College of Arts, Science & Commerce (Autonomous)

SIES

RISE WITH EDUCATION

Sion (West), Mumbai – 400022.

Department of Chemistry

Program: B.Sc.

Course: Chemistry

Syllabus for S.Y.B.Sc. Semester III & IV

(Implemented from 2022 – 2023)

Credit Based Semester and Grading System

SEMESTER – III

Contents:		
Paper I	:	**General Chemistry**
SIUSCHE31.1	:	Chemical Thermodynamics – II, Electrochemistry
SIUSCHE31.2	:	Chemical Bonding
SIUSCHE31.3	:	Reactions and reactivity of halogenated hydrocarbons, alcohols, phenols and epoxides
Paper II	:	**General Chemistry**
SIUSCHE32.1	:	Chemical Kinetics – II, Solutions
SIUSCHE32.2	:	Selected topics on p block elements
SIUSCHE32.3	:	Aldehydes, ketones and active methylene compounds
Paper III	:	**Elective (Basics of Analytical Chemistry)**
SIUSCHE33.1	:	Introduction to Analytical Chemistry and Statistical Treatment of analytical data – I
SIUSCHE33.2	:	Classical Methods of Analysis
SIUSCHE33.3	:	Instrumental Methods – I
Practical		
SIUSCHE3P1	:	Chemistry Practical
SIUSCHE3P2	:	Chemistry Practical
SIUSCHE3P3	:	Chemistry Practical

SEMESTER – IV

Contents:		
Paper I	:	**General Chemistry**
SIUSCHE41.1	:	Electrochemistry – II , Phase equilibria
SIUSCHE41.2	:	Comparative chemistry of the transition metals, Coordination chemistry
SIUSCHE41.3	:	Carboxylic Acids and their Derivatives, sulphonic acids
Paper II	:	**General Chemistry**
SIUSCHE42.1	:	Solid State, Catalysis
SIUSCHE42.2	:	Ions in aqueous medium, Uses and Environmental Chemistry of Oxo-acids
SIUSCHE42.3	:	Nitrogen containing compounds, heterocyclic compounds and Stereochemistry.
Paper III	:	**Elective (Basics of Analytical Chemistry)**
SIUSCHE43.1	:	Separation Techniques in Analytical Chemistry
SIUSCHE43.2	:	Instrumental Methods – II
SIUSCHE43.3	:	Statistical treatment of analytical data – II
Practical		
SIUSCHE4P1	:	Chemistry Practical
SIUSCHE4P2	:	Chemistry Practical
SIUSCHE4P3	:	Chemistry Practical

S.Y.B.Sc. Chemistry Syllabus

SEMESTER III

Course Code	Unit	Topics	Credits	L/Week
SIUSCHE31	1	**Chemical Thermodynamics – II, Electrochemistry**	2	1
		1.1 Chemical Thermodynamics – II		
		1.2 Electrochemistry		
	2	**Chemical Bonding**		1
		2.1 Non-Directional Bonding		
		2.2 Directional Bonding: Orbital Approach		
		2.3 Molecular Orbital Theory		
	3	**Reactions and reactivity of halogenated hydrocarbons, alcohols, phenols and epoxides**		1
		3.1 Reactions and reactivity of halogenated hydrocarbons		
		3.2 Alcohols, phenols and epoxides		
SIUSCHE32	1	**Chemical Kinetics – II, Solutions**	2	1
		1.1 Chemical Kinetics		
		1.2 Liquid state		
	2	**Selected topics on p block elements**		
		2.1 Comparative Chemistry of Main Group Elements		
	3	**Aldehydes, ketones and active methylene compounds**		
SIUSCHE33	1	**Introduction to Analytical Chemistry and Statistical Treatment of analytical data – I**	2	1
		1.1 Role of Analytical Chemistry		
		1.2 Significance of Sampling in Analytical Chemistry		
		1.3 Results of Analysis		
	2	**Classical Methods of Analysis**		
		2.1 Titrimetric Methods		

		2.2 Standard solutions (Primary and Secondary standards in Titrimetry) and Calculations in Titrimetry		**1**
		2.3 Neutralisation Titrations		
		2.4 Gravimetric analysis		
	3	**Instrumental Methods – I**		**1**
		3.1 General Introduction to analytical Chemistry		
		3.2 Types of Analytical Instrumental methods		
		3.3 Spectrometry		
SIUSCHE3P1	**1**	**Chemistry Practical**	**1**	**3**
SIUSCHE3P2	**1**	**Chemistry Practical**	**1**	**3**
SIUSCHE3P3	**1**	**Chemistry Practical**	**1**	**3**

Course Code: SIUSCHE31

Paper I

Credits: 2 Credits (45 Lectures)

Unit – 1, 1L/Week		15L
Course Code: SIUSCHE31.1 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain the concept of thermodynamics with respect to first law of thermodynamics.* 2. *Describe the comprehend thermo-chemistry with respect to heats of various reactions, bond energy, bond dissociation and resonance energy.* 3. *Discuss the conductivity phenomenon for electrolytes.* 4. *Classify applications of conductance measurements.* 5. *Outline the concept of transference number and factors affecting it.*		
1 Chemical Thermodynamics – II, Electrochemistry		**15 L**
1.1	**Chemical Thermodynamics – II:** 1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's free energy with Pressure and Temperature, Gibbs-Helmholtz equation. 1.1.2 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation. 1.1.3 Concept of Fugacity and Activity 1.1.4 Van't Hoff reaction isotherm and van't Hoff reaction isochore. (Numericals expected)	**8 L**
1.2	**Electrochemistry:** 1.2.1 Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. 1.2.2 Kohlrausch law of independent migration of ions. 1.2.3 Debye – Huckel theory of strong electrolytes – Relaxation or a symmetry effect, Electrophoretic effect. 1.2.4 Applications of conductance measurements: determination of degree of ionization and ionization constant of weak electrolyte, solubility and solubility product of sparingly soluble salts (Numerical expected). 1.2.5 Transference number and its experimental determination using Moving boundary method. (Numericals expected). Factors affecting transference number.	**7 L**

Unit – 2, 1L/Week		15L
Course Code: SIUSCHE31.2 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Describe ionic molecules and their crystal structure on the basis if radius ratio rule.* 2. *Explain covalent molecules in details with respect to Valence Bond Theory and Molecular Orbital Theory.*		
2 Chemical Bonding		**15 L**
2.1	**Non-Directional Bonding (Ionic Bonding)** 2.1.1 Recapitulation of Ionic Bond 2.1.2 Types of Ionic Crystals 2.1.3 Radius Ratio Rules.	**2 L**
2.2	**Directional Bonding: Orbital Approach (Covalent Bonding)** 2.2.1 Covalent Bonding: The Valence Bond Theory- Introduction and basic tenets. 2.2.2 Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system. 2.2.3 Resonance and the concept of Formal Charge, Rules for Resonance or Canonical structures. 2.2.4 Bonding in Polyatomic Species: The role of Hybridization and types of hybrid orbitals-*sp, sp^2, sp^3, sp^3d, sp^2d^2, sp^2d and sp^3d^2*. 2.2.5 Equivalent and Non-Equivalent hybrid orbitals. 2.2.6 Contribution of a given atomic orbital to the hybrid orbitals (with reference to sp^3 hybridisation as in CH_4, NH_3 and H_2O and series like NH_3, PH_3, AsH_3, BiH_3).	**8 L**
2.3	**Molecular Orbital Theory** 2.3.1 Comparing Atomic Orbitals and Molecular Orbitals. 2.3.2 Linear combination of atomic orbitals to give molecular orbitals LCAO-MO approach for diatomic homonuclear molecules). 2.3.3 Homo-nuclear diatomic molecules: H_2, He_2, Li_2, Be_2, C_2, N_2, O_2, F_2 and Ne_2. 2.3.4 Wave mechanical treatment for molecular orbitals (H_2^+, and H_2 ,) Molecular orbital Theory and Bond Order and magnetic property: with reference to O_2, O_2^+, O_2^-, O_2^{2-}. (Problems and numerical problems expected wherever possible)	**5 L**
Unit – 3, 1L/Week		**15 L**

