interferences, Ionization Interferences, Refractory Compound Formation,Hallow cathode lamps, Physical Interferences, Use of Organic Solvents, Sample Preparation, Applications of AAS. Comparison of AAS with atomic emission methods

Ref.-1: 467 - 475

Ref. 2-6:Relevant Pages

UNIT 4:-Potentiometry (9L, 12M)

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.

Ref.-1: 312-313,316-325

Ref.-2 -6: Relevant Pages

UNIT 5:-P^Hmetry (9L, 10M)

Introduction to pH meter, The Glass pH Electrode Principle, Accuracy of pH Measurements, Measurements with the pH-meter, Making the pH Measurement, Fundamental limitations, Maintenance.

Ref.-8: 327-333

Ref.-2 - 8: Relevant Pages

Reference Books:-

1. *Analytical Chemistry, G.D. Christian, 5th Edition.*
2. *Analytical Chemistry Principal- J. H. Kennedy. 2nd Edition (1990)*
3. *Analytical Chemistry, An Introduction, Skoog, West and Holler, 6 th Edition*
4. *Instrumental Method of Chemical Analysis, Chaitwal and Anand, 5th Edition.*
5. *Basic Concept of Analytical Chemistry, S.M. Khopkar*
6. *Instrumental Methods of Chemical Analysis- Willard, Merritt, Dean and Settle, 6th Edition*
7. *Introduction to Instrumental Analysis, R.D. Braun*
8. *Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J. D. Barnes, M. J. K. Thomas, 6th Edition,*

Important Instrument web links

Instruction Manual Operation Guide UV-1800 Shimadzu Spectrophotometer,
http://www.sustainable-desalination.net/wp-content/uploads/2013/05/UV-1800.pdf

Instruction Manual Operation Guide Agilent 5500 Series FTIR,
https://www.agilent.com/cs/library/usermanuals/public/5500_series_ftir_operation_manual.pdf

Instruction Manual Operation Guide Agilent 700 Series ICP Optical Emission Spectrometers,
https://www.agilent.com/cs/library/usermanuals/public/8510230100_700SeriesICP_UserManual.pdf

Instruction Manual Operation Guide Flame Atomic Absorption Spectrometry,
https://www.agilent.com/cs/library/usermanuals/Public/0009.pdf

Instruction Manual Operation Guide Potentiometry,
http://nhp.mowr.gov.in/docs/HP2/MANUALS/Water%20Quality/5014/-download-manuals-WaterQuality-WQManuals-32PotentiometricAna.pdf
http://shop.hannasingapore.com/media/pdf/2016-01-11-HI901C-Full.pdf

User Manual pH meter F-71, HORIBA, Ltd. 2011
http://library.metergroup.com/Manuals/Horiba/BenchtopPh/F-71%20Manual.pdf

Semester VI **Skill Enhancement Course**

CH-605

Subject- Analytical Techniques

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Course Objectives

- To provide knowledge of instruments which are used in Chemical, Pharma, Petroleum, and insecticide and pesticide industry
- To increase student technical skill as per industry need.
- To develop an understanding of the range and uses of analytical methods in chemistry.

Learning Outcomes

- Compare the Instrumental methods and non instrumental methods and there advantages.
- Solve the problem of detection and separation using analytical instruments.
- Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- Students will be able to explain why chemistry is an integral activity for addressing social, economic, and environmental problems.

UNIT 1:- Solvent Extraction **(9L, 12M)**

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, Analytical Separations, Multiple Batch Extractions, Countercurrent Distribution, Simple numerical problems on Percent Extracted and Multiple Extraction, Problems

Ref.1: 484 to 498.

Ref. 2-6: Relevant Pages

UNIT 2:- High-Performance Liquid Chromatography (9L, 12M)

Introduction, Principles, Equipment for HPLC, Choice of Column Materials for HPLC, Application

Ref.1: 537 to 545

Ref.2-6: Relevant Pages

UNIT 3:- Gas Chromatography (9L, 12M)

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

Ref.1: 522 to 528, 511 to 515

Ref.2-6:- Relevant Pages

UNIT 4:- Ion Exchange Chromatography (9L, 12M)

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

Ref.1: 517 to 522

Ref. 2-6: Relevant Pages

UNIT 5:-Thermal Methods (9L, 12M)

General Discussion, Thermogravimetry- Instruments for thermogravimetry, Applications of thermogravimetry, Differential Techniques- Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC), Instruments for DTA and DSC, Experimental and Instrumental Factors, Applications of DTA and DSC, Problems

Ref.-6: 503 - 519

Ref. 1-6: Relevant Pages

Reference Books:-

1. *Analytical chemistry, G.D. Christian, 5th Edition,*
2. *Instrumental Methods of Chemical Analysis, Chatwal and Anand*
3. *Basic Concept of Analytical Chemistry, S.M. Khopkar, 2nd edition,*
4. *Chemical Analysis by A. K. Shriwastawa, P. C.Jain, S. Chand and Company.*
5. *Quantitative Analytical Chemistry, James S. Fritz, George H.Schenk,5th Edition.*
6. *Vogel's Text Book of Quantitative Chemical Analysis, J. Mandham, R.C.Denney, J. D. Barnes, M. Thomas, B. Shivashankar, 6th Edition.*

