S. Y. B. Sc.

Autonomous Syllabus (Proposed)

Department of Chemistry

K. J. Somaiya College of Science and Commerce

To be effective from 2019-20

Scheme:

Semester III

Course (Paper)	Course Name	Course Code
I	Physical Chemistry	19US3CH1
II	Inorganic Chemistry	19US3CH2
III	Organic Chemistry	19US3CH3
Practical	Practical in Physical, Inorganic and Organic Chemistry	19US3CHP

Semester IV

Course Paper	Course Name	Course Code
I	Physical Chemistry	19US4CH1
II	Inorganic Chemistry	19US4CH2
III	Organic Chemistry	19US4CH3
Practical	Practical in Physical, Inorganic and Organic Chemistry	19US4CHP

S.Y. B.Sc. SEM III/IV: Credits per Semester

Course	Credit
	Theory
I	02
II	02
III	02
Practical	03
Total	09
Per Subject 9 Credit	Total = 9 X 2 = 18
Skill enhancement course	02
Total credits per semester	**20**

Evaluation pattern: Theory

For each course I, II and III

External (60 M) + Internal (40 M)

External: End Semester Examination

Paper Pattern: S. Y. B.Sc. Semester III/ IV

External : 60 Marks **Duration: 2 hrs**

Question No.	Module	Marks (with option)	Marks (Without option)
Q1	I	5 M X 5 Q = 25 M	5 M X 4 Q = 20 M
Q2	II	5 M X 5 Q = 25 M	5 M X 4 Q = 20 M
Q3	III	5 M X 5 Q = 25 M	5 M X 4 Q = 20 M

Each question will have sub questions a, b, c, d, e out of which any 4 should be answered.

Internal: 40 Marks:

1. 30 marks – continuous evaluation using ICT technique
2. 10 marks – workshop/Project/industrial visit

Evaluation pattern: Practical

Practical Evaluation: 50 Marks practical examination at the end of each semester per paper.

Semester III
Course I (Paper I)
Course Name: Physical Chemistry
Course Code: 19US3CH1

Semester-III		
Module	**Course Before: 2019-20**	**Course from: 2019-20**
I	Quantum Chemistry and UV Visible Spectroscopy	Photochemistry and UV Visible Spectroscopy
II	Solutions of Electrolytes	Solutions of Electrolytes
III	Titrimetric Analysis and Use of Instrumental Methods in Titrimetric Analysis	Titrimetric Analysis and Use of Instrumental Methods in Titrimetric Analysis

SEMESTER III

COURSE (PAPER) I

Course Name-Physical Chemistry

COURSE CODE 19US3CH1

After completion of this course the student should be able to

CO1: Understand the basic concepts of Photochemistry and spectroscopy.

CO2: Recognize the different electrical properties of electrolytes.

CO3: Have knowledge of classical and instrumental methods of analysis.

Module– I

Photochemistry and UV Visible spectroscopy

Learning Objective:

- The module is intended to introduce the main conceptual framework of photochemistry and spectroscopy.

Learning Outcome:

- A student will understand the basics concepts photochemistry and importance of spectroscopy in our daily life.

1.1 Photochemistry **6L**

1.1.1 Photochemistry: Consequences of light absorption- The Jablonski diagram, radiative and non -radiative transition.

1.1.2 Laws of photochemistry, quantum efficiency, quantum yield, experimental determination of quantum yield, study of photochemical reactions:1) Reaction between hydrogen and chlorine, 2) Dissociation of hydrogen iodide, Photochemical rate law.

1.1.3. Energy transfer in photochemical reactions: Photosensitization and quenching, Chemiluminescence, photochemical smog, ozone depletion concept of flash photolysis.

1.1.4. Solar cells, solar energy, photovoltaic effect, semiconductors as solar energy converters, silicon solar cell.

1.2 UV- Visible Spectroscopy **6L**

1.2.1U.V and visible spectroscopy, absorption spectrosco.py, terms involved: radiant power, absorbance, transmittance, percentage transmittance, wavelength of maximum absorption.

1.2.2 Statement of the Beer's law and the Lambert's law (derivation expected), Combined expression, molar extinction coefficient, deviations from Beer – Lambert law, limitations of the law.

1.2.3 Components of an optical instrument, photometers and spectrophotometers, construction of a single beam photometer & double beam photometer.

1.2.4 Photometric Titrations: Basic principles, titration curves, advantages and limitations.

Module 2 Solutions of Electrolytes

Learning Objective:

- A student will study different electrical properties of electrolytes.

Learning Outcome:

- A student will be able to differentiate between electronic and electrolytic conductors. He/She will be able to define, understand and correlate different terms conductance, specific conductance, equivalent conductance, molar conductance, transport number.

