Course Objectives and Outcomes

The outcome of the course should be as per the objectives outlined for the degree course in chemistry**.**

The objectives underlined are equated with the acquisition of following criteria viz. the knowledge gained, skills acquired and the exposure gained.

On the knowledge front, the understanding of the student about the subject should be dependent on the courses undertaken, credits obtained , the contents of the course and the evaluation done for the student over the period of three years.

Through the three years of the degree course the students should be well acquainted with the fundamental topics in physical chemistry, such as thermodynamics, kinetics, catalysis , structure and bonding, phenomena at the atomic, subatomic and the molecular level.

In the realm of inorganic chemistry the student should gain the knowledge of the chemistry of the elements and their compounds, the methods of obtaining them , large scale manufacture of bulk and fine chemicals. The preparation and the properties of special materials synthesized and the chemistry of the complexes and their utility in different fields. The student should be introduced to the concept of the behaviour of the groups of atoms.

In chemistry of organic compounds, the student must understand the course of the reactions that they will undergo, the routes of synthesis of different types of materials and their characteristics. The side canvass of organic chemistry from the bio molecules on one side of the spectrum to the polymers and compounds developed and synthesized as per the demand or the requirements . The journey should cover different fields like food, petrochemicals, polymers and speciality compounds. The student should know the synthesis; both on the laboratory scale and the manufacture of the same and the parameters involved in the large scale of preparation.

The student should get introduced to the techniques used in analytical chemistry such as optical ,electroanalytical, separation methods , radioanalytical and miscellaneous methods including the classical methods of analysis.

The student should learn about the basic principles involved in the instrumentation and the field to which the techniques become applicable. The student should also learn the limitations with respect to a measurement and the concentration level at which the technique becomes applicable.

The skills acquired in the practical component of the three year course will include the use of methods of identification , separation, characterisation and estimation of the components present. It will include familiarity of the student with the techniques to be adopted depending on the organic or inorganic origin of the material.

The student should also develop the necessary skills to determine the parameters like the rate of a reaction, the equilibrium constant, the solubility, the characterisation of the complexes and the determination of the properties of the materials like polymers and catalysts.
The student should get hands on training in the various analytical techniques learnt in the course of three years through the prior use of the instruments such as conductometers, potentiometers, colorimeters, pH meters, separation instruments.

The third aspect of exposure should be covered through three steps.
a) The **certificate courses** made available to the students at each year such as ‘ Certificate course in basic analytical chemistry’; ‘ Certificate Course in basic Instrumentation’ etc.
These will make the students gain additional information and skills that cannot be imparted through the regular coaching.

b) The **project work** that the student will take for each year should teach the student the non chemistry aspects of the work mainly getting along with the colleagues working in a group the group ethics and so on.

c) The **internship** that can be given to some selected students, if not all, should be the best exposure that is available especially for the students who seek employment immediately after graduation.

The graduate program in Chemistry aims at equipping the student in whatever endeavour that he / she undertakes after the graduation. It is envisaged that after the graduation the student either goes for higher studies or seeks a Job or totally changes the direction of navigation to opt for a totally different shore.

The graduate programme so proposed in Chemistry should be able to equip the student with basic requirements for all the three aspects mentioned above.

The expected outcome for the same can be under the category of basic knowledge, skills developed and exposure .

1. As far as the basic foundation of the subject is concerned the student should gain the fundamental knowledge of the main chemistry branches as Physical , organic , analytical and inorganic.
2. On the front of the skill development after graduation the student should be able to identify and separate components of organic or inorganic origin and develop the necessary skill for operation and handling of the instruments.
3. In the span of three years the student should take advantage of the certificate courses offered by the department to supplement the gains through the regular theory and practicals. The department should also provide opportunities to the students through the projects undertaken and the internships made available to the students to make the best use of the summer vacation.

S.P. Mandali's
Ramnarain Ruia Autonomous College

Syllabus for F.Y.B.Sc
Programme – B.Sc.
Course: Chemistry (RUSCHE)
Resolution No. AC/II(18-19).2.RUS5

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

Semester-I

1. Paper-I: Physical Chemistry.
2. Paper-II: Unit I and II Inorganic Chemistry and Unit III- Organic Chemistry.

Semester-II

1. Paper-I: Organic Chemistry.
2. Paper-II: Unit I and II Inorganic Chemistry and Unit III- Physical Chemistry.

SEMESTER I

Course Code	Unit	TITLE	Credits	L / Week
	I	Chemical calculations		**1**
	II	Gaseous State Solid State		**1**
	III	Chemical Kinetics Liquid State		**1**
RUSCHE101			**2**	
	I	Atomic structure Periodic Table and periodicity of Properties Chemistry of s-block elements		**1**
	II	Chemical Bond and Reactivity		**1**
	III	Nomenclature of Organic Compounds Bonding and Structure of organic Basic concepts involved in organic reaction mechanism.		**1**
RUSCHE102			2	
RUSCHEP101		Chemistry Practicals	2	**6**

SEMESTER II

Course Code	Unit	TITLE	Credits	L / Week
	I	Stereochemistry		**1**
	II	Chemistry of Aliphatic Hydrocarbons		**1**
RUSCHE201	**III**	Aromatic Hydrocarbons	**2**	**1**
	I	Concept of Qualitative Analysis Acid-Base Theories		**1**
	II	Oxidation Reduction Chemistry Study of Oxides of carbon, Oxides of Sulfur and Nitrogen with respect to their Environmental impact	2	**1**
RUSCHE202`	**III**	Thermodynamics		**1**
RUSCHEP201		Chemistry Practicals	2	**6**

Detail Syllabus
Academic Year 2019-20

SEMESTER-I

Course Code- RUSCHE101

Paper-I (Physical Chemistry)

Credits: 2

Learning Objectives:

The basic objective of the first unit of this paper is to recapitulate the various aspects of chemical calculations by student. Also, the various units of concentration and concept of milimoles and miliequivalence must be learns by them. The concept of stoichiometry and problems based on it is discussed profusely. The second unit of this paper significantly underlines the various states of matter viz. gaseous state and liquid state. The student learns elaborately the various aspects of these states. The third unit makes student aware of the solid state and the concept of chemical kinetics.