Course Code: SIUSCHE31.3 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain different types of nucleophilic substitution reactions.* 2. *Discuss the kinetics, mechanism & stereochemistry of these reactions.* 3. *Describe the nomenclature, synthesis, chemical reactions and uses of alcohols, phenols and epoxides.* 4. *Justify comparative acidic strengths of alcohols and phenols.* 5. *Predict the conversion of one functional group into other.* 6. *Discuss M-C bond nature and reactivity order of organometallic compounds.* 7. *Explain the synthesis, importance organometallic compounds.*		
3 Reactions and reactivity of halogenated hydrocarbons, alcohols, phenols and epoxides		**15L**
3.1	**Reactions and reactivity of halogenated hydrocarbons:** **3.1.1 Alkyl halides:** Nucleophilic substitution reactions: S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and factors affecting nucleophilic substitution reactions-nature of substrate, solvent, nucleophilic reagent and leaving group. **3.1.2 Aryl halides:** Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution (S_NAr) addition-elimination mechanism and benzyne mechanism.	**6L**
3.2	**Alcohols and phenols:** **3.2.1 Alcohols:** Nomenclature, Preparation: Hydration of alkenes, hydrolysis of alkyl halides, reduction of aldehydes and ketones using Grignard reagent. Properties: Hydrogen bonding, types and effect of hydrogen bonding on different properties. Acidity of alcohols, Reactions of alcohols **3.2.2 Phenols: Pr**eparation, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols.	**6L**
3.3	**Organomagnesium and organolithium compounds:** Nomenclature, nature, type and reactivity of carbon-metal bond. Preparation using alkyl / aryl halide. Structure, stability and reactions with compounds containing acidic hydrogen, carbonyl compounds, CO_2, amides, esters, cyanides and epoxides.	**3L**

Course Code: SIUSCHE32

Paper II

Credits: 2 Credits (45 Lectures)

Unit – 1, 1L/Week	**15L**

Course Code: SIUSCHE32.1 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain the rate of a chemical reaction, factors affecting it and its mechanism.* 2. *Discuss the concept of order and molecularity of a reaction and their determination.* 3. *Describe the physical properties of liquids such as surface tension, viscosity and refractive index.* 4. *Discuss the Liquid crystals: classification, properties and their applications.*		
1 Chemical Kinetics – II, Solutions.		**15 L**
1.1	**Chemical Kinetics-II.** 1.1.1 Types of Complex Chemical reactions: Reversible or opposing, consecutive and parallel reactions (No derivations, only examples expected), Thermal chain reactions: H and Br reaction. (Only steps involved, no kinetic expression expected). 1.1.2 Effect of temperature on the rate of reaction, Arrhenius equation, Concept of energy of activation (E_a). (Numericals expected). 1.1.3 Theories of reaction rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories (Qualitative treatment only)	**7 L**
1.2	**Solutions:** 1.2.1 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. Distillation of solutions, Lever rule, Azeotropes. 1.2.2 Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids with respect to Phenol-Water, Triethylamine – Water and Nicotine – Water systems. 1.2.3 Immiscibility of liquids- Principle of steam distillation. 1.2.4 Solution of gases in liquids: Henry's law (Numerical expected).	**8 L**
Unit – 2, 1L/Week		**15L**
Course Code: SIUSCHE32.2 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain the properties and structure of boron compounds, discuss their electron deficient nature of compounds like BH_3, BF_3 and BCl_3.* 2. *Describe the structure, bonding in diborane and tetraborane.* 3. *Explain the semiconducting properties, reaction, preparation of Silicon and Germanium.* 4. *Discuss trends, reactivity and preparation of compounds of nitrogen.*		

2 Selected topics on p block elements:		**15L**
2.1	**Chemistry of Boron compounds:** 2.1.1 Inert pair effect with respect to group 13 elements and stability of oxidation state. 2.1.2 Electron deficient compounds – BH_3, BF_3, BCl_3 and BBr_3 with respect to Lewis acidity and applications. 2.1.3 Preparation of simple boranes like diborane and tetraborane. 2.1.4 Structure and bonding in diborane and tetraborane (2e-3c bonds). 2.1.5 Synthesis of Borax.	**6L**
2.2	**Chemistry of Silicon and Germanium:** 2.2.1 Silicon compounds: Occurrence, structure and inertness of SiO_2. 2.2.2 Preparation of structure of $SiCl_4$. 2.2.3 Occurrence and extraction of Germanium. 2.2.4 Preparation of extra pure Silicon (Zone refining) and Germanium (Czochralski's pulling technique).	**5 L**
2.3	**Chemistry of Nitrogen:** 2.3.1 Trends in chemical reactivity - Formation of hydrides, halides, oxides with special reference to oxides of nitrogen. 2.3.2 Oxides of nitrogen with respect to preparation and structure of NO, NO_2, N_2O, N_2O_4 and N_2O_5. 2.3.3 Synthesis of ammonia by Bosch – Haber process.	**4 L**
Unit – 3, 1L/Week		**15 L**
Course Code: SIUSCHE32.3 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain the trivial and IUPAC names of carbonyl compounds.* 2. *Analyze the structure and study reactivity of carbonyl compounds.* 3. *Explain the use of different reagent in preparation and reactions of aldehydes and ketones.* 4. *Discuss the selected name reactions and active methylene compounds reactions with their reaction mechanism.*		
3 Aldehydes, Ketones and active methylene Compounds:		**15 L**
3.1	**Aldehydes, ketones and active methylene Compounds:** 3.1.1 Nomenclature of aliphatic, alicyclic and aromatic carbonyl compounds. Structure, reactivity of aldehydes and ketones and methods of preparation; Oxidation of primary and secondary alcohols using PCC, hydration of alkynes, action of Grignard reagent on esters, Rosenmund reduction, Gattermann – Koch formylation and Friedel Craft acylation of arenes. 3.1.2 General mechanism of nucleophilic addition and acid catalyzed nucleophilic addition	**15 L**

	reactions. 3.1.3 Reactions of aldehydes and ketones with $NaHSO_3$, HCN, RMgX, alcohol, amine, phenyl hydrazine, 2, 4-Dinitrophenyl hydrazine, $LiAlH_4$ and $NaBH_4$. 3.1.4 Mechanisms of following reactions: Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Cannizzaro reaction, Perkin reaction, Wittig reaction and Aldol condensation reaction. 3.1.5 Keto-enol tautomerism: Mechanism of acid and base catalysed enolization. 3.1.6 Acidity of methylene hydrogens, Methods of formation: ethylacetoacetate. Active methylene compounds: Acetylacetone, ethyl acetoacetate, diethyl malonate, stabilised enols. Reactions of Acetylacetone and ethyl acetoacetate (alkylation, conversion to ketone, mono- and dicarboxylic acid).	