2. 0 Solutions of Electrolytes

2.1.1 Electronic and electrolytic conductors, conductance, specific conductance, equivalent conductance, molar conductance, variation of molar conductance with concentration for strong and weak electrolytes. Concept of limiting molar conductance.**3L**

2.1.2 Debye-Huckel theory of conductance of strong electrolytes. Ionic atmosphere, relaxation effect, electrophoretic effect.**2L**

2.1.3 Kohlrausch's law of independent migration of ions, applications of the law – determination of limiting molar conductance of weak electrolytes, determination of dissociation constant of a weak acid, determination of solubility product of a sparingly soluble salt.**3L**

2.1.4 Migration of ions, transport number, dependence of transport number on velocity of ions.**2L**

2.1.5 Relationship between transport number, ionic mobility and equivalent conductance.**2L**

Module 3 Titrimetric Analysis and Use of Instrumental Methods in Titrimetric Analysis
Learning Objectives:

- The module is intended to introduce the titrimetric and instrumental methods of quantitative analysis.

Learning Outcome:

- A student will understand the change in pH taking place at different stages of titration and interpretation of equivalence point using instrumental methods of analysis.

3. Titrimetric Methods of Analysis 7L

3.1.1 **Theory of acid – base titrations:** construction of titration curves and choice of indicators in the titration of (a) strong acid and strong base, (b) strong acid and weak base, (c) weak acid and weak base, (d) dibasic acid and strong base.

3.1.2 **Redox titrations:** General introduction, theory of redox indicators, criterion for a redox titration, construction of titration curves in the case of (a) Fe (II) vs Ce (IV), (b) Fe (II) vs dichromate, use of diphenyl amine and ferroin as redox indicators.

3.2 Instrumental methods in Titrimetric analysis 5L

3.2.1 **Conductometric Titrations:** Basic principles, Theory and working of conductivity cell, experimental set up, titration curves in the titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base, (iii) weak acid vs. weak base, (iv) mixture of strong acid and weak acid/ strong base and weak base vs. strong base / weak base or strong acid/ weak acid. (v) sodium chloride vs. silver nitrate (vi) Barium hydroxide vs. magnesium sulphate, advantages and limitations of conductometric titrations.

3.2.2 **Potentiometric titrations:** Basic principles, concept of indicator electrode, indicator electrodes for different types of titrations, determination of end points from the graphs of E vs. V, $\Delta E/\Delta V$ vs. mean volume, $\Delta^2E/\Delta V^2$ vs. mean volume, advantages and limitations of potentiometric titrations.

Semester III

Course II (Paper II)

Course Name: Inorganic Chemistry

Course Code: 19US3CH2

Module	**Course Before: 2019-20**	**Course from: 2019-20**
I	Comparative chemistry of group 13, Group 14, Group 15 and Group 16 Elements.	Comparative chemistry of Main Group elements and important compounds of p-block elements
II	Comparative Chemistry of Transition Elements, Chemistry of coordination compounds and Bonding in Coordination Compounds: Valence bond Theory	Comparative Chemistry of Transition Elements, Chemistry of coordination compounds and Bonding in Coordination Compounds: Valence bond Theory
III	Gravimetric Analysis and Safety in Chemistry	Gravimetric Analysis and Titrimetry in Chemistry

SEMESTER III

COURSE (PAPER) II

Course Name-Inorganic Chemistry

COURSE CODE 19US3CH2

After completion of this course student should be able to:

CO1 : understand the interrelationship between electronic configuration and properties of elements.

CO2 :appreciate various theories of bonding and applications.

CO3 :understand various properties such as colour, magnetic behavior and applications of transition elements in various fields.

CO4 :recognize link between practical and theoretical principles of quantitative analysis.

Module– I

Learning Objective:

A student will study the relationship between electronic configuration and properties of elements by a comparative methodand also study the different compounds of main group elements which are important from the point of view of theoretical chemistry like type of bonding and also their applications.

Learning Outcome:

A student can understand the interrelationship between electronic configuration and properties of elements and can predict the properties of elements based on the position of elements in the periodic table and will gain knowledge about different types of bonds, structures and properties of compounds of main group elements.

1.1 Comparative Chemistry of Main group elements **03 L**

1.1.1 Introduction, trends in properties like atomic and ionic radii, ionization energy, electronegativitiy, metallic and non-metallic character. Oxidation states, inert pair effect, covalency, catenation, allotropy.

1.1.2 Anomalous behaviour of second period elements and diagonal relationship.

1.2 Chemistry of Boron compounds **03 L**

1.2.1 Boron hydrides-preparation and properties.

1.2.2Electron deficient compounds.

1.2.3Structure and bonding in diborane.

1.3 Chemistry of Silicon and Germanium **03 L**

1.3.1Compounds of silicon-silicates, zeolites, glass, silicones (types, methods of preparation and uses of different silicones).

1.3.2Preparation of extra pure Silicon/Germanium, n-type and p-type of semiconductors.

1.4 Chemistry of Nitrogen and Oxygen family **03 L**

1.4.1 Oxides and oxyacids of nitrogen and sulphur.

1.4.2Hydrides of Group 15 and 16 elements. Trends in physical properties of hydrides based on hydrogen bonding.

Module 2 :

Learning Objective:

A student will study various properties of transition elements and basic theory co-ordination compounds.