Learning Outcome :

- The student will be able to
- perceive the concept of mole and its relation with molar mass and do the calculations based on that.
- Understand and apply the units of volume and mass based units of concentration
- understand the concept of stoichiometry and will be able to solve the problems on it.
- understand the concept of standardization and its significance.

- understand kinetic theory of gases and various gas laws.
- understand the difference between real gas and ideal gas.
- understand the characteristics of liquid state, physical properties and the concept of viscosity and surface tension and its determination.
- understand the rate of reaction and determination of molecularity of a reaction.

Unit I	**1.1 Chemical calculations:** **1.1.1** Mole concept, relation with molar mass, conversion of amount into mole and vice versa, relation with the number of particles present. **1.1.2** Amount and concentration, volume based units for concentration, molarity, normality, formality, mass based unit for concentration - molality and mole fraction, ppm and ppb, concept of milimoles and miliequivalents **1.1.3** Problem solving based on various concentration units **1.1.4** Stoichiometry and calculations based on it, concept of limiting reactant and yield for a chemical reaction. **1.1.5** Calculations based on stoichiometry. **1.1.6** Primary standards, properties of primary standards, primary standards for different types of titrations, secondary standards, standardization, standard solutions.	**(15L)**
Unit II	**2.1 Gaseous State:** **2.1.1** Postulates of kinetic theory of gases and Gas Laws **2.1.2** Ideal and real gases, deviations from the gas laws, reasons for the deviations, compressibility factor, Boyle temperature. **2.1.3** Volume correction and pressure correction, van der Waals equation of state, use of the equation to explain the deviations from the gas laws. **2.1.4** Problem solving based on gaseous laws and van der Waals equation of state **2.1.5** Joule-Thomson effect, Joule-Thomson coefficient, inversion temperature, Linde's process of liquefaction of gases. **2.1.6** Maxwell - Boltzmann's distribution of velocities, the graphical presentation and its interpretation, average velocity, most probable velocity and R.M.S. velocity. **2.2 Solid state** **2.2.1** Solid state and its characteristics, crystalline and amorphous solids. **2.2.2** Space lattice and unit cell. **2.2.3** Laws of crystallography, law of constancy of interfacial angles, law of symmetry, axes, planes and centre of symmetry. **2.2.4** Law of rationality of indices, Weiss coefficients, Miller indices, 100, 110 and 111 planes in a crystal.	**(10L)** **(5L)**

Unit III	**3.1 Chemical Kinetics:** **3.1.1** Rate of a reaction, rate constant and measurement of reaction rates. **3.1.2** Order and molecularity of reaction. **3.1.3** Integrated rate equation for zero, first and second order reactions (with equal and unequal initial concentration of the reactants). **3.1.4** Kinetic characteristics of zero, first and second order reactions. **3.1.5** Numerical problems based on zero, first and second order reactions. **3.1.6** Methods for the determination of the order of a reaction (a) Integration method (b) Graphical method (c) Half time method (d) Ostwald's isolation method (e) differential method. **3.2 Liquid State:** **3.2.1** Introduction to liquid state, characteristics of liquid state, physical properties of the liquids. **3.2.2** Determination of surface tension by drop number method using stalagmometer. **3.2.3** Surface active solutes and surface tension, applications of surface tension measurement. **3.2.4** Viscosity: Introduction, coefficient of viscosity. **3.2.5** Determination of coefficient of viscosity by Ostwald viscometer. **3.2.6** Applications of viscosity measurement. **3.2.7** Problem solving on surface tension and viscosity measurements.	**(8L)** **(7 L)**

SEMESTER-I
Paper-II (Inorganic and Organic Chemistry)
Course Code- RUSCHE102
Academic Year 2019-20
Credits: 2

Learning objectives :

The basic objective of the first unit of this paper is to recapitulate earlier theories pertaining to atomic structure, the Concept of quantum numbers, Shapes of orbitals etc.
The student should learn the periodic development of construction of periodic table and its classification. The various types of bonds, and the reactivity of compounds is discussed n the second unit which increases the curiosity of the student learn about the structural aspects of the compounds of ABn type.
The very important IUPAC name of mono and bi-functional aliphatic compounds including their cyclic analogues are expected to learn by student.The fundamental concepts which govern the structure, bonding, hybridization, bond angles and shapes of molecules.
Electronic effects and their applications with respect to stability of reactive intermediates and determination of relative strengths of acids and bases. Types of organic reactions.

Learning Outcome : The student will be able to understand the

- Earlier theories pertaining to atomic structure.
- Concept of quantum numbers.
- Difference between orbit and orbitals.
- Shapes of orbitals

Also, after studying this chapter students should be able to understand

- Concept of atomic weight and atomic number for the construction of periodic table
- Classification of elements depending on entry of valence electrons viz. s, p, d and f block elements.
- Different types of elements viz main group, transition, and inner transition elements.
- Trends in following properties Atomic and ionic size; electron gain enthalpy; ionization enthalpy, effective atomic number

The student will be able to:

- Write IUPAC name of mono and bi-functional aliphatic compounds including their cyclic analogues.
- Understand the fundamental concepts which govern the structure, bonding, hybridization, bond angles and shapes of molecules.
- Know Electronic effects and their applications with respect to stability of reactive intermediates and determination of relative strengths of acids and bases. Types of organic reactions.