Important Instrument web links

The LC Handbook Guide to LC Columns and Method Development,

https://www.agilent.com/cs/library/primers/public/LC-Handbook-Complete-2.pdf

Handbook and user manual of Gas chromatography

https://www.agilent.com/cs/library/usermanuals/Public/G3430-90011.pdf

Handbook and user manual of Ion Exchange Chromatography

https://www.agilent.com/cs/library/primers/Public/5991-3775EN_BioIEX_HowTo_LR.pdf

Handbook and user manual of Ion Differential Scanning Calorimetry

https://www.perkinelmer.com/CMSResources/Images/46-74542GDE_DSCBeginnersGuide.pdf

Semester V **Elective Course**

CH-506(A)

Subject- Biochemistry

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Learning Objectives

- To study different types of biomolecules.
- To study structure of biomolecules.
- To study classification of each type of biomolecules.
- To study reactions of the biomolecules.
- Study of metabolism and thus, study of metabolic processes and reactions involved.
- To study energetics of the metabolic processes.
- Students should understand: Structure and role of Carbohydrates, Amino acids, Proteins, Enzymes, lipids, Nucleic Acids and energy rich compounds in biochemical reactions.

Course Outcomes

- Students will study biomolecules like carbohydrates, amino acids, proteins, enzymes, lipids and nucleic acids.
- Students will understand definitions, classifications and examples of these biomolecules.
- Students will learn the detailed structure of these biomolecules along with types of bonds or linkages present in their molecules.
- Students will learn the chemical properties of these biomolecules and the action of some reagents on them in the form of reactions or graphical presentation.
- Students will understand biochemical energetics of common energy rich compounds along with hydrolytic reactions.

- Students will learn metabolisms like Glycolysis, TCA cycle, Transamination, deamination and β- oxidation through reactions, enzymes involved, outlines and energetics.

Unit 1. Carbohydrates (L-09, M-12)

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, NH_2OH and phenyl hydrazine, mutarotation.

c) Disaccharides: structure of sucrose, lactose and maltose.

d) Polysaccharides: storage polysaccharides, structure of starch, Structural polysaccharides, structure of cellulose.

Ref 1 and 2: Relevant pages

Unit 2. Amino Acids and Proteins (L-09, M-12)

a) Amino acids: Introduction, structure of ammo 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: α keratins and hemoglobin. Separation of amino acids and proteins by paper electrophoresis and dialysis

Ref 1 and 2: Relevant pages

Unit 3. Enzymes and Lipids (L-09, M-12)

a) Enzymes: Introduction, specificity of enzymes, classification, role of enzymes in biochemical reactions, Michaelis Menten equation (no derivation). Effect of substrate concentration, P^H and temperature on enzyme catalyzed reactions. Enzyme inhibitors: introduction and types.

b) Lipids: Introduction, classification of lipids, fatty acids, nomenclature of fatty acids, triacyl glycerols, hydrogenation of oils, Saponification value and iodine value of oils, phospholipids and waxes.

Ref 1 and 2: Relevant pages

Unit 4. Nucleic Acids and Energy Rich Compounds (L-09, M-12)

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

Ref 1 and 2- Relevant pages

Unit 5. Metabolism (L-09, M-12)

Definition of metabolism,

a) Carbohydrate metabolism: Glycolysis: reactions involved and energetics, TCA cycle (Kreb cycle): Reactions involved and energetic

b) Amino acid Metabolism: Transamination, deamination (by enzymes - glutamic dehydrogenase, ammonia lyases, deaminases and deamidases), decarboxylation

c) Lipid Metabolism: β- oxidation of fatty acids, reactions involved in β –oxidation, energetics of β –oxidation of palmitic acid.

Ref 1 and 2- Relevant pages

Reference Books

1. *Outlines of Biochemistry, Conn and Stumpf (4^{th}Edition)*
2. *Principles of Biochemistry, A. L. Lehninger (2^{nd} Edition)*

Semester V **Elective Course**

CH-506(B)

Subject- Green Chemistry

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Course Objectives:

- There is rising concern since 1970 about environmental 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.
- We are facing the challenge to work towards sustainable development. Since 1990, today's society is moving towards becoming more and more environmentally conscious.
- Green chemistry has been introduced in1990 for overall sustainable development against the environmental concerns.
- Green chemistry is not a new branch of chemistry, but it is a new way chemistry, which should be practiced regularly.
- Innovations and applications of green chemistry in education has helped companies not only to gain environmental benefits but at the same time to achieve economic and societal goals also.
- This is possible because these undergraduate students are ultimate scientific community of tomorrow.