Learning Outcome:

A student will be able to understand various properties such as colour, magnetic behavior and applications of transition elements such as catalyst, alloys and applications of coordination compounds in various fields such as Photography, qualitative estimation, volumetric estimation, metallurgy, colorimetric and spectrophotometry.

2.1 Comparative Chemistry of Transition Elements: 06 L

2.1.1 Introduction, definition, position in the periodic table, electronic configuration and classification.

2.1.2 Physical properties with respect to atomic and ionic radii, metallic character, electrical and thermal conductivities, atomic volume and density, M.P. and B.P.

2.1.3 Ionization potential and relation between ionization potential and stability of metal in a given oxidation state, Standard reduction potential values, Variable oxidation state, stabilization of low and high oxidation state, Acidic and basic character of the compounds of given transition metal in various oxidation states.

2.1.4 Colour and magnetic properties, Determination of para and diamagnetic nature of a given substance.

2.1.5 Tendency of transition metals to form complex compounds, Formation of interstitial compounds, Catalytic activity and applications.

2.2Chemistry of coordination compounds: 06 L

2.2.1 Basic concepts: Distinction betweendouble salts and coordination compounds.

Terms involved in coordination chemistry, complex ion, ligands.

Ambidentate ligands: NO_2^- SCN^-, CN^- $S_2O_3^{2-}$

Bridging ligands: OH^-, NH_2^-, NH^{2-}, O_2^{2-}, NO_2^-

Flexidentate ligands: SO_4^{2-}, CO_3^{2-}

Chelating ligands

2.2.2 Werner's theory of coordination compounds and EAN. (Problem based)

2.2.3 Isomerism: Conformation: Ionisation, Hydrate, coordination, linkage, coordination position, ligand, polymerization, Stereoisomerism: Geometrical isomerism in square planar and octahedral geometry, Optical isomerism

2.2.4 Applications of coordination compounds, Complex formation in various fields: Photography, qualitative estimation, volumetric estimation, metallurgy, colorimetric and spectrophotometry.

Module-III

Learning objectives:

A student will study theoretical and practical aspects of two classical methods of analysis which are used widely for quantitative analysis i.egravimetric analysis and titrimetric analysis.

Learning outcome:

This module will establish an important link between practical and theoretical principles of quantitative analysis

3.1 Gravimetric analysis 05L

3.1.1 Definition and types of gravimetric analysis.

3.1.2. Solubility considerations: common ion effect, diverse ion effect, pH, temperature and nature of solubility, controlling particle size and treatment of gravimetric precipitrates.

3.1.3 Different steps involved in gravimetry: Digestion, Filtration and washing, Drying and ignition

3.1.4 Use of organic reagents in gravimetric analysis (Numerical problems on this topic expected)

3.2Precipitation titrations 03L

3.2.1 Introduction and theoretical aspects of precipitation

3.2.2 Aregentimetric titration, construction of titration curves.

3.2.3 Mohr's method, Volhard's method for determination of halides

3.2.4 Use of Adsorption indicators.

3.3 Complexometric titrations 04L

3.3.1 General introduction, use of EDTA as a titrant, absolute and conditional stability constant of metal-EDTA complexes.

3.3.2 Types of EDTA titrations, methods for increasing selectivity of EDTA titrations.

3.3.3 Theory of metalochromic indicators, examples and use.

3.3.4 Applications of EDTA titrations.

Semester III

Course III (Paper III)

Course Name: Organic Chemistry

Course Code: 19US3CH3

Module	**Course Before: 2019-20**	**Course from: 2019-20**
I	Mechanism of Organic reaction and aromatic electrophilic substitution reaction	Mechanism of Organic Reactions and Aromatic electrophilic substitution reactions

II	Aromatic hydrocarbons, haloarenes, phenols and ethers and epoxides	Stereochemistry
III	Chemical Industry, Sources of organic and manufacture of bulk chemicals	Chemical industry, Sources of organic compounds and Manufacture of bulk chemicals
		OR
		Renewable and Non renewable sources of Energy

Semester III
Course III (Paper III)
Course Name: Organic Chemistry
Course Code: 19US3CH3

Course Name-Organic Chemistry

COURSE CODE 19US3CH3

After completing the course the student should be able to

CO1 :predict and account for the most commonly encountered reaction mechanisms in organic chemistry

CO2 appreciate the importance of stereochemistry in organic chemistry and apply the knowledge gained in this course to a variety of chemical problems.

CO3 : recognize the application of organic chemistry in synthesis of drug, dyes and perfumeries..

Module I

Mechanism of organic reaction

Learning Objective:

A student will distinguish the different of organic reactions mechanisms. Predict outcomes and draw mechanisms for reactions.

Learning Outcomes

The students can predict and account for the most commonly encountered reaction mechanisms in organic chemistry

1.1: Mechanism of organic reactions 6 L

The mechanism of reactions involving the following reactive intermediates:

1.1.1: Carbocations: Different types of carbocations such as alkyl, allyl, benzyl. SN^1 reaction, Electrophilic addition across an olefinic double bond, Elimination: E1 mechanism, Rearrangement: Wagner Meerwein rearrangement.