Unit I	**1 Atomic Structure and Periodic Table and Periodicity of Properties**. **1.1 Atomic Structure** **1.1.1** Rutherford's Atomic Model; Bohr's Theory and its limitations, Somerfield extension to Bohr's theory Zeeman effect ; their relationship with quantum number; orbit and orbital **1.1.2** Quantum Numbers of last electron; Hund's rule, Aufbau principle; Pauli exclusion Principle **1.1.3** Wave function, Schrodinger wave equation (Mathematical expression not to be discussed), Radial and Angular forms of the wave function; Relationship between Radial function and probability; plots of probability for different orbitals; shapes of orbitals : s,p,d,f. **1.2 Periodic Table and Periodicity of Properties**. **1.2.1** Long form of the Periodic Table; Classification of elements as main group, transition, and inner transition elements; **1.2.2** Periodicity in the following properties: Atomic and ionic size; electron gain enthalpy; ionization enthalpy, effective nuclear charge (Slater rule); Electronegativity: Pauling and Mulliken (Numerical problems expected, wherever applicable). **1.3 Chemistry of s- block elements** 1.3.1. Chemical properties, Uses of alkali and alkaline earth metals, Diagonal relationship of Li and Mg. 1.3.2 **Role of Na and K in biological systems**	**(15 L)**
Unit II	**2.1 Chemical Bond and Reactivity** **2.1.1** Types of chemical bonds; comparison between ionic and covalent bonds **;** polarizability and its effect on a bond, (Fajan's Rules). **2.1.2** Shapes of simple molecules: Lewis dot structures; Sedgwick-Powell theory; Basic VSEPR Theory for AB_n type of molecules (neutral or charged species), with and without lone pair of electrons. **2.1.3** Isoelectronic species; applications and limitations of VSEPR Theory.	**(15 L)**
Unit III	**3.1 Nomenclature of Organic Compounds:** 3.1.1 IUPAC nomenclature of mono functional aliphatic compounds. 3.1.2 IUPAC nomenclature of bi-functional aliphatic compounds and their cyclic analogues. **3.2 Bonding and Structure of organic compounds:** Concept of Hybridization (sp3, sp^2 and sp hybridization) Hybridization: sp^3, sp^2 and sp hybridization of carbon and nitrogen; sp^3 and sp^2 hybridizations of oxygen in organic compounds and their geometry with suitable examples.	**(5L)** **(5L)**

	3.3 Basic concepts involved in organic reaction mechanism: **3.3.1 Electronic Effects:** Inductive, electromeric, resonance effects, hyperconjugation. **3.3.2 Carbocations, Carbanions and Free radicals:** Homolytic and heterolytic fission, examples of the same. Formation of carbocations, carbanions and free radicals. (primary, secondary, tertiary, allyl, benzyl), their relative stability. **3.4** Organic acids and bases; their relative strengths.	**(3L)** **(2L)**

Semester-I
Chemistry Practicals
Credits: 2

Course Code	Experiments
RUSCHEP101	**Paper I:** .**Preparation of a solution of a primary standard for acid base titrations :** **1** Determination of the strength of the supplied sodium hydroxide solution, using solution of a primary standard for acid base titration. **Preparation of a solution of a primary standard for oxidation reduction titrations:** **2** Determination of the strength of the supplied sodium thiosulphate solution. **Use of the secondary standard:** **3** Determination of the strength of the supplied iodine solution using the sodium thiosulphate solution of known strength. [determined in experiment - **2]** **4** To determine the rate constant of the acid catalyzed hydrolysis of methyl acetate. **5** To determine relative viscosity of a given polymer solution using Ostwald's viscometer. **Paper II:** 1. Commercial analysis of (ANY ONE) a) Mineral acid b) Acetic acid in vinegar 2. Analysis of solution containing Na_2CO_3 and $NaHCO_3$ using two indicators 3. Gravimetric analysis a) To determine the percentage composition of a mixture of $BaSO_4$ and NH_4Cl. b) To determine the percentage composition of a mixture of ZnO and $ZnCO_3$. 4. Method of Purification**:** Purification of a given organic compound by crystallization. (Minimum three)

SEMESTER-II
Course Code- RUSCHE201
Paper-I (Organic Chemistry)
Academic Year 2019-20
Credits: 2

Learning Objectives:

In order to facilitate the student to understand, the basic concepts of Organic Chemistry, the coherence of the topics were observed and the topics are included in the current syllabi. The topics such as Stereochemistry, Chemistry of Aliphatic Hydrocarbons and Aromatic Hydrocarbons form the basis of Organic Chemistry, and it is essential for students, who are pursuing higher studies in Chemistry, to have profound knowledge of these topics.

Learning Outcome :

After studying these topics, the students will be able to know

- Isomerism and its types
- CIP Rules and E-Z notations
- Types of cycloalkanes and their relative stability with energy
- Electrophilic aromatic substitutions.
- Directing effects of the groups in electrophilic aromatic substitutions.

Unit I	**1.1 Stereochemistry:** 1.1.1 Optical Isomerism: optical activity, specific rotation, chirality, enantiomers, molecules with two similar and dissimilar chiral-centres, distereoisomers, meso structures,racemic mixture. 1.1.2 Flying-wedge, Fischer, Newman and Sawhorse projection formulae (erythro, threo isomers) and their interconversion. 1.1.3 Relative and absolute configuration: D/L and R/S designations. 1.1.4 Geometrical isomerism in alkenes and cycloalkanes: cis–trans isomerism and E/Z notations with C.I.P rules. 1.1.5 Conformation analysis of alkanes (ethane, propane and n-butane) and their relative stability on the basis of energy diagrams. **1.2 Cycloalkanes and Conformational Analysis:** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, boat, half chair, and twist boat forms and their relative stability with energy.	**(15L)**

Unit II	**2.1 Chemistry of Aliphatic Hydrocarbons:** **2.1.1 Carbon-Carbon sigma bond:** **Chemistry of alkanes:** Methods of Preparation of alkanes, Wurtz reaction, Wurtz-Fittig reaction, reactions of alkanes,free radical substitutions: Halogenation - relative reactivity and selectivity. **2.1.2 Carbon-Carbon pi bonds:** alkenes and alkynes**,** methods of preparation of alkenes and alkynes by elimination reactions: mechanism of E_1 and E_2. Saytzeff and Hofmann eliminations. **2.1.3 Reactions of alkenes:** electrophilic addition and mechanism (Markownikoff/ Anti Markownikoff addition). mechanism of ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2 and 1, 4-addition reactions in conjugated dienes, Diels-Alder reaction; Allylic and benzylic bromination using N-bromosuccinimide and its mechanism. **2.1.4 Methods of Preparation and reactions of alkynes:** Acidity, ectrophilic and nucleophilic additions. hydration to form carbonyl compounds, alkylation of terminal alkynes.	**(15L)**
Unit III	**3.1Aromatic Hydrocarbons:** **3.1.1** Aromaticity: Benzene, Kekule's formulation of benzene structure (historical background), Hückel's rule, anti-aromaticity, aromatic character of arenes. **3.1.2** Aromaticity: cyclic carbocations/carbanions and heterocyclic compounds with suitable examples, aromaticity and acidity, relative stabilities. **3.1.3** Electrophilic aromatic substitution: sulphonation and Friedel-Craft alkylation/acylation and mechanisms for the same, mechanism of halogenation, nitration of benzene: **3.1.4** Directing effects of the substituent groups on electrophilic aromatic substitution, reactions of mono substituted benzene derivatives (-CH_3, -NH_2, -OH, NO_2, ^-X) **3.1.5** Nucleophilic aromatic substitution of Aryl halides (replacement by –OH group and effect of nitro substituent).	**(15L)**