Learning Outcomes:

- With this course, the graduate students will be able to understand the twelve principles of green chemistry that will help to build the basic understanding of toxicity, hazards and risk of chemical substances.
- The course will help to understand stoichiometric calculations and relate them to green chemistry metrics. The students will learn about atom economy and understand its importance over percentage yield.

- The students will learn to design safer chemicals, products and processes that are less toxic than the conventional chemistry, understand significance of catalysis, use of renewable feed stock, renewable energy sources, importance of green solvents, etc.
- The course will train the students to appreciate green chemistry and boost the students to think and develop the skills to innovate and search for the solutions to environmental problems.
- Green chemistry is only way of future chemistry to ensure sustainability with absolute zero waste. The success stories and real-world cases will motivate the young generation to practice green chemistry.

UNIT 1. Introduction to Green Chemistry (L-04, M-04)

Definition of Gr**e**en Chemistry. Drawbacks of conventional chemistry. Need of Green Chemistry, Minamata Disease. Goals of Green Chemistry

Ref:1 Relevant Pages

Ref:6 Relevant Pages

UNIT 2. Principles of Green Chemistry and Designing a Chemical Synthesis (L-12, M-18)

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, 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, industrial safety.

Ref:1 Relevant Pages

Ref:2 Relevant Pages

UNIT 3. Techniques in Green Chemistry (L-12, M-16)

a) Microwave assisted synthesis- Introduction and importance, Applications- Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction,Hofmann Elimination.

b) Ultrasound assisted reactions- Introduction and importance, Application- Esterification, saponification, aromatic substitution reactions, alkylation, oxidation, reduction.

Ref:1 Relevant Pages

Ref:3 Relevant Pages

UNIT 4. Solvents, Reagents and Catalysts in Green Chemistry (L-14, M-18)

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

b) Reagents- Introduction and Importance, Examples- Alkylation using dimethyl carbonate, 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.

Ref:1 Relevant Pages

Ref 2: Relevant Pages

UNIT 5. Future Trends in Green Chemistry (L-03, M-04)

Biomimetic, Photochemical reactions, Multifunctional Reagents, Green chemistry in sustainable development.

Ref:1 Relevant Pages

Ref 3: Relevant Pages

Ref 5: Relevant Pages

Reference Books:

1. *New Trends in Green Chemistry, V.K. Ahluwalia and M.R. Kidwai: Anamalaya Publishers (2005).*
2. *Green Chemistry- Theory and Practical, P.T. Anastas and J.K. Warner: Oxford University Press (1998).*
3. *Introduction to Green Chemistry, A. S. Matlack: Marcel Dekker (2001).*
4. *Real-World Cases in Green Chemistry, M.C. Cann & M.E. Connely: American Chemical Society, Washington (2000).*
5. *Introduction to Green Chemistry, M. A. Ryan & M. Tinnesand, American Chemical Society, Washington, (2002).*
6. *Silent Spring, Rachel Carson, Houghton Mifflin Company, (1962).*

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Semester VI **Elective Course**

CH-606(A)

Subject- Polymer Chemistry

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 03)**

Learning 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

After completing this course, the graduate should 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 1. Basic Concepts of Polymers **(L-09, M-12)**

Introduction, brief history, monomers and polymers, degree of polymerization, functionality, linear, branched and cross linked polymers, homopolymers, 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 backbone chain – organic and inorganic polymers c) thermal response – thermoplastic and thermo setting polymers d) ultimate form and use – plastic, elastomer, fibre and liquid resin, Degradation of polymers:- types of degradation: chain end and random degradations.

Ref. 1 and 2: Relevant pages

UNIT 2. Chemistry of Polymerization **(L-09, M-12)**

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.

Ref. 1 and 2: Relevant pages

UNIT 3. Polymerization Techniques & Polymer Processing Techniques

(L-9, M-12)

Polymerization techniques: - Bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, interfacial condensation polymerization.
Polymer processing techniques:- Calendaring, die casting, film casting, and compression moulding.

Ref. 1 and 2: Relevant pages

UNIT 4. Study of Some Important Polymers **(L-09, M-12)**

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 - Polyethyleneterephthalate[PET], Polyamides (Nylon-6 and Nylon-6,6), Poly(vinyl alcohol) [PVA], Poly(lactic acid) [PLA], Polyaniline, and Polybutadiene.

Ref. 1 and 2: Relevant pages

UNIT 5. Glass Transition Temperature **(L-09, M-12)**

Glass transition temperature:- Definition and explanation, factors affecting glass transition temperature, Glass transition temperature and molecular weight, Glass transition temperature and melting point, importance of glass transition temperature, determination of glass transition temperature by dilatometry.

Molecular weights of polymers:-types of molecular weights-number average molecular weight, weight average molecular weight, viscosity average molecular weight, sedimentation average molecular weight, and poly dispersity index.

