B.Sc. Programme in CHEMISTRY

(*Choice Based Credit System*)

Core Papers: Chemistry (Theory & Practical)

Semester	Course Code	Name of the Course	Credits / Hours
I	CHC101	Inorganic Chemistry & Organic Chemistry	(6 credits: Theory-04, Practicals-02) Theory: 60 Hours (04 Credits) Practical: 60 Hours (02 Credits)
II	CHC102	Physical Chemistry & Organic Chemistry	
III	CHC103	Chemistry & Organic Chemistry	
IV	CHC104	Physical Chemistry & Inorganic Chemistry	

Skill Enhancement Course (SEC)

Semester	Course Code	Name of the Course	CREDITS/HOURS
III	CHS101	Natural Resources And Analysis	4 Credits: Theory -03, Practical-01 Theory: 45 Hours (03 Credits) Practical: 30 Hours (01 Credit)
IV	CHS102	Chemistry of Cosmetics and Perfumes	

F.Y.B.SC CHEMISTRY

The F.Y.B.Sc. programme enables the students to

- To provide in-depth knowledge of scientific and technological aspects of Chemistry.
- Master a broad set of chemical knowledge in the basic areas of the discipline (organic, inorganic)
- Understand good laboratory practices and safety.

SEMESTER I

CHC-101: Inorganic and Organic Chemistry

Course Objectives: To impart knowledge and understanding of the development of the structure of the atom. To introduce the concept of quantum mechanics, quantum numbers and orbitals. To understand the shapes of different orbitals and different principles for filling electrons. Students will learn to explain bonding in molecules using various theories of bonding. To introduce the basics of organic chemistry, stereochemistry and preparation of hydrocarbons.

Learning Outcome: Upon Successful Completion of this course students will be able to

- ❖ State the fundamental assumptions of atomic theory and explain the composition of atoms.
- ❖ Write electronic configuration of any given atom.
- ❖ Tell the name of orbitals by recognizing shapes of orbitals.
- ❖ Assign quantum numbers to electrons in an atom.
- ❖ Explain the formation of ionic and covalent bonds. Name molecular and ionic compounds and compare/contrast their physical and chemical properties.
- ❖ Draw molecular orbital diagrams of different molecules and calculate bond order.
- ❖ To determine shape of molecules and determine the hybridization involved.
- ❖ Understand basic concepts in organic chemistry.
- ❖ Know the basic principles of stereochemistry.
- ❖ Learn a few methods of preparation and basic reactions of alkenes, alkanes & alkynes

Course Structure

Section A: Inorganic Chemistry-1 (30 Lectures: 02 Credits)

Chapter 1: Atomic Structure: (14 Lectures)

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Quantum numbers and their significance, Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Shapes of s, p and d atomic orbitals, nodal planes.

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Chapter 2: Chemical Bonding and Molecular Structure (16 Lectures)

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

Covalent bonding: VB Approach, Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of Resonance and Resonating structures in various Inorganic and Organic compounds.

MO Approach, Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1^{st} and 2^{nd} periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^{+}. Comparison of VB and MO approaches.

Section B: Organic Chemistry – I (30 Lectures: 02 Credits)

Chapter 1: Fundamentals of Organic Chemistry (8 Lectures)

Curved arrow notation, drawing electron movement with arrows, half and double headed arrows, in organic reaction mechanisms.

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

Chapter 2: Stereochemistry (10 Lectures)

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

Chapter 3: Aliphatic Hydrocarbons (12 Lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

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

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

Alkynes: (Upto 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. *Reactions:* formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

Reference Books:

Inorganic Chemistry

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.

Organic Chemistry

1. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
2. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
4. Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
5. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.

6. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.

7. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.