SEMESTER-II
Course Code- RUSCHE202
Paper-II (Inorganic and Physical Chemistry)
Credits: 2

Learning Objectives:

Taking into consideration, the relevance of topics and the convenience of understanding, the topics are framed accordingly. The students are required to know chemistry of main group elements and their important properties. Also , the synthesis, properties and uses of inorganic compounds of commercial importance viz. Plaster of Paris and bleaching powder etc. must be known by them. The concept of Chemical Thermodynamics is of utmost importance in order to study spontaneity of any chemical reaction. Hence, it is included in the syllabi.

Learning Outcome :

The Students will be to :

- Do the comparison of the properties of main group elements in the respective groups.
- Understand Concept of metallic and non metallic character with respect to electropositivity.
- Know The methods of preparation of the compounds which are commercially available along with their properties and uses.
- Understand different types of oxides and oxyacids of sulphur , nitrogen - their sources and reactions
- Identify health hazards their environmental implications remedial measures
- Understand basic terms used in thermodynamics.
- Understand different laws of thermodynamics and their applications
- Learn different processes in thermodynamics and its effect and various thermodynamic properties.
- Learn first law of thermodynamics and its expression in terms of relationship between Heat (q), work (w) and internal energy (U).
- Understand second law of thermodynamics and its implications.

Unit I	**1.0 Concept of Qualitative Analysis** 1.1.1 Macro, Semi-Micro, Micro, Ultra Micro, Trace Analysis **1.1.2** Reactions involving liberation of gases, Use of Papers impregnated with Reagents in qualitative analysis (With reference to papers impregnated with starch-iodide, potassium dichromate, lead acetate, dimethyl glyoxime, and oxine reagents) (balanced Chemical Reactions expected). **1.1.3** Precipitation equilibria: Factors affecting the solubility of an ionic compound viz. common ions, uncommon ions, temperature, nature of the solvent, pH, complexing agents (Balanced Chemical Equations and Numerical Problems Expected) **1.2 Acid-Base Theories** **1.2.1** Arrhenius; Lowry-Bronsted concept ; Classification of solvents, auto dissociation of amphi protic solvents, Lewis concept ; Usanovich concept **1.2.2** Hard and Soft Acids and Bases-HSAB (with respect to occurrence and feasibility of chemical reaction);.	**(9L)** **(6L)**
Unit II	2.1 **Oxidation Reduction Chemistry** **2.1.1** Oxidation state, oxidation number, oxidation- reduction in terms of oxidation number **2.1.2** Balancing redox equations by i) oxidation number method and ii) ion-electron method **2.1.3** Calculation of equivalent weight on the basis of chemical nature. **2.2 Study of, oxides of carbon, sulfur and nitrogen with respect to their Environmental impact.**	**(9L)** **(6L)**
Unit III	**3.1 Chemical Thermodynamics:** **3.1.1Recapitualation:** Introduction, terms involved: System, surrounding, open closed and isolated systems, intensive and extensive properties of system, state of a system, state function and path function. Different processes in thermodynamics. **3.1.2**: Heat (q), work (w) and internal energy (U) and their sign conventions. **3.1.3** Statement of first law, work done in isothermal and adiabatic reversible processes, work done in irreversible process, internal energy change for isothermal and adiabatic processes. Numerical problems based on **3.1.3** **3.1.4** Enthalpy and enthalpy change in a constant volume and constant pressure process, enthalpy change in a reversible process. Numerical problems based on **3.1.4**	**(15L)**

	3.1.5 limitations of first law, need for the direction of the energy **c**hange**,** conversion of heat into other energy forms, heat engines, mechanical efficiency of a heat engine, Carnot's cycle, Carnot's theorem, Introduction to entropy, second law of thermodynamics, different statements of second law, entropy changes in a reversible and an irreversible process, combined statement of first and second law ,entropy changes for different physical processes. Numerical problems based on **3.1.5** **3.1.6** Spontaneous processes**,** need for prediction of a spontaneous process**,** Free energy, Gibbs free energy and Helmholtz free energy, changes in Gibbs and Helmholtz's free energy and inter relation between them, criteria for spontaneity of a process.	

Semester-II
Chemistry Practicals
Credits: 2

Course Code	Experiments
RUSCHEP201	**Paper I** 1. **Characterization of organic compound containing C, H, (O), N, S and X** (Minimum of 6 compounds) **Chemical synthesis (one step)** a) Preparation of Iodoform derivative of methyl ketone. b) Preparation of acetyl derivative of primary amine. c) Preparation of 2,4-DNP derivative of carbonyl compound. **Paper II:** 1. **Qualitative analysis:** (at least 5 mixtures to be analyzed) Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions. Cations (from amongst): Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+}, Al^{3+}, Cr^{3+}, K^{+},NH_4^{+} Anions (From amongst): CO_3^{2-}, NO_2^{-}, NO_3^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, (The Qualitative analysis should not involve use of H_2S in any form) 2. To determine the valence factor of $KMnO_4$ by titrating with oxalic acid. 3. To determine the acid-neutralizing power of commercially available antacid formulation.

Reference Books

Organic Chemistry

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education)
2. Stereochemistry, P. S. Kalsi, New Age International Publishers.
3. Paula Y. Bruice, Organic Chemistry, Pearson Education.
4. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition.
5. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education
6. Organic reactions and their mechanism, P.S. Kalsi, New Age International Publishers.
7. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall.