Ref. 1 and 2: Relevant pages

Reference Books

1. *Polymer Science, V. R. Govarikar, N. V. Viswanathan, JayadevSreedhar, New Age International (P) Ltd., New Delhi, 1997.*
2. *Text books of Polymer Science, F. W. Billmeyer, John Wiley & Sons; 3rd edition,1984.*

Semester VI **Elective Course**

CH-606(B)

Subject- Research Methodology for Chemistry

(Theory: Lectures = 45 hrs, Marks 60) **(Credits: 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.
- To 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.
- To learn the presentation of scientific information
- To aware the students about proper laboratory safety and techniques.

Learning outcomes:

The learning outcomes for this course of the following Chemistry Graduate Program Goals:

- Students will learn about what is research, research methods and impact of chemical research on society through pure and applied research.
- Students will learn how to analyze research in chemistry drawn from contemporary primary chemical literature.
- Student will formulate thesis topic, explain its significance and propose the methodology to be used in the thesis topic research.
- Student will demonstrate proficiency in scientific writing which includes:

- Ability to interpret and synthesize primary research literature related to the student's thesis topic.
- Ability to write a coherent narrative that explains the significance of the thesis research with regard to the primary research literature.
- Ability to report original research results in a coherent narrative.
- Ability to explain and defend conclusions draw from original results in narrative form.
- Prepare and present scientific topics orally utilizing presentation software such as PowerPoint.

- Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
- Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
- Students will be able to communicate the results of scientific work in oral, written and electronic formats.
- Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.

UNIT 1: Introduction to Research **(L-9, M-12)**

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 theoretical knowledge in designing of experiments. Methods of Data Collection

List of National Importance Institutes and List of CSIR Laboratories

Ref. 3: 1-24.

UNIT 2: Print Literature Resources **(L-9, M-12)**

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.

Ref. 1: 299-317;

Ref. 2: 1569-1603

UNIT 3: Digital Literature Resources (L-9, M-12)

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 infonet, E-books. The introduction of Search engines, Scirus, Google, Google Scholar, Chem Industry, Wiki- Databases, ChemSpider, American Chemical Society, Royal Society of Chemistry, Wiley-inter science, Science Direct, Springer, SciFinder, Scopus, C&EN News Reaxys.

Ref. 1: 299-317;

Ref. 2:1569-1603

UNIT 4: Writing Scientific Reports (L-9, M-12)

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 download Research Paper? How to Read Research Paper, Abstract and Summary. What are Paper, Patent and Review? Introduction of Plagiarism and self Plagiarism.

Ref. 1: 325-348; Ref. 3: 344-360.

UNIT: 5 Chemical Safety and Ethical Handling of Chemicals (L-9, M-12)

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, incineration and transportation of hazardous chemicals.

Ref. 6: 1.31–1.36, 1.40, 2.1-2.16, 5.79-5.85, 7.41-7.50, 8.25-8.31.

Reference Books:

1. *Practical Skills in Chemistry, 2nd Ed, .Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. and Jones, A. Prentice-Hall, Harlow (2011)*
2. *APPENDIX A: The Literature of Organic Chemistry March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Seventh Edition, by Michael B. Smith and Jerry March Copyright John Wiley & Sons, Inc. (2013)*
3. *Research Methodology: Methods And Techniques, 3rd edition, Kothari, C.R. Published by New Age International (P) Ltd., Publishers (2004),*
4. *How to Use Excel in Analytical Chemistry and in general Scientific Data Analysis. Levie, R. de, Cambridge Univ. Press (2001).*
5. *Chemical Safety Matters – IUPAC – IPCS, Cambridge University Press, (1992).*
6. *OSU Safety Manual 1.01*
7. *Laboratory Safety for Chemistry Students, Hill R. H., Finster D. C. 8th ed.; John Wiley and Sons: Hoboken, NJ, March (2017).*

T.Y.B.Sc. Chemistry

Semester -V **Course No:- CH-507**

Subject: Physical Chemistry Practical

(Practical: Lectures = 60 hrs, Marks 60) **(Credits: 02)**

Course Objectives

- To develop skills required in chemistry such as the appropriate handling of apparatus, instruments 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.

Learning Outcomes

- Students will get basic analytical and technical skills to work effectively in the various fields of chemistry.
- Students will able to calibrate and handle instruments like conductometer, potentiometer, pH meter, colorimeter, spectrophotometer, polarimeter.
- They have ability to perform accurate quantitative measurements with an understanding of the theory and use of contemporary chemical instrumentation, interpret experimental results, perform calculations on these results and draw reasonable, accurate conclusions.
- They get skills required in chemistry such as the proper handling of apparatus and chemicals.
- They will have ability to present scientific and technical information resulting from laboratory experimentation in both written and oral formats.

- Students will apply conductometer, potentiometer, pH meter, colorimeter, spectrophotometer, polarimetery techniques for analysis and measurement.

Instructions:

- The student should perform at least 10 experiments from each semester. It is expected to perform at least one experiment from each technique.
- Use dilute solutions and in minimum amount.
- Use 50 ml volumetric flasks for preparation of solutions
- Scientific calculators (non-programmable) and practical handbooks are allowed during practical examination.