1.1.2: Carbanions: Concept of carbon acid. Alkylation of carbon acids (active methylene compounds and terminal alkynes) using alkyl halides and synthetic applications of these reactions. Reactions of Grignard reagents at sp^3 carbon and carbonyl group. Aldol reaction.

1.1.3: Carbon radicals: General reactions of radicals – abstraction, addition to C=C, combination, disproportionation. Addition of HBr to alkenes in presence of peroxide. Polymerization.

1.1.4: Carbenes: Generation of carbenes through alpha elimination, from diazoalkanes, from ketenes. Structure and stability. Reactions: insertion into C-H bond and addition to olefins.

1.2: Tautomerism

Keto-enoltautomerism in aldehydes and ketones, acid and base catalysedenolisation, enol content and stabilized enols : β –ketoesters, β-diketones, phenols.

1.3: Aromatic Electrophilic Substitution Reaction 6 L

1.3.1: Electronic structure and Huckel's Rule of aromaticity and its applications to carbocyclic and heterocyclic, benzenoid and nonbenzenoid compounds and ions. Concept of antiaromaticity.

1.3.2: General mechanism of aromatic electrophilic substitution reaction with energy profile diagram with reference to halogenation, nitration, sulfonation and Friedel-Crafts alkylation and acylation reaction.

1.3. 3: Drawing resonance structures of monosubstituted benzenes - Activated and deactivated aromatic rings.

1.3.4: Effect of electron withdrawing and electron donating substituents on the orientation of an incoming electrophile on the basis of – (i) electron density distribution (ii) stability of intermediate. Cases to be studied: Mono and disubstituted benzenes containing groups - alkyl, amino, hydroxyl, alkoxy, halo, acyl, nitro, carboxy. ortho - para ratio.

Module II

Stereochemistry **12 L**

Learning Objective:

1.Differentiate chiral and achiral molecules.

2.Recognize and draw structural isomers (constitutional isomers), stereoisomers including enantiomers and diastereomers, racemic mixture, and meso compounds.

3.Identify the stereocenters in a molecule and assign the configuration as R or S.

4. Know the relationship between enantiomers and their specific rotations.

Learning Outcomes:

1.Upon successful completion of this module, students will be able to appreciate the importance of stereochemistry in organic chemistry and apply the knowledge gained in this course to a variety of chemical problems.

2.1:Isomerism:4L

Types of isomerism, structural isomerism (chain, position & functional) and stereoisomerism (Geometrical & optical).

2.2:Chirality: asymmetric carbon atom, enantiomers, stereogeniccentre, configuration,

Representation of configuration by flying wedge formula & projection formula- Fischer, Newmann, sawhorse and interconversion of these.

2.3:Assigningstereodescriptors to chiralcentres:6L

2.3.1: Cahn-Ingold-Prelog (CIP) Rules of assigning absolute configuration (R and S) to stereogeniccentres, Assigning absolute configuration to molecules having maximum two chiral carbon atoms.

2.3.2: Stereochemistry of carbon compounds with one and two similar and dissimilar asymmetric carbon atoms; enantiomers, diastereomers and racemic mixture and their properties, threo, erythro and meso isomers., Resolution of enantiomers: chemical and chromatographic

2.4: **Geometrical isomerism** **2L**

Diastereomers (geometrical isomerism) due to restricted rotation around carbon-carbon double bond, E and Z stereodescriptors to geometrical isomers, Diastereomers of disubstituted cycloalkanes (3 and 4 membered rings).

ModuleIII

Chemical industry

Learning Objective:

Learner will study the basic terminologies used in chemical industry. Students will understand the importance and use of organic chemistry in synthesis of drugs, dyes, artificial sweeteners and natural products**.**

Learning Outcomes:

Learner will gain the basic idea of the chemical plant. Learner will understand the use of flow diagram in manufacture of chemicals.

Learner will appreciate the application of organic chemistry in synthesis of drug, dyes and perfumeries.

3.1: Chemical Industry **4 L**

Introduction to aspects of a chemical plant, terminology [raw materials, intermediates, end products, by-products, waste], unit operations, unit processes [single and multiple], batch and continuous operations, block diagrams, flow diagrams

3.2: Manufacture of bulk chemicals **3 L**

3.2.1 : Phenol and dodecyl benzene [including reactions and reaction conditions, block / flow diagram, description]

3.3 Synthesis of Molecules of Commercial importance 5 L

3.3.1 Artificial sweeteners-Aspartame, Saccharin, Sucralose

3.3.2 Dyes- Para Red, Alizarin, Metanil Yellow

3.3.3. Dye intermediate: β-Nitro styrene

3.3.4 Drugs- Pethidine (Demerol), Lidocaine

3.3.5 Perfumes: Civetone, Coumarin

3.3.6 Nutraceutical: β-Alanine

3.3.7 Natural Product: Piperine, Geranic acid

3.3.8 Flavour: Fumaric acid

OR

Module III (Optional)

3.1 Renewable and Non renewable sources of Energy 12L

Learning Objectives

Understand the renewable and nonrenewable sources of aromatic and alipahatic organic compounds.