8. Francis Carey, Organic Chemistry; 3rd Edition, Tata McGraw Hill India.

9. Paula Yurkanis Bruice, Organic Chemistry; 3rd Edition, Pearson Education Asia.

10. Jerry March, Advanced Organic Chemistry; 4rd Edition, John Wiley

SEMESTER I

CHC-101 LAB: Inorganic and Organic Chemistry (Practicals)

Course Objectives: Students should learn the various principles of titrimetric analysis and develop skills for performing volumetric analysis. Follow proper procedures and regulations for safe handling and use of chemicals. Communicate the concepts and results of laboratory experiments through effective writing and oral communication skills.

Learning Outcome: On completion of this course students will

- ❖ Be able to prepare solutions of different concentrations
- ❖ Learn about laboratory safety
- ❖ Understand the concept of volumetric analysis and apply it to different elemental analysis.
- ❖ Perform pertinent laboratory experiments, record observations, analyse data, and present the results in written form.
- ❖ Perform qualitative analysis of organic compounds
- ❖ Purify organic compounds.
- ❖ Determine physical constant (melting point, boiling point) of organic compounds.

Course Structure

Section A-(Inorganic Chemistry) **(30 Hours: 01 Credit)**

Volumetric Analysis: **(5 x 6 Hours = 30 Hours)**

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

Section B:(Organic Chemistry) **(30 Hours: 01 Credit)**

1. Purification of organic compounds: **(2 x 4 Hours = 8 Hours)**

i) Solids by recrystallization process using water and ethanol as solvent. Determination of melting point.

ii) Liquids by distillation process, a) acetone b) nitrobenzene. Determination of boiling point.

2. Determination of chemical type, detection of elements, group test for any one compound. **(4 Hours)**

3. Identification of unknown organic compounds. **(12 Hours)**

i) Water insoluble solids (Acid, Base, Phenol and Neutral)

ii) Water soluble solid (Acid and Neutral)

4. Thin layer chromatographic techniques: plate preparation, spotting, Separation of mixtures by thin layer Chromatography: Measure the Rf value in each case (combination of two compounds to be given eg. Mixture of o- and p-nitroaniline). **(6 Hours)**

Reference Books:

Inorganic Chemistry

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

Organic Chemistry

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
3. Pandey, O.P., Bajpai D. N. & Giri S. *Practical Chemistry*, *Revised Edition*, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014.

S.Y.B.Sc Chemistry

SEMESTER III

CHC-103 Physical and Organic Chemistry

Course Objectives: Progress the understanding of the core concepts of physical chemistry, especially solutions, electrochemistry and equilibrium. To impart the students a thorough knowledge about the chemistry of some selected functional groups with a view to develop proper aptitude towards the study of organic compounds and their reactions. To enable the students to understand and study Organic reaction mechanisms.

Course Outcomes: Upon completion of this course students will

- ❖ Interpret the phase equilibrium in simple systems, uses the phase diagrams and expresses the effect of pressure on the vapour pressure.
- ❖ Be able to State the basic principles electrochemistry
- ❖ Mention and explain various methods for the determination of transport number.
- ❖ Explain the concepts of electrolytic conduction and dilution

Course Structure

Section A: Physical Chemistry-2 (30 Hours; 02 credits)

1. Solutions (7 Hours)

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Azeotropes.

Partial miscibility of liquids: Critical solution temperature, distillation and fractional distillation.

2. Phase Equilibrium (8 Hours)

Phases, components and degrees of freedom of a system, criteria of phase equilibrium,

Phase diagrams of one-component systems (water, sulphur and CO_2) and two component systems

involving eutectics, congruent and incongruent melting points (Zn-Mg, NaCl-H_2O).

3. Conductance (5 Hours)

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions. Ionic mobility and factors affecting ionic mobility. Transference number and its experimental determination using moving boundary methods. Applications of conductance measurements: solubility and solubility products of sparingly soluble salts, ionic product of water, conductometric titrations (only acid-base).

4. Electrochemistry (10 Hours)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential.

Electrochemical series. Thermodynamics of a reversible cell, Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode.