Physical Chemistry

1. The Elements of Physical Chemistry, P.W. Atkins, Oxford University Press, Oxford.
2. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
3. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001).
4. The Elements of Physical Chemistry, P.W. Atkins, Oxford University Press, Oxford.
5. Principles of Physical Chemistry. By Maron and Pruton 4th Ed. Oxford and IBH publication.
6. Physical Chemistry, G.M. Barrow, Tata McGraw Hill Publishing Co.Ltd. New Delhi.
7. An Introduction to the Liquid State by P.A. Egelstaff, Publisher OUP Oxford

Inorganic Chemistry

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
3. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970

Modality of Assessment FYBSc:

Theory Examination Pattern:

A) Internal Assessment - 40%:

		(40 marks)	
Sr No	Evaluation type		Marks
1	One Assignment		15
2	One class Test (multiple choice questions / objective)		20
3	Active participation in class		05
	(seminars/presentation)		
B) External examination - 60 %			
Semester End Theory Assessment - 60%		**60 marks**	

i. Duration - These examinations shall be of **two hours** duration.

ii. Theory question paper pattern :-

1. There shall be **three** questions each of **20** marks. On each unit there will be one question.
2. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions on
Q.1)A)	Any 4 out of 6	16	Unit I
Q.1)B)	Any 4 out of 6	04	
Q.2)A)	Any 4 out of 6	16	Unit II
Q.2)B)	Any 4 out of 6	04	
Q.3)A)	Any 4 out of 6	16	Unit III
Q.3)B)	Any 4 out of 6	04	

Practical Examination Pattern:

(A)Internal Examination:-

Heading	Paper I	Paper II
Journal	05	05
Test	10	10
Participation	05	05
Total	20	20

(B) External (Semester end practical examination) :- 50 Marks Per Section

Sr.No.	Particulars	Marks		Total
1.	**Laboratory work (Paper I + Paper-II)**	**25 + 25**	**=**	**50**
2.	**Viva**	**05 + 05**	**=**	**10**

PRACTICAL BOOK/JOURNAL

Semester I& II:

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department ; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Semester I

Course	101			102			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practicals	20	30	50	20	30	50	100

Semester II

Course	201			202			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practicals	20	30	50	20	30	50	100

S.P. Mandali's
Ramnarain Ruia Autonomous College

Syllabus for S.Y.B.Sc
Programme – B.Sc.
Course: Chemistry (RUSCHE)
Resolution No. AC/II(18-19).2.RUS5

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

For the subject of chemistry there shall be three papers for 45 lectures each comprising of three units of 15 L each.

Semester-III

1. Paper-I: Unit-I Physical Chemistry

   Unit-II Physical Chemistry

   Unit-III Inorganic Chemistry.

2. Paper-II: Unit-I Organic Chemistry

   Unit-II Organic Chemistry

   Unit-III Inorganic Chemistry.

3. Paper III: Unit I and II- Analytical Chemistry

   Unit III- Environmental Chemistry

Semester-IV

1. Paper-I : Unit-I Physical Chemistry

   Unit-II Physical Chemistry

   Unit-III Inorganic Chemistry.

2. Paper-II: Unit-I Organic Chemistry

   Unit-II Organic Chemistry

   Unit-III Inorganic Chemistry.

3. Paper III: Unit I and II- Analytical Chemistry

   Unit III- Industrial Chemistry

Semester III

Course Code	Unit	Topics	Credits	L/Week
RUSCHE301	I	Chemical Thermodynamics-II	2	1
	II	Electrochemistry-I : Electrolytic Conductance And Transport Number		1
	III	Chemical Bonding		1
RUSCHE302	I	Reactivity and reactions of halogenated hydrocarbons, Organomagnesium and organolithium compounds, Alcohols, phenols and epoxides	2	1
	II	Carbonyl Compounds		1
	III	Chemistry of p-block elements: (Group 13 and 14)		1
RUSCHE303	I	Introduction to Analytical Chemistry	2	1
	II	Gravimetric Analysis Titrimetric Analysis		1
	III	Environmental Chemistry: Chemistry of water		1
RUSCHEP301		Chemistry Practicals I	1	3
		Chemistry Practicals II	1	3
		Chemistry practicals III	1	3

Semester IV

Course Code	Unit	Topics	Credits	L/Week
RUSCHE401	I	Electrochemistry-II: Electromotive Force of Galvanic Cells pH and Buffers		1
	II	Solutions of Liquid In Liquid Phase Equilibria	2	1
	III	Comparative Chemistry of the transition metals Coordination Chemistry Nature of the Metal-Ligand Bond		1
RUSCHE402	I	Carboxylic acids and their derivatives, Sulphonic acids		1
	II	Amines, Diazonium Salts, Heterocyclic Compounds		1
	III	Chemistry of Group 15 and 16 elements Organometallic Chemistry	2	1
RUSCHE403	I	Separation Techniques Solvent Extraction Chromatography		1
	II	UV- Visible Absorption spectroscopy Photometric titrations Conductometric titrations	2	1
	III	Industrial Chemistry		1
RUSCHEP401		Chemistry Practicals I	1	3
		Chemistry Practicals II	1	3
		Chemistry Practicals III	1	3

Detail Syllabus

Academic Year 2019-20

Semester III
Course Code: RUSCHE301
Paper: I (Physical and Inorganic Chemistry)
Credits: 2

Learning Objectives:

As the learner progresses from FYBSc to SYBSc, taking into the account the concepts he has grasped in the first year, the syllabus for the SYBSc class has been designed. The student is now expected to correlate Free Energy Changes with various parameters like Temperature and pressure. Also, the liquid state is studied in deeper details and the applications of Raoult's law are explored. After studying basics of Electrochemistry in the First year, the students are made to explore even more finer aspects of the subject. Valence Bond Theory, being the most basic theory put forth to explain chemical bonding, has its applications which are incorporated in the syllabus followed by which the limitations of VBT have also been studied and the student is finally introduced to Molecular Orbital Theory and its application to Homonuclear diatomic molecules.

Learning Outcome :

After studying the syllabus, the student will have thorough knowledge of the following aspects of Physical and Inorganic Chemistry

- Significance of Gibbs' and Helmholtz Free Energy and its applications.
- Applications of Clapeyron-Clausius Equation.
- Van't Hoff's Reaction Isochore and Isotherm.
- Raoult's Law and deviations from the same.
- Concept of Critical Temperature and applications.
- Concept of Transport Number and its determination.
- Applications and Limitations of Valence Bond Theory
- Concept of Hybridization and its applications.
- Basic Postulates of Molecular Orbital Theory and determination of Bond Order, bond energy and magnetic behavior of the compound.