Course Code: SIUSCHE33

Paper III (Elective)

Credits: 2 Credits (45 Lectures)

Unit – 1, 1L/Week		**15L**
Course Code: SIUSCHE33.1 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain method of analysis.* 2. *Discuss sample preparation for analysis.* 3. *Describe procedure for analysis* 4. *Identify sources of possible errors in the results obtained.*		
(Problems including numerical expected wherever necessary)		
1 Introduction to Analytical Chemistry and Statistical Treatment of analytical data – I		**15 L**
1.1	**Role of Analytical Chemistry:** 1.1.1 Language of analytical chemistry: important terms and their significance in Analytical Chemistry. 1.1.2 Purpose of Chemical Analysis; Analysis Based (i) On the nature of information required: (Proximate, Partial, Trace, Complete Analysis) and (ii) On the size of the sample used (Macro, semi-micro and micro analysis) 1.1.3 Classical and Non-Classical Methods of Analysis; their types and importance.	**3 L**
1.2	**Significance of Sampling in Analytical Chemistry:** Terms involved in Sampling, Types of Sampling, Sampling techniques 1.3.1 Purpose, significance and difficulties encountered in sampling. 1.3.2 Sampling of solids: Sample size – bulk ratio, size to weight ratio, multistage and sequential sampling, size reduction methods, sampling of compact solids, equipment and methods of sampling of compact solids, sampling of particulate	**8 L**

	solids, methods and equipment used for sampling of particulate solids. 1.3.3 Sampling of liquids: Homogeneous and heterogeneous, Static and flowing liquids. 1.3.4 Sampling of gases: Ambient and stack sampling: Apparatus and methods for sampling of gases. 1.3.5 Collection and preservation of the sample.	
1.3	**Results of Analysis:** 1.3.1 Errors in Analysis and their types 1.3.2 Precision and Accuracy in Analysis 1.3.3 Corrections for Determinate Errors *(Problems including Numerical expected wherever required)*	**4 L**
Unit – 2, 1L/Week		**15L**
Course Code: SIUSCHE33.2 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Investigate classical methods of chemical analysis by titrimetric and gravimetric method.* 2. *Explain the various types of titrimetric method and role of indicators in these titrations.* 3. *Explain gravimetric analysis and their types.* 4. *Discuss various parameters involved during gravimetric precipitation analysis.*		
2 Classical Methods of Analysis		**15 L**
2.1	**Titrimetric Methods:** 2.1.1 Recapitulation: Terms involved in Titrimetric methods of analysis. Comparing volumetry and titrimetry. 2.1.2 Conditions suitable for titrimetry. 2.1.3 Types of titrimetry – Neutralisation (Acidimetry, alkalimetry), Redox, (Iodometry, Iodimetry,) Precipitation and Complexometric titrations and indicators used in these titrations. Tools of Titrimetry: Graduated glasswares and Callibration.	**3L**
2.2	2.2.1 **Standard solutions** (Primary and Secondary standards in Titrimetry) and Calculations in Titrimetry.	**1 L**
2.3	**Neutralization Titrations:** 2.3.1 Concept of pH and its importance in Neutralisation Titrations 2.3.2 End point and Equivalence point of Neutralisation titrations 2.3.3 Determination of End point by using i. Indicators causing colour change ii. Change in potential (by potentiometry)	**5 L**

	iii. Change in conductance (by conductometry) 2.3.4 Construction of titration curve (on the basis of change in pH) of a titration of i) Strong acid-weak base ii) Strong base-weak acid	
2.4	**Gravimetric analysis:** 2.4.1 General Introduction to Gravimetry. 2.4.2 Types of Gravimetric Methods. 2.4.3 Precipitation Gravimetry: i. Steps involved in precipitation gravimetry analysis ii. Conditions for precipitation iii. Completion of precipitation, iv. Role of Digestion, Filtration, Washing, Drying and Ignition of precipitate. v. Applications of Gravimetric Analysis: Determination of sulfur in organic compounds; Estimation of Nickel in Cu-Ni alloy using dimethyl glyoxime. Determination of Aluminum as its oxinate.	**6 L**
Unit – 3, 1L/Week		**15 L**
Course Code: SIUSCHE33.3 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Discuss he various instrumental methods of analysis.* 2. *Explain advantages and applications of different analytical tools according to analyte.* 3. *Identify a suitable instrumental method for analysis.* 4. *Describe suitable method for photometric titrations.*		
3 Basic concepts in instrumental methods		**15 L**
3.1	**General introduction to analytical Chemistry:** 3.1.1 Relation between the analyte, stimulus and measurement of change in the observable property 3.1.2 Block Diagram of an analytical instrument.	**1 L**
3.2	**Types of analytical instrumental methods based on** 3.2.1 Optical interactions (eg. spectrometry: UV-Visible, polarimetry) 3.2.2 Electrochemical interactions (eg. potentiometry, conductometry) 3.2.3 Thermal interactions (eg. thermogravimetry)	**2 L**
3.3	**Spectroscopy:** 3.3.1 Interaction of electromagnetic radiation with matter: Absorption and emission	**12 L**

	spectroscopy. 3.3.2 Basic Terms: Radiant Power, absorbance, transmittance, monochromatic light, polychromatic light, wavelength of maximum absorbance, absorptivity and Molar Absorptivity. 3.3.3 Statement of Beer's Law and Lambert's law, combined mathematical expression of Beer-Lambert's law, validity of Beer-Lambert's law, deviations from Beer-Lambert's law (real deviations, instrumental deviations and chemical deviations) (numerical problems based on Beer-Lambert's law) 3.3.4 Instrumentation for absorption spectroscopy: Colorimeters and Spectrophotometers 3.3.5 Block diagrams for single beam and double beam colorimeter and single beam spectrophotometer (Principles, construction and working-details of components expected i.e. source, sample holder, filters/monochromators, detectors such as photomultiplier tube) 3.3.6 Applications of UV-Visible spectrophotometry. i) Qualitative analysis like identification of functional groups in organic Compounds, chromophores and auxochromes, c*is* and *trans* isomers ii) Quantitative analysis by calibration curve method. 3.3.7 Photometric titrations: Principle, instrumentation, types of photometric titration curves with examples.	

Suggested References for SIUSCHE31.1 & SIUSCHE32.1

1. A text book of Physical Chemistry by K. L. Kapoor.
2. Essentials of Physical Chemistry by B.S. Bahl, Arul Bahl and G.D. Tuli.
3. Chemical Kinetics by Keith J. Laidler
4. Principles of Physical Chemistry by Maron and Pruton.
5. Chemical Thermodynamics by I.M.Klotz

Suggested References for SIUSCHE31.2 & SIUSCHE32.2

1. J. Barrett and A. Malati, 'Fundamentals of Inorganic Chemistry', East-West Press Edition(2006)
2. C.M. Day and Joel Selbin, 'Theoretical Inorganic Chemistry', Affiliated East West Press Pvt. Ltd., (1985).
3. J.D. Lee, Concise 'Inorganic Chemistry', 5th edition, Blackwell Science Ltd., (2005).
4. James E. Huheey, 'Inorganic Chemistry', 3rd edition, Harper & Row, Publishers, Asia, Pte Ltd., (1983).
5. R. J. Gillespie and I. Hargittai, The VSEPR Model of Molecular Geometry, Dover Publication, (2012).
6. J. Barrett, 'Inorganic Chemistry in Aqueous Solutions'; The Royal Society of Chemistry (2003).
7. T. Moeller and R. O'Connor, 'Ions in Aqueous Systems'; McGraw-Hill Book Company, (1972).
8. Gary L. Miessler Donald A. Tarr, St. Olaf College, Northfield, Minnesota. Pearson Prentice Hall