Conductometry:

1. Conductometric titration of mixture of acids and hence determine the strength of acids.
2. Determine the degree of hydrolysis and hydrolysis constant of sodium acetate conductometrically.

Potentiometry:

1. Determine Ecal and pH of buffer solution (Citric acid + Na_2HPO_4) using quinhydrone electrode.

2. Determine the pKa and Ka of weak monobasic acid by potentiometric titration.

P^Hmetry:

1. Determine the amount of aspirin in the given tablet.
2. Determine the pKa of various mixtures of sodium acetate and acetic acid in solution and hence to find the dissociation constant.

Polarimetry:

1. To study the kinetics of inversion of cane sugar by polarimeter.
2. Determine the concentration of given solution of an optically active substance (cane sugar) by polarimetric measurement.

Flame Photometry:

3. Estimation of Na / K by flame photometer in the given sample.

Refractometery:

1. Determine the refractive indices of series of KCl solution and hence unknown concentration of given KCl solution**.**

Chemical Kinetics:

1. Study the hydrolysis of methyl acetate in presence of hydrochloric acid.
2. Determine the energy of activation of the reaction between $K_2S_2O_8$ and KI. (Equal initial concentration)
3. Investigate the kinetics of iodination of acetone (zero order reaction).

Viscosity:

1. Determine the molecular weight of high polymer using its solution of different concentration.

Partition coefficient:

1. Determine the partition coefficient of iodine between carbon tetrachloride and water**.**

T.Y.B.Sc. Chemistry

Semester -VI **Course No:- CH-607**

Subject: Physical Chemistry Practical

(Practical: Lectures = 60 hrs, Marks 60) **(Credits: 02)**

Instructions:

- The student should perform at least 10 experiments from each semester. It is expected to perform at least one experiment from each technique.
- Use dilute solutions and in minimum amount.
- Use 50 ml volumetric flasks for preparation of solutions.
- Scientific calculators (non programmable) and practical handbooks are allowed during practical examination

Conductometry:

1. Determine the relative strength of monochloro acetic acid and acetic acidconductometrically.
2. Determine the basicity of organic acid by conductometric measurement.

Potentiometry:

1. Determine the amount of sodium chloride in a given solution by potentiometric titration with silver nitrate.
2. Determine formal redox potential of Fe^{2+} to Fe^{3+} by potentiometric titration.

Colorimeter / Spectrophotometer:

1. Determination of λ max and concentration of unknown Cu^{2+} solution and verify Beer's law.
2. Verify Beer's law, determine unknown concentration and molar extinction coefficient of Potassium permanganate.

P^Hmetry:

1. Determine the pKa and Ka of weak monobasic acid by pH metric titration.
2. Determine the degree of hydrolysis and hydrolysis constant of aniline hydrochloride pH metrically.

Polarimetry:

1. Determine the percentage of two optically active substances (d- sucrose and d-tartaric acid) in a mixture polarimetrically**.**

Radioactivity:

1. Determine the E_{max} of Beta particle.

Refractometry:

1. Determine the refractive index of four liquids, hence specific and molarrefraction.
2. Determine the molar refraction of homologous methyl, ethyl and propylalcohol and show that constancy configuration to molar refraction by $–CH_2$group.

Chemical Kinetics:

1. Investigate the reaction between H_2O_2 and KI by gas burette method.
2. Determine the order of the reaction between potassium persulphate and potassium iodide by fractional change method.

Viscosity:

1. Determine the radius of glycerol/sucrose molecule by viscosity measurement.

References:-

1. *Findley's Practical Physical Chemistry, B.P.Levitt, 9th Edition, Longman group Ltd.*
2. *Advanced Physical Chemistry Experiments, J.N.Gurtu and Amit Gurtu, Pragati Prakashan*
3. *Systematic Experimental Physical Chemistry S.W. Rajbhoj, Dr. T.K. Chondekar, 3rd edition, Anjali Publication, Aurangabad.*
4. *Experimental Physical Chemistry, V.D.Athawale, P. Mathur, New age International Ltd,New Delhi.*
5. *Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House, Meerut*
6. *Advanced Practical's in Physical Chemistry. Dr. Pande, Dr. Mrs. Datar, Dr. Mrs. Bhadane, 4th revised Edition, Manali Publication, Pune.*
7. *Experimental Physical Chemistry, R.C. Das, B.Behra, Tata McGrawHill.*

STRUCTURE OF INTERNAL PRACTICAL EXAMINATION

Time allowed – 3 Hours **Marks – 40**

Q.1 Any One experiment from (CH-507/607)	**30 Marks**
Q.2 Oral	**10 marks**

Total: 40 Marks

STRUCTURE OF EXTERNAL PRACTICAL EXAMINATION

Time allowed: 3 Hours **Marks: 60**

Semester V (CH-507)

Q. 1. Any One experiment from CH-507	**40 Marks**
Q.2 Oral	**10 Marks**
Q.3 Certified Journal	**10 Marks**

Total: 60 Marks

STRUCTURE OF EXTERNAL PRACTICAL EXAMINATION

Time allowed: 3 Hours **Marks: 60**

Semester VI (CH-607)