Unit I	**Physical Chemistry** **1.0 Chemical Thermodynamics-II** 1.1 Recapitulation 1.2 Variation of Gibb's free energy with Pressure and Temperature, Gibbs-Helmholtz equation. 1.3 Thermodynamics of open systems: partial molal properties, chemical potential and its variation with pressure and temperature, Gibb's Duhem equation. 1.4 Clapeyron equation and its application to phases in equilibria. Clausius-Clapeyron equation and its application to Liquid-Vapour equilibrium. 1.5 Concept of fugacity and activity 1.6 van't Hoff reaction isotherm and van't Hoff reaction isochore. 1.7 Maxwell's relations.	**15 L**
Unit II	**Physical Chemistry** **2.0 Electrochemistry-I : Electrolytic Conductance And Transport Number** 2.1 Electronic and electrolytic Conductors: Conductance, cell constant, specific conductance, equivalent conductance and molar conductance and their relationships. Variation of Molar conductance with concentration, for weak and strong electrolytes. Concept of limiting molar conductance. Numerical problems based on 2.1 2.2 Debye-Huckel theory for strong electrolytes: 1) Relaxation effect 2) Electrophoretic effect. 2.3 Kohlrausch's law of independent migration of ions. Limiting molar conductances for ions, determination of limiting molar conductance for weak electrolytes. 2.4 Measurement of conductance and determination of cell constant. 2.5 Applications of conductance measurements: 1) Determination of degree of dissociation and dissociation constant of weak electrolyte. 2) Determination of solubility and solubility product of sparingly soluble salts. 2.6 Transport number, relation between transport number and velocity of ions. Factors affecting transport number. 2.7 Hittorfs Rule and experimental determination of transport number using Hittorf's method 2.8 Experimental determination of transport number by moving boundary method. Numerical problems based on 2.8 **2.9** Absolute ionic mobility, relation between transport number, absolute ionic mobility and limiting molar conductance of ion.	**15L**
Unit III	**Inorganic Chemistry** **3.1 Chemical Bonding** 3.1.1 Valence bond theory: postulates of VBT, need for hybridisation, Orbitals involved in hybridisation (*sp, sp^2, sp^3, dsp, sp^2d, and sp^3d^2*,sd), energetics of hybridisation, interaction between two hydrogen atoms and their Potential energy	**(7L)**

	diagram, Bond energy of hydrogen molecule (experimental value), Theoretical improvements in bond energy of hydrogen molecule, 3.1.2 Concept of resonance and Formal Charge; rules for resonance or canonical structures with examples. 3.2 **Molecular Orbital Theory** 3.2.1. Concept of orbital overlaps, types of orbital overlaps (s-s,s-p,p-p) 3.2.2. Linear combination of atomic orbitals to form molecular orbitals (LCAO-MO approach). 3.2.3. Application of MOT to Homonuclear diatomic molecules from He_2 molecule and for all the elements of second period, heteronuclear diatomic molecules (HCl, NO) 3.2.4 Molecular orbital Theory and determination of Bond Order and magnetic behavior for $O_2, O_2^+ O_2^-, O_2^{2-}$ (Problems are expected wherever applicable)	**(8L)**

Semester III
Course Code: RUSCHE302
Paper: II (Organic and Inorganic Chemistry)
Credits: 2

Learning Objectives :

After introduction to the fundamentals of Organic Reaction Mechanism in the FYBSc Class, the student is expected to apply these concepts to various functional groups like the Halogen Derivatives, Arenes, Phenols, Ethers and Epoxides. So also, the student is now newly introduced to the Organometallic Compounds viz Organomagnesium and Organolithium compounds. Chemistry of p-block elements will facilitate students to understand the concept of electron-deficient compounds. Also the chemistry of Silicon and Germanium is very important as the compounds of these elements have immense commercial importance. Chemical reactivity of Nitrogen group, their hydrides and their oxides have major environmental impact.

Learning Outcome:

After studying this syllabus, the student will know

- Reactions and reactivity of halogenated hydrocarbons.
- Nomenclature, nature, type and reactivity of carbon-metal bond of Organomagnesium and organolithium compounds.
- Preparation and reactions of Organomagnesium and organolithium compounds.
- Nomenclature, Preparation and reactions of Alcohols, phenols and epoxides.
- Comparative acidic strengths of alcohols and phenols.
- Mechanisms of some condensation reactions.
- Active methylene compounds and their synthetic applications.
- Concept of electron deficient compounds and its correlation with Lewis acidity;
- Structure and bonding in diborane and tetraborane; formation of banana bond

- Synthesis of Borax-compound with commercial importance.
- The electronic configuration of group 14 elements
- Silicon compounds ; their occurrence; structure and inertness of SiO_2
- Synthesis of commercially important hydride of nitrogen i.e. Ammonia by Haber's process.
- Physicochemical principles involved in the synthesis.

Unit I	**Organic Chemistry** **1.1. Reactivity and reactions of halogenated hydrocarbons:** 1.1.1. **Alkyl halides:** Nucleophilic substitution reactions: S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects, factors affecting nucleophilic substitution reactions: nature of substrate, solvent, nucleophile and leaving group. 1.1.2. **Aryl halides:** Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution (S_NAr), addition-elimination and benzyne mechanism. **1.2 Organomagnesium and organolithium compounds:** Type, Nomenclature. Nature, and reactivity of carbon-metal bond. Method of preparation using alkyl / aryl halide. Structure, stability and reactions of these compounds with compounds containing, acidic hydrogen, carbonyl, cyanides group, epoxides and CO_2. **1.3 Alcohols, phenols and epoxides:** 1.3.1.**Alcohols:** Nomenclature, Methods of Preparation: 1. Hydration of alkenes 2.Hydrolysis of alkyl halides 3. Reduction of aldehydes and ketones 4. Using Grignard reagent. Properties: Hydrogen bonding, effect of hydrogen bonding on properties. Acidity of alcohols, Reactions of alcohols 1.3.2. **Phenols:** methods of preparation, physical properties and acidic character, comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion, reactions of phenols. 1.3.3.**Epoxides:** Nomenclature, methods of preparation and reactivity of epoxides, reactions of epoxides, ring opening reactions by nucleophiles , acid hydrolysis, reaction with halogen halide, alcohol, hydrogen cyanide. Reactions with ammonia, amines, Grignard reagents, alkoxides.	**(4L)** **(3L)** **(8L)**
Unit II	**Organic Chemistry** **2.1 Carbonyl Compounds:** 2.1.1 Nomenclature of aliphatic, alicyclic and aromatic carbonyl compounds, structure, reactivity of aldehydes and ketones .	**(15L)**