9. Inorganic Chemistry, Catherine E. Housecroft and Alan G. Sharpe. Pearson Prentice Hall.

Suggested References for SIUSCHE31.3 & SIUSCHE32.3

1. Organic Chemistry: S. H. Pine McGraw Hill. Kogakusha Ltd.
2. Organic Chemistry : John Mc Murry 5th Edition Cornell University
3. Advance Organic Chemistry: Jerry March, Wiley Eastern Ltd.
4. A guide to IUPAC Nomenclature of Organic Compound,: Richer Interscience Publications
5. Organic Chemistry : T. W. G. Solomons, C. B. Fryhle, 2000 John Wiley and Sons
6. Organic Chemistry: Morrison and Boyd, Allyn& Bacon Inc.
7. Organic Chemistry: Francis A. Carey, 1996 3rd Ed. McGraw Hill
8. Fundamentals of Organic Chemistry: G. Mare Loudon, 2002 4th Edition.
9. Reaction Mechanism: Peter Sykes, 1999 Orient Longman
10. Organic Chemistry: Seyhan N. Ege, 1984. D. C. Heath & Co.
11. Organic Reactions with Mechanism: S. P. Bhutani, Ane book Pvt. Ltd.
12. Stereochemistry of Organic Compound: E. L. Eliel and S.H. Wilen, Wiley.
13. Stereochemistry: V. M. Potapov, Mir Publishers, Moscow.
14. Stereochemistry Conformation and Mechanism: P.S. Kalsi, Wiley Eastern Ltd.
15. Stereochemistry of Organic Compound: Principles and Applications: D. Nasipuri, Wiley Eastern Ltd.
16. Stereochemistry and Mechanism: David Whittaker, Oxford Chem. Series.
17. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2012.
18. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.

Suggested References for SIUSCHE33.1

1. Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch
2. Instrumental methods of analysis by Willard, H.H.; Merritt, L.L. Jr, Dean, J.A.; Settle,7th Edition
3. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch
4. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education

Suggested References for SIUSCHE33.2

1. Skoog et al. “Fundamentals of Analytical chemistry" Cengage Learning, Eight Edition, chapter 13, 14 and 15.
2. Day and Underwood, “Quantitative analysis" prentice hall 1991, chapter 3.
3. S.M. Khopkar, “Basic Concepts of Analytical Chemistry”, IInd Edition New Age International Publisher.

4. Gary D. Christian," Analytical Chemistry", VIth Edition, Wiley Students Edition, Chapter No 8,9,10.
5. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch.
6. Modern Analytical Chemistry, David Harvey (page numbers 232 -265)

Suggested References for SIUSCHE33.3

1. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal, Sham K.Anand pp 2.107-2.148
2. Principles of Instrumental Analysis by Skoog, Holler, Nieman, 5th Edition pp 143-172.
3. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle 7th Edition pp 118-181.

Course Code: SIUSCHE3P

Paper I, II, III

Credits: 2 Credits (45 Lectures)

PRACTICAL COURSE CHEMISTRY LABORATORY:

Course Code: SIUSCHE3P	
Course Outcomes: Upon completion of this course, student will be able to 1. *Explain calibration of volumetric apparatus.* 2. Plan *to perform experiments that has specific aims with correct techniques.* 3. Discuss *skills of observation, recording and analyzing data.* 4. Explain *to present the experimental work in a systematic manner.*	
Unit	**Course Code: SIUSCHE3P1 and SIUSCHE3P2 (Paper – I and II)**
1	**Physical Chemistry** 1. To verify Ostwald's dilution law for weak acid conductometrically. 2. To determine dissociation constant of weak acid conductometrically. 3. To determine the critical solution temperature (CST) of Phenol - Water System. 4. Determination of energy of activation of acid catalyzed hydrolysis of methyl acetate. 5. To investigate the reaction between $K_2S_2O_8$ and KI with equal initial concentrations of the reactants. 6. To determine solubility of sparingly soluble salts (any two) conductometrically.
2	**Inorganic Chemistry** 1. Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions. Cations (from amongst): Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Fe^{3+}, Ni^{2+}, Mg^{2+}, Al^{3+}, Cr^{3+}, Co^{2+}, K^+, NH_4^+. Anions (From amongst): CO_3^{2-}, SO_3^{2-}, NO_2^-, NO_3^-, Cl^-, Br^-, I^-, SO_4^{2-}. (*Scheme of analysis should avoid use of sulphide ion in any form for precipitation / separation of cations.)* 2. Estimation of total hardness of water sample. 3. Determination of total salinity of water sample.
3	**Organic Chemistry**

	Short organic preparation and their purification: Use 0.5-1.0g of the organic compound. Purify the product by recrystallization. Report theoretical yield, percentage yield and melting point of the purified product. One step preparation of: 1. Cyclohexanone oxime from cyclohexanone. 2. 2-naphthol aniline dye. 3. Tribromoaniline from aniline. 4. *m*-Dinitrobenzene from nitrobenzene. 5. Dibenzalpropanone from Benzaldheyde and acetone. 6. *N*-acetylation of *p*-toluidine.
	Course Code: SIUSCHE3P3 (Paper – III) (Elective)
1	**Tools of Analytical Chemistry-I:** a) Analytical glass wares like burettes, pipettes, Standard flasks, Separating funnels. b) Weighing tools such as two pan balance and monopan balance, digital balances. c) Incineration devices: Burners, Electrical Incinerators, Muffle Furnace. d) Drying Devices: Hot Air Oven, Microwave Oven, Desiccators, Vacuum desiccators e) Monochromators, Filters, Sample holders, Prisms, Diffraction Gratings, Photoemissive cells, Photomultiplier tubes. (The learner should draw diagrams and write-ups providing uses, care and maintenance of the items mentioned in (a) and principle, construction and uses of items (b) to (e) in his/her journal)
2	1. Colorimetric Determination of Copper ions in given Solution by using calibration curve method and calculation of % error. 2. Determination of buffer capacity of acid buffer and basic buffer. 3. Estimation of Aspirin 4. Estimation of Benzoic acid 5. Gravimetric estimation of Nickel (II) as Ni-DMG and calculation of % error. OR 5. Gravimetric estimation of barium ions using K_2CrO_4 as precipitant and calculation of % error.

Suggested References for SIUSCHE3P1 and SIUSCHE3P2

1. Fundamental of Analytical Chemistry-Skoog D.A. and West D.M. Saunders, College Publication.
2. Quality in the Analytical Chemistry laboratory –Neil T. Crosby, Florence Elizabeth Prichard, Ernest J. Newman – John Wiley & Sons Ltd.
3. Principles and Practice of Analytical Chemistry-Fifield F.W. and Kealey D, Black well Science
4. Chemical Analysis in the laboratory –A Basic guide by Irene Muller-Harvey, Richard M. Baker, Royal Society of Chemistry
5. Textbook of Quantitative Inorganic Analysis -Vogel A.I.
6. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
7. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
8. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
9. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).
10. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
11. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
12. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
13. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
14. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
15. 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.