Section B: Organic Chemistry-3 (30 Hours; 02 Credits)

1. Carboxylic acids and their derivatives (6 Hours)

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

Carboxylic acid derivatives (aliphatic): (upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversions.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky reaction, Perkin condensation (mechanism).

2. Amines and Diazonium Salts (6 Hours)

Amines (aliphatic and aromatic): (upto 5 carbons)

Preparation: from alkyl halides, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (Hofmann rearrangement).

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

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

3. Amino Acids and Peptides (6 Hours)

Preparation of Amino Acids: Strecker synthesis, Gabriel's phthalimide synthesis.

Terms: Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: Ester of – COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

4. UV –Visible Spectroscopy in Organic Chemistry (8 Hours)

Introduction to spectroscopy :

UV Spectroscopy: Beer-Lambert's law, Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption.

Visible Spectroscopy: Effect of conjugation on colour. Application of Woodward - Fieser rules for calculation of λ_{max} for the following systems: α, β unsaturated aldehydes, ketones. Conjugated dienes: alicyclic, homoannular and heteroannular, extended conjugated systems (aldehydes, ketones and dienes). Distinction between cis and trans isomers.

5. Carbohydrates: (4 Hours)

Classification and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, Osazone formation, Killiani Fischer synthesis.

Reference Books:

1. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
2. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009)
3. Undergraduate Physical Chemistry, Vol II, J.N. Gurtu, Pragati Prakashan.
4. Advanced Physical Chemistry, Gurtu and Gurtu, Pragati Prakashan
5. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
6. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
7. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
11. Berg, J. M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.Kemp, W. Organic Spectroscopy, Palgrave.
12. Pavia, D. L. et al. Introduction to Spectroscopy 5th Ed. Cengage Learning India
13. Silverstein, Bassler and Morill, Spectrometric Identification of Organic Compounds Ed. (2015).

SEMESTER III

CHC-103: LAB COURSE (Physical Chemistry & Organic Chemistry)

Course Objectives: To perform and identify functional groups in organic compounds by chemical tests in the laboratory with related reactions. To learn and perform practical techniques employed for systematic processes for the identification of unknown organic solid and liquid compounds. - Identify organic compounds by physical and chemical experimental methods. - Synthesis of organic derivatives. The course will aim at introducing basic as well as advanced level experiments in Physical Chemistry involving conductometry, potentiometry, equilibrium, etc.

Course Outcomes: Upon Successful Completion of this course students will be able to

- To provide the student with practical experience in the techniques of experimental physical chemistry.
- Develop experimental skills like collection, analysis of data, the ability to draw conclusions and set up glassware and apparatus to conduct experiments in Physical Chemistry.
- Interpret data from an experiment, including the construction of appropriate graphs and the evaluation of errors. Present the results of a practical investigation in a concise manner.
- Identify the functional groups in an organic compound.

COURSE STRUCTURE

Section A: Physical Chemistry-2 **(30 Hours: 01 credit)**

Phase Equilibria **12 Hours**

a) To draw the phase diagram of the binary system - diphenyl amine and α – Naphthol and find the eutectic temperature. (4 Hours)

b) Study the mutual solubility of phenol and water at various temperatures and hence determine the critical solution temperature. (4 Hours)

c) Study the effect of addition of NaCl on critical solution temperature of phenol water

system and study of the effect of impurities on it. (4 Hours)

Conductance **10 Hours**

a) Determination of cell constant. (2 Hours)

b) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. (4 Hours)

c) Conductometric titrations: (4 Hours)

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

Potentiometry **08 Hours**

Potentiometric titrations

i. Strong acid vs. strong base (Quinhydrone method) (4 Hours)

ii. Potassium dichromate vs. Ferrous Ammonium sulphate (4 Hours)

Section B: Organic Chemistry - 3 **(30 Hours: 1 Credit)**

I) Systematic Qualitative Organic Analysis: **(6x2 =12 Hours)**

Analysis of Organic Compounds possessing monofunctional groups (carboxylic, aldehyde, ketone, amide, nitro, amines) and preparation of one derivative of each group. (Analysis of single compound and its derivative preparation)

II) Organic Preparations : **(14 Hours)**

Synthesis, yield, recrystallisation and Melting Point.