Learning Outcomes*:*

Students will recognize the importance of using carefully the fast replenishing energy sources

3.1.1 Introduction to Energy Sources 1L

3.1.2 Non renewable energy sources - Coal, Petroleum, Natural gas 4L

3.1.3 Renewable energy Sources : Synthesis gas, Biomass ,Biofuel ,Oligomerisation and metathesis of olefins 5L

1.4 Future of the renewable and nonrenewable energy sources 2L

SEMESTER IV

COURSE (PAPER) I

Course Name-Physical Chemistry

COURSE CODE 19US4CH1

Semester-IV		
Module	**Course Before: 2019-20**	**Course from: 2019-20**
I	Chemical kinetics and Electrochemical Cells	Chemical kinetics and Electrochemical Cells
II	Solutions of Non-electrolytes and Nernst distribution Law	Solutions of Non-electrolytes and Nernst distribution Law
III	Crystalline state and Introduction to physical chemistry of Polymers	Crystalline state and Introduction to physical chemistry of Polymers

SEMESTER IV

COURSE (PAPER) I

Course Name-Physical Chemistry

COURSE CODE 19US4CH1

After completion of this course the student should be able to

CO1: Discriminate different types of reactions based on order and molecularity and different types of electrochemical cells.

CO2: Understand the behavior of ideal solutions, separation methods and technique of solvent extraction.

CO3: Recognize different crystalline systems such as simple cubic, face-centered and body-centered cubic systems and different crystal defects with examples.

Module 4 :

Chemical Kinetics and Electrochemical cells

- **Learning Objectives:**

This module is intended to introduce the basic concepts of Chemical kinetics and to give ideas about different electrochemical cells and electrodes.

- **Learning Outcome:**

A Student will be able to discriminate different types of reactions based on order and molecularity. He/She will be able to distinguish between different types of electrochemical cells and will be able to write respective cell reactions.

4.1 Chemical Kinetics **4 L**

4.1.1 Definition of terms – order, rate and molecularity

4.1.2 Experimental methods to study the kinetics of reactions, rate law, rate constant, units of rate constant.

4.1.3 Integrated rate equation for zero, first and second order reactions, pseudounimolecular reactions.

4.1.4 Methods of determination of order of reactions.

4.2 Electrochemical Cells **8L**

4.2.1 Galvanic and electrolytic cells-

Reference electrodes- Calomel electrode,

Metallic Indicator Electrodes :

Electrodes of First kind-

Electrodes of Second kind,

Electrodes of Third kind

Metallic redox Indicator

Membrane Indicator Electrodes : Ion Selective electrode-Glass electrode

4.2.2 Cell representation and cell reaction (students are expected to write the cell reaction for a given cell and vice versa). Reversible & irreversible cells, chemical &concentration cells, primary & secondary cells.

4.2.3 Thermodynamic parameters - ΔG, ΔH and ΔS for the cell reaction taking place in a cell.

4.2.4 Nernst's equation for cell EMF and hence for a single electrode potential. (Derivation and numerical problems expected).Determination of equilibrium constant from EMF measurements.

Module 5:

Solutions of Non-electrolytes and Nernst Distribution Law

- **Learning objectives:**

The module is intended to introduce the behavior and applications of non- electrolytes.

- **Learning outcome:**

A student will understand the behavior of ideal solutions and techniques for the separation and purification of liquid-liquid mixture. He/She will learn the method of solvent extraction.

5.1 Solutions of Non-electrolytes 7L

5.1.1 Solution of gases in liquids, Henry's law.

5.1.2 Solutionsof liquids in liquids – Completely miscible liquids, Raoult's law, ideal solutions, phase diagrams – pressure vs. composition and temperature vs. composition. Distillation of mixtures forming ideal solutions, fractional distillation, distillation under reduced pressure, deviation from Raoult's law – positive and negative deviation, non-ideal solutions, azeotropes, distillation of azeotropic mixtures, breaking of azeotropic mixtures.

5.1.3 Partially miscible liquids – (i) with upper critical solution temperature (UCST) (ii) with lower critical solution temperature (LCST), (iii) with UCST & LCST.

5.1.4 Completely immiscible liquids, steam distillation.

5.2 Nernst Distribution Law 5L

5.2.1 The Nernst distribution law, partition coefficient and distribution ratio, solutes undergoing association and dissociation.

5.2.2 Applications of the law – study of complex ions and solvent extraction.

Module 6:

Crystalline State and Introduction to physical chemistry of Polymers

Learning objectives:

module intended to introduce crystalline states and physical chemistry of polymers.

Learning outcome:

A student will learn different crystalline systems such as simple cubic, face-centered and body-centered cubic systems. He/She will learn different crystal defects with examples.