Suggested References for SIUSCHE3P3

1. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp. 345-381.
2. A.I. Vogel. “Textbook of Quantitative Inorganic Analysis,” Longman, London (1961).
3. R.V. Dilts. “Analytical Chemistry. Methods of Separation,” van Nostrand, N.Y. (1974).
4. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J.B.Baruah, Mrs. Abhilasha Mohan Baruah and Mr. Parikshit Gogoi

S.Y.B.Sc. Chemistry Syllabus

SEMESTER IV

Course Code	Unit	Topics	Credits	L/Week
SIUSCHE41	1	**Electrochemistry – II , Phase equilibria**	2	1
		1.1 Electrochemistry – II		
		1.2 Phase Equilibria		
	2	**Comparative chemistry of the transition metals and Coordination chemistry**		1
		2.1 Comparative chemistry of the transition metals		
		2.2 Coordination chemistry		
	3	**Carboxylic Acids and their Derivatives, sulphonic acids**		1
		3.1 Carboxylic Acids and their Derivatives		
		3.2 Sulphonic acids		
SIUSCHE42	1	**Solid State, Catalysis**	2	1
		1.1 Solid State		
		1.2 Catalysis		
	2	**Ions in aqueous medium, Uses and Environmental Chemistry of oxo-acids**		
		2.1 Ions in aqueous medium		
		2.2 Uses and Environmental Chemistry of oxo-acids		
	3	**Nitrogen containing compounds, heterocyclic compounds and Stereochemistry**		
		3.1 Amines		
		3.2 Diazonium salts		
		3.3 Heterocyclic compounds		
		3.4 Stereochemistry		
SIUSCHE43		**Separation Techniques in Analytical Chemistry**		

	1	1.1 An Introduction to Analytical Separations and its importance in analysis.	**2**	**1**
		1.2 Estimation of an analyte without effecting separation.		
		1.3 Types of separation methods.		
		1.4 Electrophoresis		
		1.5 Solvent extraction		
		1.6 Chromatography		
	2	**Instrumental Methods – II**		**1**
		2.1 Potentiometry		
		2.2 pH metry		
		2.3 Conductometry		
	3	**Statistical Treatment of analytical data – II**		**1**
		3.1 Nature of Indeterminate Errors.		
		3.2 Distribution of random errors		
		3.3 Concept of Confidence limits and confidence interval and its computation		
		3.4 Criteria for rejection of doubtful result		
		3.5 Test of Significance		
		3.6 Graphical representation of data and obtaining best fitting straight line		
SIUSCHE4P1	**1**	**Chemistry Practical**	**1**	**3**
SIUSCHE4P2	**1**	**Chemistry Practical**	**1**	**3**
SIUSCHE4P3	**1**	**Chemistry Practical (Elective)**	**1**	**3**

Course Code: SIUSCHE41

Paper I

Credits: 2 Credits (45 Lectures)

Unit – 1, 1L/Week		15L
Course Code: SIUSCHE41.1 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain the concept of reversible and irreversible cell, electrochemical series.* 2. *Find out the different thermodynamic properties and calculation of equilibrium constant.* 3. *Explain Gibbs phase rule and its thermodynamic derivation.* 4. *Predict phase diagrams of one component system and two component systems.*		
1 Electrochemistry – II and Phase equilibria		**15 L**
1.1	**Electrochemistry-II:** 1.1.1 Recapitulation: Electrochemical conventions, Reversible and irreversible cells. 1.1.2 Secondary calomel electrode, glass electrode. 1.1.3 Nernst equation and its importance, Types of electrodes, Standard electrode potential, Electrochemical series (Numericals expected). 1.1.4 Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. (Numericals expected) 1.1.5 Calculation of equilibrium constant from EMF data. (Numericals expected) 1.1.6 Concentration cells with transference and without transference. Liquid junction potential and salt bridge. 1.1.7 pH determination using hydrogen electrode and quinhydrone electrode. (Numericals expected)	**8 L**
1.2	**Phase Equilibria:** 1.2.1 Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. 1.2.2 Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. (Numericals expected) 1.2.3 Phase diagrams of one-component systems (water and sulphur). 1.2.4 Two component systems involving eutectic system (lead-silver system).	**7 L**

Unit – 2, 1L/Week		15L
Course Code: SIUSCHE41.2 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Discuss the basic concepts of transition elements, position in periodic table and their properties.* 2. *Explain the oxide and chloride chemistry for Titanium and Vanadium.* 3. *Describe qualitative detection of selected transition metal ions.* 4. *Explain the role of transition elements as coordination compounds.* 5. *Discuss theories of coordination compounds and with application.* 6. *Explain Werner's theory, Effective atomic number rule, Eighteen electron rule and Valence Bond theory.*		
2 Comparative chemistry of the transition metals and Coordination chemistry		**15 L**
2.1	**Comparative Chemistry of the transition metals:** **2.1.1** Position in the periodic table; Natural occurrence principle ores and minerals; **2.1.2** Significance of special stability of d^0, d^5 and d^{10} leading to variable oxidation states, unusual oxidation states and their stabilities in aqueous solutions (with special reference to vanadium and chromium.) **2.1.3** Origin of colour for transition metals and their compounds: such as reflectivity, surface coatings, particle size, packing density for metals and nature of d-orbitals, number of electrons in the d-orbitals, geometry and ability for charge transfer. **2.1.4** Magnetic properties of transition metal compounds: Origin of magnetism-spin and orbital motion of electrons, equation for spin only and spin-orbital magnetism in terms of Bohr magneton (No derivation of relevant equations expected), reasons for quenching of orbital moments. **2.1.5** Chemistry of Titanium and Vanadium: properties of oxides and chlorides, use in titrimetric analysis	**8 L**
2.2	**Coordination Chemistry:** **2.2.1 Introduction to Chemistry of Coordination Compounds** i. Historical perspectives: Early ideas on coordination compounds ii. Basic terms and nomenclature. iii. Types of ligands iv. Isomerism: General Types with special reference to stereoisomerism of coordination compounds (Coordination number = 6) v. Evidence for the formation of coordination compounds. **2.2.2 Theories of coordination compounds** i. Werner's Theory of coordination compounds.	**7 L**

	ii. Effective atomic number rule. iii. Eighteen electron rule. **2.2.3 Nature of the Metal-Ligand Bond:** i. Valence Bond Theory; Hybridization of the central metal orbitals-sp^3, sd^3/d^3s, sp^3d^2/d^2sp^3, sp^2d. ii. Inner and outer orbital complexes (suitable examples of Mn(II), Fe(II), Fe(III), Co(II)/Co(III), Ni(II), Cu(II), Zn(II) complexes with ligands like aqua, ammonia CN^- and halides may be used) iii. Limitations of V.B.T **2.2.4 Application of coordination compounds**	
Unit – 3, 1L/Week		**15 L**
Course Code: SIUSCHE41.3 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Discuss the method of naming carboxylic acids and sulphonic acids.* 2. *Explain the basic properties of carboxylic acids and sulphonic acids.* 3. *Describe the various methods of preparation of carboxylic acids and sulphonic acids.* 4. *Predict the comparative acidity of carboxylic acid and sulfonic acids.* 5. *Explain the mechanism of various reactions of carboxylic acid and sulfonic acids.* 6. *Discuss the term arenium ion and ipso substitution.*		
3 Carboxylic acids and their derivatives, sulphonic acids.		**15 L**
3.1	**Carboxylic acids and their derivatives :** **3.1.1.** Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids. **3.1.2** Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard reagent and hydrolysis of nitriles. **3.1.3** Reactions: Acidity, salt formation, decarboxylation, reduction of carboxylic acids with $LiAlH_4$, diborane, Hell-Volhard-Zelinsky reaction, conversion of carboxylic acid to acid derivatives and their relative reactivity. **3.1.4** Mechanism of nucleophilic acyl substitution and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution. **3.1.5** Mechanism of Claisen condensation and Dieckmann condensation. **3.1.6** Preparation and properties of dicarboxylic acid.	**9L**
3.2	**Sulphonic acids:** Nomenclature, preparation of aromatic sulphonic acids by sulphonation of benzene (with mechanism), toluene and naphthalene, Reactions: Acidity of arene sulfonic acid,	**3L**