	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. 2.1.2 Mechanism of nucleophilic addition, and acid catalyzed nucleophilic addition reactions. 2.1.3 Reactions of aldehydes and ketones with $NaHSO_3$, HCN, RMgX, alcohol, amine, phenyl hydrazine, 2,4-Dinitrophenyl hydrazine, $LiAlH_4$ and $NaBH_4$. 2.1.4 Mechanism of the following reactions: Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt and Cannizzaro reaction. 2.1.5 Keto-enol tautomerism: mechanism of acid and base catalysed enolization 2.1.6 Compounds with active methylene: Acetylacetone, ethyl acetoacetate diethyl malonate, stabilised enols. Reactions of Acetylacetone and ethyl acetoacetate: alkylation, conversion to ketone, mono- and dicarboxylic acid.	
Unit III	**3.0 Chemistry of p block elements (Group 13 & 14)** **3.1 Chemistry of Group 13 elements** 3.1.1 Electronic configuration, Trends in metallic characters: Oxidation states and Inert pair effect. 3.1.2 Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. 3.1.3 Preparation of simple boranes like diborane and tetraborane. 3.1.4 Structure and bonding in diborane and tetraborane (2e-3c bonds) 3.1.5 Borazine – Preparation, properties, Structure and bonding. **3.2 Chemistry of Group 14 elements** 3.2.1 Electronic configuration, Trends in metallic characters: Oxidation states and Inert pair effect. 3.2.1 Silica: Occurrence, Structure and inertness. 3.2.2 Methods of preparation of $SiCl_4$ and its structure. 3.2.3 Preparation of extra pure Silicon – Zone refining and Single Crystal method 3.2.4 Silicones – Preparation, classification, properties and uses.	**(15L)**

Semester III
Paper: III (Analytical Chemistry)
Course Code: RUSCHE303
Credits: 2

Learning Objectives:

Analytical Chemistry is of utmost importance since it requires thorough knowledge of all other branches of chemistry. The current syllabus introduces the learner to the basic concepts of Analytical chemistry and various methods of analysis which have major industrial and academic relevance.

Learning Outcome:

After studying the syllabus, the student will be able to understand the following nuances of analytical chemistry:

- Scopes and Importance of Analytical Chemistry
- Concept of Accuracy and Precision
- Classical Methods of Analysis
- Chemistry of Water and various aspects of assessment of quality of water.

Unit I	**1.1 Introduction to analytical chemistry** **1.1.1** - Scope and importance of analytical chemistry, difference between analytical chemistry and chemical analysis, qualitative and quantitative analysis, steps involved in analytical chemistry, types of analysis on the basis of sample size and the components estimated. Factors for choosing a method. **1.1.2** Classification of analytical methods, classical and instrumental, subdivision of classical and instrumental methods with the emphasis on the property measured, devices used and the nature of analysis . **1.1.3** Steps involved in chemical analysis from sampling to presentation of results and the conclusions. **1.1.4** Performance characteristics of an analytical method- qualitative and quantitative: LOD. LOQ. dynamic range, working range, sensitivity, selectivity. **1.1.5** Quantitative analysis using calibration curve method, standard addition method and internal standard method **1.1.6** LR and AR grade chemicals, MSDS of chemicals, glassware and its categories, calibration of volumetric glassware, burettes, pipettes and volumetric flasks. **1.1.7** Measurement, errors involved in the measurement, propagation of errors, random, gross and determinate errors, classification of determinate errors ,instrumental, methodic, operational personal errors, minimization of errors. **1.1.8 A**ccuracy and precision, measures of accuracy: absolute error and relative error, constant error and proportionate error, measures of central tendency and dispersion: mean, mode, median, deviation, absolute, relative, average, standard deviation, range, review of data with respect to accuracy and precision.	**(15L)**

Unit II	**Classical methods of analysis** **2.1 Gravimetric analysis:** **2.1.1** Introduction to gravimetric analysis, types of gravimetric analysis, conditions for a reaction to be used in gravimetric analysis, solubility and solubility product, factors affecting solubility: temperature, common and diverse ion effect, pH, nature of the solvent, complexation. **2.1.2** Unit operations in gravimetric analysis, precipitation, homogenous and heterogeneous precipitation, relative super saturation, nucleation and crystal growth, their effect on particle size, Ostwald's ripening, impurities associated with precipitate formation, filtration, washing of the precipitate, drying and incineration, use of thermal methods. **2.2 Titrimetric analysis** **2.2.1** Introduction to titrimetric analysis, conditions for a reaction to be used in titrimetric analysis, terms involved: titrant, titrand, indicator, equivalence point, endpoint, titration error, types of titrations. **2.2.2 Acid –base titrations** **2.2.2.1** Acid base indicators, theory of acid base indicators, conditions for choosing an indicator. **2.2.2.2** Types of acid base titrations, titration curves. **2.2.2.3** Construction of the titration curves and the choosing of the indicator for A) strong acid –strong base B) strong acid –weak base C) weak acid – strong base D) weak acid –weak base **2.2.4** Titration of dibasic acid with a strong base, condition for obtaining two separate equivalence points, qualitative description of the titration curve, determination of the dissociation constant **2.2.4** Titration of phosphoric acid with a strong base	**(07L)** **(08L)**
Unit III	**Environmental Chemistry** **3.1** Chemistry of water **3.1.1** Water as a natural resource : Physical and Chemical properties of water, significance of water as an universal solvent and its properties viz. pH , Dielectric constant ,boiling point. Anomalous behaviour of water. **3.1.2** Hydrological cycle. chemical composition of ground water. **3.1.3** Factors affecting solubility of gases in water . Solubility of CO_2 and O_2 in water **3.1.4** Water quality : Parameters for determining water quality i) Physical parameters: - pH, pE, conductivity, TS , TSS, TDS ii) Chemical Parameters- acidity, alkalinity, hardness, salinity , chlorine demand , DO, COD, iii) Biological parameter – BOD, MPN **3.1.5** Standards for Potable and industrial water.	**(15L)**