6.1 Crystalline State 8L

6.1.1Characteristics of simple cubic, face-centered and body-centered cubic systems, Interplanar distance in cubic lattices.

6.1.2 Use of X-rays in the study of crystal structure, Bragg's equation, (derivation expected), X-ray diffraction method of studying crystal lattices, structure of NaCl and KCl. Determination of Avogadro's number.

6.1.3 Types of crystals – Molecular, covalent, metallic and ionic crystals with examples.

6.1.4 Crystal defects – Schottky and Frenkel defects.

6.2 Introduction to physical chemistry of Polymers 4L

6.2.1 Basic terms and their definitions.

6.2.2 Classification based on (1) source, (2) structure, (3) thermal response, (4) physical properties, (5) method of preparation

6.2.3 Molar mass of polymers – number average, weight average, viscosity average ad Z-average. Monodispersity and polydispersity.

6.2.4 Methods of determination of molar masses of polymers – (1) ultracentrifuge (limiting or sedimentation velocity method only), (2) Viscosity method (Mark – Hauwink equation).

6.2.5 Introduction to light emitting polymers, applications of LEP.

Semester IV4211222

Course II (Paper II)

Course Name: Inorganic Chemistry

Course Code: 19US3CH2

Module	**Course Before: 2019-20**	**Course from: 2019-20**
IV	Comparative Chemistry of Group 17, 18 elements and Chemistry of Organometallic compounds.	Comparative Chemistry of Group 17, 18 elements and Chemistry of Organometallic compounds.
V	Molecular orbital theory and Valence bond Theory.	Molecular orbital theory and Valence bond Theory.
VI	Corrosion and methods of protection of metals, Environmental studies	Corrosion and methods of protection of metals, Environmental Chemistry

SEMESTER IV

COURSE (PAPER) II

Course Name-Inorganic Chemistry

COURSE CODE 19US4CH2

After completion of this course the student should be able to:

CO1: gain knowledge about different compounds of group 17, 18 elements and organometallic compounds.

CO2: recognize importance of hybridization, limitations of valence bond theory and various features of Molecular orbital theory such as application of LCAO-MO approach to diatomic molecules.

CO3: appreciate and address various environmental pollution aspects.

Module4 :

Learning objective:

A student will study chemistry of group 17, 18 elements and basic chemistry of organometallic compounds.

Learning outcome:

A student will be able to understand about different compounds of group 17, 18 elements, organometallic compounds and variations in the properties of group 17, 18 elements and importance of organometallic compounds.

4.1Comparative Chemistry of group 17 elements: 05L

4.1.1General trends in their physical and chemical properties

4.1.2Chemistry ofpseudo-halogens with respect to comparison with halogens,Preparationanduses

4.1.3Oxyacids of halogens

4.2Comparative Chemistry of group 18 elements: 03L

4.2.1History andPreparation and structure of xenon fluorides and oxy fluorides

4.3Organometallic compounds: 04L

4.3.1Introduction, definition, andclassification on the basis ofhapticityandNature of metal-carbon (M-C) bond

4.3.2Eighteen Electron Rule with respect to applications and exceptions

4.3.3Metal carbonyls with respect to classification and bonding,General methods of preparations, properties.

4.3.4 Applications of Organometallic compounds

Module 5:

Learning Objective:

A student will learn Molecular orbital theory and Valence bond theory to study homonuclear and heteronuclear diatomic molecules.

Learning Outcome:

A student will be able to understand importance of hybridization, limitations of valence bond theory and various features of Molecular orbital theory such as application of LCAO-MO approach to diatomic molecules.

5.1 Molecular orbital theory: 08 L

5.1.1 Salient feature of MOT

5.1.2 LCAO – MO approach, variation of electron charge density with internuclear distance in H_2 molecule.

5.1.3 Molecular orbitals formed by the combination of two s-orbitals, s and $p_x$orbitals.Characteristics of σ and Π orbitals

5.1.4 Necessary conditions to be satisfied by atomic orbitals to combine together to form molecular orbitals, Comparison between AO and MOs.

5.1.5 Application of LCAO-MO for the formation of homonuclear diatomic molecules. H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, Ne_2 with respect to bond order, bond length, bond energy, magnetic properties, mixing orbitals.

5.1.6 Bond order in O_2, O_2^+, O_2^- and O_2^{2-}.

5.1.7 Heteronuclear diatomic molecules of molecular ions CO, NO, CN^-, HCl with respect to bond order, stability, magnetic properties and polarity.

5.2 Valence Bond Theory (VBT) 04L

5.2.1 Hybridization involving the use of d orbitals as in PCl_5 (sp^3d), $BaCl_2$ (sd), and MnO_4^- (d^3s)

5.2.2 Concept of Resonance and Resonance energy, Formal charge with examples

5.2.3 Limitations of VBT

Module VI

Learning objective:

A student will study basic theory of corrosion, types and some important methods for prevention of corrosion and different aspects of environmental pollution.

Learning outcome:

A student will understand the importance of corrosion and various environmental pollution aspects.