	Comparative acidity of carboxylic acid and sulfonic acids. Salt formation, desulphonation. Reaction with alcohol, phosphorus pentachloride, IPSO substitution.	
3.3	**Epoxides:** Nomenclature, methods of preparation and reactions of epoxides: reactivity, ring opening reactions by nucleophiles (a) In acidic conditions: hydrolysis, reaction with halogen halide, alcohol, hydrogen cyanide. (b) In neutral or basic conditions: ammonia, amines, Grignard reagents, alkoxides.	**3L**

Course Code: SIUSCHE42

Paper II

Credits: 2 Credits (45 Lectures)

Unit – 1, 1L/Week		**15L**
Course Code: SIUSCHE42.1 **Course Outcomes:** Upon completion of this course, student will be able to 1. *Discuss the laws of crystallography and types of crystals.* 2. *Explain the characteristics of SC, BCC and FCC crystal lattice, Bragg's equation, X-ray diffraction method.* 3. *Describe the catalytic reaction mechanism of acid-base reactions, kinetics of enzyme catalysed reactions.*		
1 Solid State, Catalysis		**15 L**
1.1	**Solid State:** 1.1.1 Recapitulation of laws of crystallography and types of crystals. 1.1.2 Characteristics of simple cubic, face centered cubic and body centered cubic systems, interplanar distance in cubic lattice (only expression for ratio of interplanar distances are expected) 1.1.3 Use of X-rays in the study of crystal structure, Bragg's equation (derivation expected), X-rays diffraction method of studying crystal lattice structure, structure of NaCl and KCl. Determination of Avogadro's number (Numericals expected).	**7 L**
1.2	**Catalysis:** 1.2.1 Types of catalysis, catalytic activity, specificity and selectivity, inhibitors, catalyst poisoning and deactivation. Preparation and role of Ziegler – Natta catalysis and Wilkinson's catalysis. 1.2.2 Mechanisms and kinetics of acid-base catalyzed reactions, effect of pH. 1.2.3 Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)	**8 L**

	1.2.4 Effect of particle size and efficiency of nanoparticles as catalyst.	
Unit – 2, 1L/Week		**15L**
Course Code: SIUSCHE42.2 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Discuss the hydration and hydrolysis of cations and anions and calculation of hydration energy using Latimer equation.* 2. *Explain the classification of cation on the basis Z^2/r and pKa value, and for anion on the basis of pkb value in aqueous medium and various factors affecting it.* 3. *Predict the properties of concentrated oxo-acids and their chemistry with special emphasis on environment aspects.*		
2 Ions in aqueous medium, uses and Environmental Chemistry of oxo-acids		**15 L**
2.1	**Acidity of Cations and Basicity of Anions:** 2.1.1 Hydration of cations; Hydrolysis of cations predicting degree of hydrolysis of cations-effect of charge and radius. Latimer equation for calculation of hydration energy (Numericals expected). 2.1.2 Relationship between pKa, acidity and Z^2/r value of metal ions graphical presentation. 2.1.3 Classification of cations on the basis of acidity category – non acidic, moderately acidic, strongly acidic, very strongly acidic with pKa values range and examples. 2.1.4 Hydration of anions- effect of charge and radius; hydration of anions- concept, diagram classification on the basis of basicity.	**9L**
2.2	**Uses and Environmental Chemistry of oxo-acids** 2.2.1 Physical properties of concentrated oxo-acids like Sulfuric, Nitric and Phosphoric acid. 2.2.2 Uses and environments aspects of these acids.	**6L**
Unit – 3, 1L/Week		**15 L**
Course Code: SIUSCHE42.3 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Discuss the trivial & IUPAC names of aliphatic and aromatic amines.* 2. *Predict the effect of substituent on basicity of aliphatic and aromatic amines.* 3. *Discuss the reactions of aliphatic amines and Electrophilic substitution in aromatic amines.* 4. *Explain diazonium salts preparation and their reactions/synthetic application.* 5. *Discuss the classification, nomenclature, electronic structure, aromaticity in 5-membered*		

and 6-membered rings containing one heteroatom. 6. *Explain synthesis and reactions of 5-membered and 6-membered rings containing one heteroatom* 7. *Predict the stereochemistry of mono and di substituted cyclohexane derivatives.*		
3 Nitrogen containing compounds, Heterocyclic compounds and Stereochemistry		**15L**
3.1	**Amines:** Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines; Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCl, Sn-HCl, Zn-acetic acid, reduction of nitriles, ammonolysis of halides, reductive amination , Hofmann bromamide reaction. Reactions- Salt Formation, N-acylation, N-alkylation, Hofmann's exhaustive methylation (HEM), Hofmann-elimination reaction, reaction with nitrous acid, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation.	**4 L**
3.2	**Diazonium Salts:** Preparation and their reactions/synthetic application-Sandmeyer reaction, Gattermann reaction, Gomberg reaction, Replacement of diazo group by –H and OH. Azo coupling with phenols, naphthols and aromatic amines, reduction of diazonium salt to aryl hydrazine and hydrazobenzene.	**3 L**
3.3	**Heterocyclic compounds:** 3.3.1 Classification, nomenclature, electronic structure, aromaticity in 5- membered and 6-membered rings containing one heteroatom. 3.3.2 Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis). 3.3.3 Reactivity and reactions of furan, pyrrole and thiophene: halogenation, nitration, sulphonation, Vilsmeier-Haack reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction, Ring opening. Pyrrole: Acidity and basicity of pyrrole, comparison of basicity of pyrrole and pyrrolidine. 3.3.4 Pyridine: Reactivity, basicity, comparison of basicity of pyridine, pyrrole and piperidine, sulphonation of pyridine (with and without catalyst), Chichibabin reaction.	**5 L**
3.4	**Stereochemistry** 3.4.1 Recapitulation: Represent the configuration through projection formulae. 3.4.2 Stereochemistry of mono and di- alkyl cyclohexanes and their relative Stabilities.	**3L**

Course Code: SIUSCHE43

Paper III (Elective)

Credits: 2 Credits (45 Lectures)

Unit – 1, 1L/Week		15L
Course Code: SIUSCHE43.1 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Discuss various methods of separation.* 2. *Explain method of separation of an analyte from the matrix.* 3. *Discuss a solute gets distributed between two immiscible phases.* 4. *Describe principle of solvent extraction and various terms involved therein.* 5. *Predict effect of various parameters on solvent extraction of a solute.* 6. *Explain classification of Chromatographic methods.*		
1 Separation Techniques in Analytical Chemistry		
1.1	**An Introduction to Analytical Separations and its importance in analysis.**	**1L**
1.2	**Estimation of an analyte without effecting separation.**	**1L**
1.3	**Types of separation methods.** 1.3.1 Based on solubilities (precipitation, filtration and crystallisation). 1.3.2 Based on gravity- centrifugation. 1.3.3 Based on volatility-Distillation. 1.3.4 Based on electrical effects-electrophoresis. 1.3.5 Based on retention capacity of a Stationary Phase –Chromatography. 1.3.6 Based on distribution in two immiscible phases-Solvent Extraction. 1.3.7 Based on capacity to exchange with a resin-Ion Exchange.	**3L**
1.4	**Electrophoresis** 1.4.1 Principles, basic instrumentation, working and application in separation of biomolecules like enzymes and DNA.	**1L**
1.5	**Solvent extraction** 1.5.1 Introduction, Nernst distribution Law, Distribution Ratio, Partition Coefficient. 1.5.2 Conditions of extraction: Equilibration time, solvent volumes, temperature, pH. 1.5.3 Single step and multi-step extraction, percentage extraction for single step and	**4L**