Q. 1. Any One experiment from CH-607)	**40 Marks**
Q.2 Oral	**10 Marks**
Q.3 Certified Journal	**05 Marks**
Q.4 Industrial Tour Report	**05 Marks**

-

Total: 60 Marks

T.Y.B.Sc. Chemistry

Semester -V **Course No:- CH-508**

Subject: Inorganic Chemistry Practical

(Practical: Lectures = 60 hrs, Marks 60) **(Credits: 02)**

Course Objectives:

- To analyze the inorganic mixtures.
- To determine metal from ore and alloy analysis.
- Using colorimetric analysis to determine amount of metal.

Learning outcomes:

- Student will able to determine cation & anion from inorganic mixtures by using qualitative analysis.
- Student will able to determine metal from ore & alloys.
- Students will be able to design & carry out scientific experiments as well as accurately record & analyze the results of experiments.
- Students will be able to handle colorimeter for estimation of metal ions.

1. **Inorganic Qualitative Analysis: (Any Five)**
   Binary mixtures containing common anions (Excluding phosphates and borates)
2. **Ore Analysis: (Any Two)**
   i) Heamatite ore - Estimation of Iron volumetrically
   ii) Pyrolusite ore- Estimation of Manganese volumetrically
   iii) Dolomite ore - Estimation of Calcium volumetrically
3. **Alloy Analysis: (Any Two)**
   i) Estimation of Zn from Brass alloy .
   ii) Estimation of Tin gravimetrically as SnO_2 from solder alloy.
   iii) Estimation of Copper iodometrically from nichrome alloy.
   iv) Determination of iron gravimetrically from stainless steel.
4. **Colourimetric analysis (any one)**
   i) Colourimetric titration of Cu(II) against EDTA method .
   ii) Estimation of Titanium using hydrogen peroxide.

IMPORTANT NOTE:

- For volumetric analysis pipette out solution should be 10 ml
- Preparation of stock solution or standard solution should be in **100/50ml volumetric flask** in order to avoid wastage of chemicals.

References

1. *A Text Book of Quantitative Inorganic Analysis, A. I. Vogel, 4th edition*
2. *Vogel's Qualitative Inorganic Analysis, A. I. Vogel.*
3. *Practical Chemistry, O. P. Pandey, D. N. Bajpai, S. Giri, S. Chand Publication, New Delhi.*
4. *Post Graduate Practical Chemistry, H. N. Patel, S. P. Turakhia, S. S. Kelker, S. **R.** Puniyani, Himalaya Publishing House.*
5. *College Practical Chemistry, H. N. Patel, S. P. Turakhia, S. S. Kelker, S.R. Puniyani, Himalaya Publishing House.*
6. *Practical Chemistry, K. K. Sharma, D. S. Sharma, Vikas Publication.*

T.Y.B.Sc. Chemistry

Semester -VI **Course No:- CH-608**

Subject: Inorganic Chemistry Practical

(Practical: Lectures = 60 hrs, Marks 60) **(Credits: 02)**

Course Objectives:

- To determine metal from gravimetric estimations.
- To determine amount of metal by volumetric analysis.
- To determine preparation /synthesis of co-ordination compound.
- To study separation techniques of metals.
- To use colorimetric analysis of metal.

Learning Outcomes:

- Students will be able to prepare co-ordination compounds.
- Students will be able to determine amount of metal by using quantitative analysis.
- Students will be able to calculate Rf value of metal.
- Students will be able to design & carry out scientific experiments as well as accurately record & analyze the results of experiments.
- Students will be able to explain why chemistry is an integral activity for addressing social, economic & environmental problems.

1. Gravimetric Estimations: (Any Two)

i) Fe as Fe_2O_3

ii) Zn as $Zn_2P_2O_7$

iii) Pb as lead chromate

iv) Al as Al_2O_3

2. Volumetric Analysis: (Any Two)

i) Manganese by Volhards method.

ii) Estimation of Nickel by EDTA method.

iii) Determination of strength of NaOH and Na_2CO_3 in a given solution.

iv) Estimation of ferrous and ferric by dichromate method.

3. **Inorganic Preparations: (Any Three)**
   i) Bis (ethylenediamine) copper (II) sulphate.
   ii) Potassium trioxalato chromate (III).
   iii) Tris (acetylacetonato) Iron (III).
   iv) Hexaaquonickel (II) chloride.
   v) Potassium tris oxalatoaluminate (III)trihydrate.
   vi) Synthesis of ZnO nanoparticles using Zinc acetate dihydrate
4. **Colourimetric Analysis: (Any One)**
   i) Estimation of iron using thiocynate method.
   ii) To determine the concentration of cobalt in the given solution using R-nitroso salt by colourimetry.
5. **Paper Chromatography: (Any Two mixtures)**

   Separation and identification of binary mixture of cations (Fe^{3+},Ni^{2+}, Cu^{2+},Co^{2+}, Mn^{2+},Zn^{2+})

IMPORTANT NOTE:

- For volumetric analysis pipette out solution should be 10 ml
- Preparation of stock solution or standard solution should be in **100/50 mL volumetric flask** in order to avoid wastage of chemicals.