6.1 Corrosion and methods of protection of metals: **05L**

6.1.1 Introduction andtypes of corrosion

6.1.2 Electrochemical theory of corrosion

6.1.3 Methods of protection- Coating, Electroplating, Cathodic protection, Anodizing, Sacrificial coating

6.2 Environmental chemistry **07L**

6.2.1 **Air pollution**: Study of various gaseous pollutants such as oxides of nitrogen, carbon and sulphur With respect to 1) Sources of emission 2) fate 3) health hazards and 4) control measures, Green house effect and its consequences, Global warming , Global warming potential and Ozone depleting substances ,National and international efforts ,international treaties - **4 L**

6.2.2 **Water pollution**- 1) Sources, 2) fate 3) health hazards and 4) control measures Water (Prevention and Control of pollution) Act- **3 L**

Semester IV
Course III (Paper III)
Course Code: 19US4CH3

Module	**Course Before: 2019-20**	**Course from: 2019-20**
IV	Aromatic nitrogen compounds Aromatic aldehydes and ketones	Aromatic nitrogen compounds Aromatic aldehydes and ketones
V	Aromatic carboxylic acids, aromatic sulphonic acids Stereochemistry Structure determination and multistep synthesis	Aromatic carboxylic acids, aromatic sulphonic acids Epoxides Structure determination and multistep synthesis
VI	Organic Chemistry of drugs Newer methods of synthesis and Manufacture of some bulk chemicals	Green Chemistry, Newer methods of synthesis and environmental aspects OR Nanochemistry- an emerging science

Semester IV
Course III (Paper III)
Course Code: 19US4CH3

Course Name-Organic Chemistry

After completing the course the student should be able to

CO1 : predict the synthetic routes using the nitro and amino compounds, aldehydes and ketones, carboxylic acids, sulphonic acids and epoxide as starting materials for a range of other organic compounds

.CO2determine the structure and predict the reaction pathway in multistep synthesis

CO3 :prepares themselves for careers as leaders in understanding and addressing complex environmental issues from a problem-oriented, interdisciplinary perspective.

Module IV

Aromatic nitrogen compounds

Learnin**g Objective:**

Know the different methods used in synthesis of amines, basicity of amines, Know the reactions of amines; in addition to behaving as bases amines can be nucleophiles.

Students will learn the different methods of preparations and reactions of Nitro compounds along with its applications

Student will learn the preparation of aldehydesand ketones the reactions that involve nucleophilic attack at the carbonyl carbon.

Learning Outcomes

Aromatic amines and nitro compounds are used as intermediates in manufacture of drugs , dyes and explosives.

Students will learn that aldehydes and ketones can be starting materials for a range of other functional groups.

4.1 : Aromatic nitro compounds **4 L**

4.1.1: Preparation: Nitration using mixed acid, Preparation of mononitro compounds through nitration of benzene (mechanism), nitrobenzene, toluene, chlorobenzene, naphthalene, anisole.

4.1.2: Reactions: Reduction of nitro compounds under different conditions.

4.2: Aromatic amino compounds **4 L**

4.2.1: Preparation: Reduction of aromatic nitro compounds using – catalytic hydrogenation, dissolving metal reduction using – Fe-HCl, Sn-HCl and Zn/AcOH, partial reduction using NaHS. Amination of halobenzenes, Chemoselective reduction of dinitrobenzene, Hoffmann bromamide reaction.

4.2.2: Reactions: Basicity of aromatic amines – effect of substituents on basicity of aniline, salt formation, N-alkylation, N-acylation, halogenation, reductive alkylation, Diazotization of aromatic primary amines (mechanism), Reactions of aryl diazonium salts, Sandmeyer and Gattermann reactions, Gomberg reaction, Replacement of diazo group by -H, -OH, -CN, Azo-coupling reaction with phenols/naphthols and aromatic amines, Reduction of diazonium salt to aryl hydrazine. Formation of azo- and hydrazo benzenes.

4.3: Aromatic Aldehydes and Ketones **4 L**

4.3.1: Preparation of aromatic aldehydes: Preparation using CO (Gattermann- Koch reaction), HCN (Gattermann reaction), DMF/$POCl_3$ (VilsmeierHaack reaction), Reimer-Tiemann reaction. Oxidation of methylarenes, Rosenmund reduction.

4.3.2: Preparation of aromatic ketones: Friedel-Crafts acylation using acid chloride and acid anhydride.

4.3.3: General reactions: Reactions with – Ammonia and amines, hydroxylamine, phenyl hydrazine, hydrogen cyanide, sodium bisulphite.

4.3.4: Reactions: Knoevenagel reaction, Claisen-Schmidt reaction, Benzoin reaction, Cannizzaroreaction(mechanism).

4.3.5: Applications of aromatic aldehydes and ketones.

Module V
Aromatic acids

- **Learning**

Objective:

Students will study the general structure, nomenclature, chemical reactions and applications of carboxylic acids, aryl sulphonic acid, epoxides. And structure determination and multistep synthesis.