	Multi-step extraction. Separation factor. 1.5.4 Batch and continuous extraction. [Numerical problems wherever applicable]	
1.6	**Chromatography** 1.6.1 Introduction to Chromatography. 1.6.2 Classification of chromatographic methods based on stationary and mobile phase. 1.6.3 Paper Chromatography: Principle, techniques and applications of Paper Chromatography in separation of cations. 1.6.4 Thin layer Chromatography Principle, technique and Applications in determining the purity of a given solute; Following progress of a given reaction.	**5L**
Unit – 2, 1L/Week		**15L**
Course Code: SIUSCHE43.2 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Explain he nature of chemical reactions that influence potential of a given cell.* 2. *Discuss the various types of electrodes or half cells.* 3. *Explain the nature, need and importance of pH.* 4. *Use of various instrumental method.*		
2 Instrumental Methods – II		
2.1	**Potentiometry** Principle, Role of reference and indicator electrodes, Applications in neutralisation reactions with reference to the titration of a strong acid against a strong base (using quinhydrone electrode) and Graphical methods for detection of end point.	**5 L**
2.2	**pH metry** Principle, Types of pH meters, Construction Working and Care of Combined Glass electrode, Applications in Titrimetry (Strong acid-Strong Base) biological and environmental analysis.	**4 L**
2.3	**Conductometry** Principle, Conductivity cell its construction and care. Applications in neutralization titrimetry with respect to i. Strong Acid-Strong Base ii. Strong Acid-Weak Base iii. Strong Base-weak Acid iv. Weak Acid- Weak Base Advantages & limitations of conductometric titrations.	**4L**

2.4	**Voltammetry:** Introduction, Principle and Applications of Voltammetry.	**2L**
Unit – 3, 1L/Week		**15 L**
Course Code: SIUSCHE43.3 **Course Outcomes**: Upon completion of this course, student will be able to 1. *Discuss the statistical methods in chemical analysis.* 2. *Explain the nature of various kinds of analytical errors.* 3. *Describe how to select the suitable analytical method with minimum error*.		
3 Statistical treatment of analytical data		
3.1	**Nature of indeterminate errors** 3.1.1 The true and acceptable value of a result of analysis. 3.1.2 Measures of central tendency: Mean, median, mode, average. 3.1.3 Measures of dispersion: Absolute deviation, relative deviation, relative average deviation, standard deviation (σ), variance, coefficient of variation.	**4L**
3.2	**Distribution of random errors** 3.2.1 Gaussian distribution curve. 3.2.2 Equation and salient features of Gaussian distribution curve.	**2L**
3.3	**Concept of confidence limits and confidence interval and its computation using** Population standard deviation, Student's *t* test and Range.	**3L**
3.4	**Criteria for rejection of doubtful result** 2.5 d rule, 4.0 d rule and Q test.	**2L**
3.5	**Test of significance** Null hypothesis and F-test (variance ratio test)	**2L**
3.6	**Graphical representation of data and obtaining best fitting straight line** i) For line passing through origin ii) For line not passing through origin [Numerical problems wherever possible, expected]	**2L**

Suggested Reference for SIUSCHE41.1 & SIUSCHE42.1

1. A text book of Physical Chemistry by Kapoor.
2. Essentials of Physical Chemistry by B.S. Bahl, Arul Bahl and G.D. Tuli.
3. Chemical Kinetics by Keith J. Laidler.

4. College Physical Chemistry by Baliga and Zaveri.
5. Basic Principle in Physical Chemistry by S.H.S Bohra, K. Raghuraman and D. V. Prabhu.
6. Mathematical preparation for Physical Chemistry by F. Daniel.
7. Principle of Physical Chemistry by Maron and Pruton.

Suggested Reference for SIUSCHE41.2 & SIUSCHE42.2

1. Fundamentals of Inorganic Chemistry by J. Barrett and A. Malati, East-West Press Edition(2006)
2. Theoretical Inorganic Chemistry by C.M. Day and Joel Selbin, Affiliated East West Press Pvt. Ltd., (1985).
3. Inorganic Chemistry by J. D. Lee, Concise 5th edition, Blackwell Science Ltd., (2005).
4. Inorganic Chemistry by James E. Huheey, 3rd edition, Harper & Row, Publishers, Asia, Pte Ltd., (1983).
5. The VSEPR Model of Molecular Geometry by R.J. Gillespie and I. Hargittai, Dover Publication, (2012).
6. Inorganic Chemistry in Aqueous Solutions by J. Barrett, The Royal Society of Chemistry (2003).
7. Ions in Aqueous Systems by T. Moeller and R. O'Connor, McGraw-Hill Book Company, (1972).
8. Gary L. Miessler Donald A. Tarr, St. Olaf College, Northfield, Minnesota. Pearson Prentice Hall
9. Inorganic Chemistry by Catherine E. Housecroft and Alan G. Sharpe. Pearson Prentice Hall.

Suggested Reference for SIUSCHE41.3 & SIUSCHE42.3

1. Organic Chemistry by S. H. Pine McGraw Hill. Kogakusha Ltd.
2. Organic Chemistry by John Mc Murry 5th Edition Cornell University
3. Advance Organic Chemistry by Jerry March, Wiley Eastern Ltd.
4. A guide to IUPAC Nomenclature of Organic Compound by Richer Interscience Publications
5. Organic Chemistry by T. W. G. Solomons, C. B. Fryhle, 2000 John Wiley and Sons
6. Organic Chemistry by Morrison and Boyd, Allyn& Bacon Inc.
7. Organic Chemistry by Francis A. Carey, 1996 3rd Ed. McGraw Hill
8. Fundamentals of Organic Chemistry by G. Mare Loudon, 2002 4th Edition.
9. Organic Chemistry by Seyhan N. Ege, 1984. D. C. Heath & Co.
10. Organic Reactions with Mechanism by S. P. Bhutani, Ane book Pvt. Ltd.
11. Organic Chemistry by Clayden J., Greeves, N., Warren S., Wothers P., Oxford University Press.
12. Name reactions in Heterocyclic Chemistry, Jie-Jack Li, Wiley Interscience publications, 2005
13. Handbook of Heterocyclic Chemistry, 2nd Edition, Alan R Karitzsky and Alexander F Pozahrskii, Elsevier Science Ltd., 2000.
14. Heterocyclic Chemistry, 5th Edition, John A. Joule and Keith Mlls, Wiley Publication, 2010.
15. Heterocyclic Chemistry, 3rd Edition, Thomas L. Gilchrist Pearson Education, 2007.

16. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
17. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.

Suggested Reference for SIUSCHE 43.1

1. Fundamentals of Analytical chemistry by D.A. Skoog, D.M. West, F.J. Holler and CX.R. Crouch, 8th edition
2. Solvent extraction in analytical chemistry by G.H. Morrison and H. Freiser
3. Chromatographic separations, Analytical chemistry by open Learning P. G. Swell and B. Clarke, John Wiley and sons, 1987
4. Modern Analytical Chemistry by David Harvey

Suggested Reference for SIUSCHE 43.2

1. Principles of Instrumental analysis by D. A. Skoog, 3rd edition, Saunders college publishing.
2. Vogel's Text book of quantitative inorganic analysis, 4th edition, ELBS/ Longman.
3. Instrumental methods of analysis by B. K. Sharma, Goel publishing house. Miscellaneous methods.