(i) Hippuric acid from glycine (Benzoylation-Schotten Baumann reaction) (4 Hours)

(ii) Osazone from Glucose (Nucleophilic addition) (2 Hours)

(iii) Phthalic acid to Phthalic Anhydride to Phthalimide (4 Hours)

(iv) Preparation of Azo dye (4 Hours)

III) Organic Estimations: (Any 2) (4 Hours)

i. Estimation of glycine by formylation method (2 Hours)

ii. Estimation of Glucose by oxidation (2 Hours)

iii. Estimation of Acetamide by hydrolysis (2 Hours)

Reference books:

1. Systematic experimental physical Chemistry by S.W. Rajbhoj, Dr. T. K. Chondhekar, Anjali Publication, Aurangabad.
2. Practical Chemistry by O.P. Pandey, D. N. Bajpai, S. Giri, S. Chand Publication
3. Khosla, B. D., Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

Organic Chemistry

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

SEMESTER III

CHS101: (Natural Resources and Analysis)

Course Objectives: To learn about natural resources, coal, the destructive distillation of coal, the importance of natural gas, the origin of petroleum and about petroleum refining.

Course Outcomes: Upon Successful completing of this course students will be able to

- Distinguish between renewable and non-renewable resources.
- Know the uses of coke, coal tar and coal gas.
- Know and understand the principles of fractional distillation
- Analyse the uses of the various fractions of petroleum
- Recognise the importance of limited natural resources.

Course Structure **(45 Hours: 3 Credit)**

I. **Review of energy sources** (renewable and non-renewable). Classification of fuels and their calorific value. **2 Hours**

II. **Coal:** Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, Producer gas and Water gas—composition and uses. Fractionation of coal tar, uses of coal tar, requisites of a good metallurgical coke, coal gasification (Hydro gasification and Catalytic gasification), coal liquefaction and solvent refining. **10 Hours**

III. **Petroleum and Petrochemical Industry:** Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its Derivatives. **10 Hours**

IV. **Analysis of food products:** Nutritional value of foods, idea about food processing and food preservation and adulteration.

a) Identification of adulterants in some common food items like coffee powder,

asafoetida, chilli powder, turmeric powder, coriander powder, pulses etc.

b) Analysis of preservatives and colouring matter. **10 Hours**

V. Analysis of soil: Composition of soil, Concept of pH and pH measurement, complexometric titrations, chelation, chelating agents, use of indicators. **7 Hours**

VI. Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. **6 Hours**

CHS101: LAB COURSE (Natural Resources and Analysis)

Course Objectives: To educate the students on the analysis of soil and water samples and provide them with the basics to carry out field analysis of soil and water.

Course Outcomes: On completion of this course students will be able to

- Identify pH of samples
- Determine the amount of alkaline and acid content in water sample
- Determine the amount of dissolved gases in water bodies
- Determine the hardness of water

COURSE STRUCTURE **(30 Hours: 1 Credit)**

Instruction: Practicals/ demonstrations

1. Determination of pH of soil samples. **3 Hours**
2. Determination of pH of a water samples **3 Hours**
3. Estimation of Calcium and Magnesium ions as calcium carbonate by complexometric titration. **6 Hours**
4. Determination of dissolved oxygen (DO) in a given water sample. **4 Hours**
5. Determination of acidity of a water sample **4 Hours**

6. Determination of alkalinity in a given water sample **4 Hours**

7. Measurement of dissolved CO_2. **4 Hours**

8. Percentage of available chlorine in bleaching powder. **2 Hours**

Reference Books for Theory and Practicals:

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990). Jain, P.C. & Jain, M. Engineering Chemistry
4. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
5. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
6. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
7. Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
8. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India