References:

1. *A Text Book of Quantitative Inorganic Analysis, 4th edition, A. I. Vogel,*
2. *Vogel's Qualitative Inorganic Analysis, A. I. Vogel.*
3. *Practical Chemistry, O. P. Pandey, D. N. Bajpai, S. Giri, S. Chand Publication, New Delhi.*
4. *Post Graduate Practical Chemistry, H. N. Patel, S. P. Turakhia, S. S. Kelker, S. R. Puniyani, Himalaya Publishing House.*
5. *College Practical Chemistry, H. N. Patel, S. P. Turakhia, S. S. Kelker, S.R. Puniyani Himalaya Publishing House.*
6. *Practical Chemistry, K. K. Sharma, D. S. Sharma, Vikas Publications.*

STRUCTURE OF PRACTICAL EXAMINATION

Inorganic Chemistry Practical

CH-508, Semester-V

Internal Examination Pattern

Time Allowed: 3Hrs. **Max. Marks: 40**

Q 1. Inorganic Qualitative Analysis/Ore Analysis/ Alloy Analysis	**30 Marks**
Q 2. Oral	**10 Marks**
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	40 Marks

External Examination Pattern

Time Allowed: 3Hrs. **Max. Marks: 60**

Q 1. Inorganic Qualitative Analysis/Ore Analysis/ Alloy Analysis	**40 Marks**
Q 2. Oral	**10 Marks**
Q 3. Journal (completed and certified)	**10 Marks**
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	60 Marks

Inorganic Chemistry Practical

CH-608, Semester-VI

Internal Examination Pattern

Time Allowed: 3Hrs. **Max. Marks: 40**

Q 1. Gravimetric Estimations/Volumetric Analysis/colorimetric Analysis/ Inorganic Preparation and Paper Chromatography	**30 Marks**
Q 2. Oral	**10 Marks**
	40 Marks

External Examination Pattern

Time Allowed: 3Hrs. **Max. Marks: 60**

Q 1. Gravimetric Estimations/Volumetric Analysis/colorimetric Analysis/ Inorganic Preparation and Paper Chromatography	**40 Marks**
Q 2. Oral	**10 Marks**
Q 3. Journal (completed and certified)	**05 Marks**
Q 4. Industrial Tour Report	**05 Marks**
	60 Marks

T.Y.B.Sc. Chemistry

Semester -V **Course No: - CH-509**

Subject: Organic Chemistry Practical

(Practical: Lectures = 60 hrs, Marks 60) **(Credits: 02)**

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.

Learning Outcomes

- Separate and analyze binary water insoluble mixture.
- Separate and analyze binary water soluble mixture.
- Estimate - Acetamide, Glucose and Glycine by volumetric method,
- Estimate basicity of various acids.
- Synthesis of various organic compounds through greener alternatives.
- Understand Thin Layer Chromatographic techniques and physical constant.
- Understand the purification technique use in organic chemistry.

I) Separation of Binary Mixtures and Qualitative Analysis (Any 6)

a) Solid-Solid (4 Mixtures) b) Solid-Liquid (1 Mixture) c) Liquid-Liquid (1 Mixture)

At least one mixture from each of the following should be given-Acid-Base, Acid-Phenol, Acid-Neutral, Phenol-Base, Phenol-Neutral, Base-Neutral and Neutral- Neutral. (Solid-solid mixtures must be insoluble in water)

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 using micro scale.

II) Organic Estimations (Any 2)

1. Estimation of acetamide
2. Estimation of basicity (Number of -COOH groups) of acid
3. Estimation of glycine
4. Saponification value of oil

III) Green Chemistry Preparation (Any 2)

1. Synthesis of acetanilide from aniline by using Zn dust / acetic acid.
2. Synthesis of dibenzalpropanone from benzaldehyde and acetone. using $LiOH.H_2O$/NaOH
3. Synthesis of p- bromo acetanilide from acetanilide by using KBr.
4. Synthesis of dihydropyrimidinone from ethyl ace to acetate, benzaldehyde and urea
5. Diels-Alder reaction between furan and maleic acid [4+2] Cycloaddition Reaction

T.Y.B.Sc. Chemistry

Semester -VI **Course No:- CH-609**

Subject: Organic Chemistry Practical

(Practical: Lectures = 60 hrs, Marks 60) **(Credits: 02)**

I) Organic preparations **(Any 6)**

1. Benzoquinone from Hydroquinone (Oxidation by $KBrO_3$ or $K_2Cr_2O_7$)
2. Preparation of Sudan-I (Diazocoupling)
3. p-nitroacetanilide from Acetanilide (Nitration)
4. 2-Naphthyl ether from 2-Naphthol (Methylation by DMS, NaOH)
5. Hippuric acid from Glycine (Benzoylation)
6. p-Iodonitrobenzene from p-Nitroaniline (Sandmeyer Reaction)
7. m- Nitro aniline from m-Dinitrobenzene (Reduction)
8. Benzoic acid from Ethyl benzoate (Ester hydrolysis)
9. Isolation of Starch from Potato
10. Adipic acid from Cyclohexanone (Oxidation by Con. HNO_3)