Suggested Reference for SIUSCHE43.3

1. Modern Analytical Chemistry by David Harvey
2. Fundamentals of analytical chemistry by Skoog and West

Course Code: SIUSCHE4P
Paper I, II, III
Credits: 2 Credits (45 Lectures)
PRACTICAL COURSE CHEMISTRY LABORATORY:

Course Code: SIUCHE4P1

Course Outcomes:
Upon completion of this course, student will be able to

1. *Plan calibration of volumetric apparatus.*
2. P*erform experiments that has specific aims with correct techniques.*
3. Examine *skills of observation, recording and analyzing data.*
4. *Discuss experimental work in a systematic manner.*

Unit	Course Code: SIUCHE4P1and SIUCHE4P2 (Paper – I and II)
1	**Physical Chemistry** 1. To determine standard EMF and the standard free energy change of Daniel cell potentiometrically. 2. To determine the amount of HCl in the given sample potentiometrically. 3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of acid hydrolysis of methyl acetate. 4. Titration of HCl and NaOH using quinhydrone electrode potentiometrically. 5. To determine the SRP of Cu^{2+}/Cu electrode at room temperature.
2	**Inorganic Chemistry** 1. Nickel dimethylglyoxime. 2. tris (ethylene diammine) nickel (II) thiosulphate. 3. Tetrammine Copper (II) sulphate 4. Bis-(8-hydroxy quinalato) magnesium (II)
3	**Organic Chemistry** Qualitative Analysis of organic compounds on the basis of 1. Preliminary examination. 2. Solubility profile. 3. Detection of elements C, H, (O), N, S, X. 4. Detection of functional groups. 5. Determination of physical constants (M.P / B.P) 6. Confirmatory test for the compound Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysis to be given: Carboxylic acids, phenol,

	carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halides. (Minimum 6 compounds to be analyzed)
Unit	**Course Code: SIUCHE4P3 (Paper – III)**
1	Tools of Analytical Chemistry-II a. Filtration Flasks, Funnels, Separating Funnels, Distillation apparatus, Vacuum Distillation assembly, Centrifuge machine, Electrophoresis apparatus. b. Development chamber for chromatography c. Electrodes like Reference Electrodes and Indicator Electrodes (with respect to care and maintenance.) d. Conductivity cell (with respect to care and maintenance.) e. Combined Glass electrode (with respect to care and maintenance.) f. Types of Salt Bridges and preparation of any one or use of salt bridge, its effect on the potential of a given electrode/cell (The learner should draw diagrams and write-ups providing uses of the items mentioned in (a. and b.) and Principle, Construction care and Uses of items (c) to (f) in his journal.)
2	1. Estimation of Fe(II) in the given solution by titrating against $K_2Cr_2O_7$ potentiometrically and calculation of % error. 2. Conductometric titration: Estimation of given acid by conductometric titration with strong base and calculation of % error. 3. Separation of a solute between two immiscible solvents to determine the distribution ratio and/or extraction efficiency. 4. Determination of acidity of a water sample. 5. Paper chromatography**:** Separation of cations like Fe (III), Ni(II) and Cu(II) in a sample. 6. To determine the saponification value of given oil.

Suggested Reference for SIUSCHE4P1 and SIUSCHE4P2

1. Fundamental of Analytical Chemistry-Skoog D.A. and West D.M. Saunders, College Publication
2. Quality in the Analytical Chemistry laboratory –Neil T. Crosby, Florence Elizabeth Prichard, Ernest J. Newman – John Wiley & Sons Ltd.
3. Principles and Practice of Analytical Chemistry-Fifield F.W. and Kealey D, Black well Science
4. Chemical Analysis in the laboratory –A Basic guide by Irene Muller-Harvey, Richard M. Baker, Royal Society of Chemistry.
5. Textbook of Quantitative Inorganic Analysis -Vogel A.I.
6. Senior Practical Physical Chemistry - Khosla B.D., Garg V.C. and Gulati A., R. Chand and

Co., New Delhi (2011).

7. Experiments in Physical Chemistry - Garland C. W., Nibler J.W. and Shoemaker D.P., 8th Ed., McGraw-Hill, New York (2003).
8. Experimental Physical Chemistry - Halpern A. M. and McBane G. C., 3rd Ed., W.H. Freeman and Co., New York (2003).
9. Experimental Physical Chemistry - Athawale V.D. and Mathur P., New Age International, New Delhi (2001).
10. Practical Inorganic Chemistry - G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
11. Practical Organic Chemistry - Mann, F.G. & Saunders, B.C., Pearson Education (2009)
12. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis - Ahluwalia, V.K. & Aggarwal, R., University Press (2000).
13. Practical Organic Chemistry - Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R., 5th Ed., Pearson (2012).

Suggested Reference for SIUSCHE4P3

1 D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp. 345-381.
2 A.I. Vogel. “Textbook of Quantitative Inorganic Analysis,” Longman, London (1961).
3 R.V. Dilts. “Analytical Chemistry. Methods of Separation,” van Nostrand, N.Y. (1974).
4 Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J.B. Baruah, Mrs. Abhilasha Mohan Baruah and Mr. Parikshit Gogoi

The scheme of examination for the course in Chemistry at the Second Year B.Sc. Semester end examination will be as follows.

MODALITY OF ASSESSMENT

I] THEORY EXAMINATION PATTERN:

(A) Internal Assessment for theory– 40 Marks

Internal Assessment	Marks
Class test	**20**
Assignment / Case Study / Project / Presentation/ Industrial Visit Report, etc.)	**15**
Active participation and overall conduct in class	**05**
Total Marks	**40**

(B) Semester End Theory Assessment - 60 Marks

Duration - **Semester End Theory** examinations shall be of **2 Hours** duration.

Semester End Theory question paper pattern:

1. There shall be **four** questions.
2. Each unit will consist of be one question with **15** Marks each and the fourth question will be based on all the three units with 15 Marks.
3. All questions are **compulsory** with internal choices within the questions.

   Question 1 (Unit-1)

   Question 2 (Unit-2)

   Question 3 (Unit-3) &

   Question 4 (combined units) will be of **15** Marks with internal options.
4. All Questions may be sub divided into sub questions of **five** marks each.
5. Please ensure that the allocation of marks depends on the number of lectures allotted for each topic.

Marks distribution pattern for theory examination

Semester End Examination	Paper I	Paper II	Paper III	Grand Total
Internal Assessment	**40**	**40**	**40**	**120**
Theory	**60**	**60**	**60**	**180**
Total Marks	**100**	**100**	**100**	**300**

II] PRACTICAL EXAMINATION PATTERN:

Scheme of examination: There will be no internal assessment for practical.

A candidate will be allowed to appear for the semester end practical examination only if the candidate submits a **certified journal** at the time of practical examination or a certificate from the Head of the Department/Institute to the effect that the candidate has completed the practical course of that semester of S.Y.B.Sc. Chemistry as per the minimum requirement.

The duration of the practical examination will be three and half hours per experiment. The questions on slips for the same should be framed in such a way that candidate will be able to complete the task and should be evaluated for its skill and understanding of chemistry.

Note: Minimum 75% experiments of prescribed syllabus should be completed in the 3rd and 4th semester. Certified journal is a must to be eligible to appear for the semester end practical examination, failing which they will not be allowed to appear for the examination.

Marks distribution pattern for practical examination

Sr. No.	Practical Examination	Papers			Total
		P1	P2	P3	
1.	Experiment	35	35	35	105
2.	Journal	05	05	05	15
3.	Viva Voce	10	10	10	30
Practical Marks		50	50	50	150

Overall Examination and Marks Distribution Pattern

Semester End Examination	Paper I	Paper II	Paper III	Grand Total
Internal Assessment	40	40	40	120
Theory	60	60	60	180
Practical	50	50	50	150
Total Marks	150	150	150	450