- ***Learning Outcomes***:

Students will understand that carboxylic acids, sulphonic acids and epoxide can be the precursor for many reactions which can be used in various industries.

Structure determination and multistep synthesis will increase their curiosity in chemistry.

5.1 Aromatic carboxylic acids 3 L

5.1.1: Preparation of mono- and di-carboxylic acids: Preparation by – side chain oxidation of alkyl benzenes, reaction of Grignard reagents with solid carbon dioxide, Hydrolysis of aryl nitriles, Kolbe-Schmidt reaction (mechanism).

5.1.2: Reactions of aromatic carboxylic acids: Acidity, Effect of substituent on the acidity of benzoic acid, Acid catalyzed esterification, esterification by alkylation, Conversion to acid chloride, amide and anhydride. Reduction and decarboxylation.

5.1.3: Applications of aromatic carboxylic acids.

5.2: Aromatic sulfonic acids 3 L

5.2.1: Preparation of aromatic sulfonic acids: Commonly used sulfonating agents. Sulfonation of benzene (with mechanism) and naphthalene.

5.2.2: Reactions: Acidity of arene sulfonic acids. Comparative acidity of carboxylic acids and sulfonic acids, salt formation, desulfonation.

5.2.3: Uses of – pTSA and sulfonated polystyrene.

5.2.4: Aromatic chlorosulfonyl compounds: Aromatic chlorosulfonation using chlorosulfonic acid. Reaction of aryl sulfonyl chlorides with water, ammonia and amines.

5.3 Epoxides 2 L

5.3.1: Preparation: Oxidation of olefins – ethylene oxide; Reaction of per acids with olefins; from vicinal halohydrins.

5.3.2: Reactions: Reactivity. Ring opening reactions by nucleophiles (a) In acidic conditions; hydrolysis, reaction with – HX, alcohol, HCN. (b) In neutral or basic conditions: ammonia,

amines, metal cyanides, Grignard reagents, alkoxides.

5.3.3: Applications of epoxides (including chiral epoxides).

5.4 Structure determination and multistep synthesis 4 L

5.4: Structure Determination and Multistep Synthesis

5.4.1: Structure determination through a series of reactions.

5.4.2: Planning multistep synthesis of polysubstituted benzenes.

Module VI

Green Chemistry

- **Learning Objective:**

Student will study the basic concept of green chemistry, newer methods of Synthesis and environmental aspects. Understand core concepts and methods from ecological and physical sciences and their application in environmental problem-solving.

- **Learning Outcomes:**

Students can understand the basic principles of green and sustainable chemistry and the renewable feedstock for the chemical industry, present and under development. The environmental studies prepares students for careers as leaders in understanding and addressing complex environmental issues from a problem-oriented, interdisciplinary perspective.

6.1 Basic Principles 5L

Definition, Need, importance, twelve principles of Green Chemistry with relevant examples), Concepts and simple calculations on yield and selectivity, E-factor, atom economy.

Examples of Green Chemistry in Industry

a) Green reactions- halide free synthesis of aromatic amines.
b) Green chemistry and catalysis- Novel homogenous, heterogeneous and enzymatic catalysts in industry.
    i) Catalytic liquid phase selective hydrogenation of nitrobenzene to p-amino phenol
    ii) Liquid phase air oxidation of p-cresol to p-hydroxybenzaldehyde

6.2 Newer Methods of Synthesis 3 L

6.2.1. The use of Phase Transfer Catalysis and Polymer Support

6.2.2. Synthesis using microwave and ultrasound.

Module VI

6.1 **Nanochemistry-an emerging Science**

· Learning Objective:

To provide a broad overview of fundamental principles, different types of nanomaterials, methods of preparation, and applications of nanomaterials.

· Learning Outcomes:

The learners will be equipped with the knowledge and skills necessary to understand and harness the potential of nanomaterials in future advanced manufacturing, ICT, chemical, bio pharma, medical device (diagnostics, drug delivery, and therapeutics) and other industries with a view to future employment and research in these sectors.

6.1.1 Introduction -, Basics - distinction between molecules, Nanoparticles and bulk materials; nanoparticles: nano cluster, nano rod, nanotube(CNT) and nanowire. 3L

6.1.2 Methods of preparation- Top to bottom approach and bottom to top approaches for synthesis 3L
precipitation, thermolysis, hydrothermal, solvothermal, electrodeposition, chemical vapour deposition, laser ablation;

6.1.3 Properties – Electrical properties, optical properties, surface properties, 2L

6.1.4 Typical characterization techniques- SEM. TEM, AFM 2L

6.1.5 Applications- Medicinal and Environmental 2L

SEMESTER III

Practicals: 3 credits

Course Code: 19USCH3P

Experiments	No. of Credits
Physical Chemistry	1
Inorganic Preparation + Inorganic Qualitative analysis	1
Organic derivative + Organic estimation	1

SEMESTER IV

Practicals: 3 credits

Course Code: 19USCH4P

Experiments	No. of Credits
Physical Chemistry	1
Gravimetric Analysis + Volumetric Analysis	1
Organic Spotting	1