II) Preparation of derivatives **(Any 3)**

1. Oxime derivative of aldehydes or Ketones
2. Aryloxy acetic acid derivative of Phenol
3. 2, 4 DNP derivative of aldehydes or Ketones
4. Glucosazone derivative of Glucose
5. Anilide derivative of acid

III) Purification techniques **(Any 1)**

1. Solvent extraction using separating funnel
2. Preparative TLC
3. Steam distillation

Note:

- The Preparation or derivative should be carried out on small scale and the starting compound should not be given more than one gm.

- Purity of the sample in Preparation and derivative can be checked by thin layer Chromatography (TLC).
- If product is impure, it should be purified.
- The Head of the Department must see that the industrial tour will be arranged collectively by the Department staff members.

Reference Books

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

STRUCTURE OF INTERNAL PRACTICAL EXAMINATION

Time allowed – 3 Hours **Marks – 40**

Q.1 Any One experiment from CH-509/609) **30 Marks**

Q.2 Oral **10 marks**

STRUCTURE OF EXTERNAL PRACTICAL EXAMINATION

Time allowed: 3 Hours **Marks: 60**

Semester V (CH-509)

Q.1 Separation of Binary Mixtures and Qualitative Analysis of any one Compound
OR Organic Estimation
OR Green Chemistry Experiment **40 Marks**

Q.2 Oral **10 Marks**

Q.3 Journal (completed and certified) **10 Marks**

Semester VI (CH-609)

Q.1 Organic Preparation / Derivative / Purification technique **40 Marks**

Q.2 Oral **10 Marks**

Q.3 Journal (completed and certified) **05 Marks**

Q.4 Industrial Tour Report **05 Marks**

Instructions

- In case of binary mixture experiment, examinee should identify type of mixture and should separate the mixture. After separation, examiner should ask the examinee to analyze any one compound from the mixture.
- In case of preparation of organic compounds and derivatives, product should be purified by recrystallization.
- Industrial tour is compulsory for each student.

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North Maharashtra University, Jalgaon
T.Y.B.Sc Chemistry
(CBCS) Pattern equivalence

Equivalence in accordance with titles and contents of papers (for revised syllabus from June 2020) are as follows…

Sr. No.	Title of Old Paper		Title of New Paper	
	Semester-V			
1.	CH -351	Physical Chemistry	CH – 501	Principles of Physical Chemistry-I
2.	CH -352	Inorganic Chemistry	CH – 502	Inorganic Chemistry
3.	CH -353	Organic Chemistry	CH – 503	Organic Reaction Mechanism
4.	CH -354	Analytical Chemistry	CH – 504	Industrial Chemistry
5.	CH -355	Industrial Chemistry	CH – 505	Analytical Instrumentation
6.	CH -356 (A)	Bio Chemistry	CH – 506 (A)	Biochemistry
7.	CH -356 (B)	Environment Chemistry	CH – 506 (B)	Green Chemistry
8.	CH -357	Physical Chemistry Practical	CH – 507	Physical Chemistry Practical
9.	CH -358	Inorganic Chemistry Practical	CH – 508	Inorganic Chemistry Practical
10.	CH -359	Organic Chemistry Practical	CH – 509	Organic Chemistry Practical
11.	Non-Credit Audit Course **(Any One)**		AC-510	NSS
			AC-511	NCC
			AC-512	Sports
	Semester-VI			
1.	CH -361	Physical Chemistry	CH - 601	Principles of Physical Chemistry-II
2.	CH -362	Inorganic Chemistry	CH - 602	Novel Inorganic Solids
3.	CH -363	Organic Chemistry	CH - 603	Spectroscopic Methods of Structure Determination
4.	CH -364	Analytical Chemistry	CH - 604	Chemistry of Industrially Important Products
5.	CH -365	Industrial Chemistry	CH - 605	Analytical Technique
6.	CH -366 (C)	Polymer Chemistry	CH – 606 (A)	Polymer Chemistry
7.	CH -366 (D)	Chemistry In Every Day Life	CH – 606 (B)	Research Methodology for Chemistry
8.	CH -367	Physical Chemistry Practical	CH – 607	Physical Chemistry Practical
9.	CH -368	Inorganic Chemistry Practical	CH – 608	Inorganic Chemistry Practical
10.	CH -369	Organic Chemistry Practical	CH - 609	Organic Chemistry Practical
11.	Non-Credit Audit Course **(Any One)**		AC-610	Soft Skill
			AC-611	Yoga
			AC-612	Practicing Cleanliness