Semester- III
Chemistry Practicals I, II and III
Credits: 3

Course Code	Experiments
RUSCHEP301	**Physical Chemistry** 1. To study the kinetics of the reaction between $K_2S_2O_8$ and KI for equal concentration. 2. To determine conductance, specific conductance and molar conductance for given electrolyte solution. 3. To determine degree of dissociation and dissociation constant of weak electrolyte and hence to verity Ostwald's dilution law. 4. To determine solubility of a sparingly soluble salt conductometrically. 5. To determine the amount of strong acid in the given solution by conductometric titration. 6. To determine the amount of strong acid in the given solution by pH-metric titration. **Paper II Inorganic and Organic Chemistry** Qualitative determination of anion and Quantitative determination of cation from the salts such as copper sulphate pentahydrate, nickel chloride hexahydrate, anhydrous cupric chloride using volumetric methods.(Students will prepare EDTA solution)
	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. **Preparation of:** 1. Cyclohexanone oxime from cyclohexanone. 2. Tribromoaniline from aniline. 3. m-Dinitrobenzene from nitrobenzene 4. Phthalic anhydride from phthalic acid by sublimation 5. Preparation of 5-nitrosalicylic acid from salicylic acid. 6. Benzoic acid from benzamide. 7. Magneson – II from p-nitroaniline
	Chemistry practicals III 1. Gravimetric estimation of Nickel (II) as Ni-DMG. 2. Gravimetric estimation of barium ions as $BaSO_4$. 3. To carry out the calibration of pipette and burette. 4. To determine hardness of given water sample. 5. To determine Dissolved Oxygen of the given water sample. 6. To determine the COD of water sample.

Semester IV
Paper: I (Physical and Inorganic Chemistry)
Course Code: RUSCHE401
Credits: 2

Learning Objectives:

The current syllabus aims at correlating the concepts that the learner has understood in the previous semester. The first unit correlates the thermodynamic parameters with EMF measurements. Also, the classification of galvanic cells and their applications are studied. The concept of pH and Buffer action is of immense importance since it has major biological implications. Keeping in mind the syllabi of TYBSc, the learner is introduced to the basic concepts of the Solid State chemistry, Phase Rule and its applications and Co-Ordination chemistry.

Learning Outcome :

After studying the syllabus, the student will be able to have thorough knowledge of the following aspects of Physical and Inorganic Chemistry

- Significance of Gibbs' and Helmholtz Free Energy and its applications to EMF measurements.
- Types of Electrodes and Electrochemical Cells
- Nernst Equation and its importance.
- Calculation of pH for strong and weak electrolytes.
- Buffer Action
- Laws of Crystallography
- Bragg's Equation and its applications.
- Phase Rule and its applications to One-Component and Two-Component systems.
- Various Properties of Transition Metals
- Basic Terms involved in Co-ordination chemistry, Werner's Theory
- Applications of Co-Ordination Compounds
- Nature of the Metal-Ligand Bond

Unit I	**Physical Chemistry** **1.1 Electrochemistry-II: Electromotive Force of Galvanic Cells** 1.1.1 Electrochemical cells, galvanic cells, reversible cells and reversible electrodes, conventions to represent Galvanic cells. 1.1.2 Types of electrodes, standard electrode potential, Electrochemical series. 1.1.3 Cell potential and standard cell potential. 1.1.4 Nernst equation and its importance. 1.1.5 Calculation of thermodynamic parameters: ΔG, ΔH, ΔS and equilibrium	**(10L)**

	constant from EMF data. 1.1.6 Classification of galvanic cells: chemical cells and concentration cells 1.1.7 Determination of pH using glass electrode and quinhydrone electrode. **1.2 pH and Buffers** 1.2.1 pH concept, calculation of pH for strong and weak electrolytes 1.2.2 Buffer, Henderson's equation for acidic and basic buffer 1.2.3 Buffer Capacity. Numerical Problems based on 1.2	**(5 L)**
Unit II	**Physical Chemistry** **2.1 Solutions of Liquid In Liquid** **2.1.1** Thermodynamics of ideal solutions: ideal solutions and Raoult's law, deviations from Raoult's law. **2.1.2** Vapour pressure-composition and temperature –composition curves of ideal and non-ideal solutions. Distillation of liquids forming ideal and non-ideal solution, Azeotropes, steam distillation. **2.1.3** Partially miscible liquids: critical solution temperature; systems with upper critical solution temperature, lower critical solution temperature and having both. **2.1.4** Nernst distribution law and its applications to solvent extraction. **2.2 Phase Equilibria** **2.2.1** Terms involved: Phases, components and degrees of freedom. Gibbs Phase Rule. **2.2.2** Phase diagrams of one-component systems (water, CO_2 and sulphur). **2.2.3** Two component systems involving eutectic (lead-silver system)	**(8 L)** **(7L)**
Unit III	**Unit-III** **3.1 Comparative Chemistry of the transition metals** **3.1.1** Position in the periodic table, electronic configuration. **3.1.2** Significance of special stability of d^0, d^5 and d^{10} configurations, Variable oxidation states and their stabilities in aqueous solutions; ability to form complexes, colour, magnetic property, catalytic property, **3.2 Coordination Chemistry:** **3.2.1** Historical perspectives; **3.2.2**Molecular compounds – Double salts and Complex salts **3.2.4** Werner's theory **3.2.5**Basic terms viz complex ion, charge on the complex, ligands, coordination number, oxidation state, & Nomenclature **3.2.6** Sidgwick – Powel Theory of coordination compounds; Effective atomic number rule. **3.2.7** Stereoisomerism and optical isomerism of coordination compounds (C.N= 4	**(6 L)** **(5 L)**

	and 6) **3.2.8** Evidence for the formation of coordination compounds. **3.2.9**. Application of coordination compounds. **3.3. Nature of the Metal-Ligand Bond:** **3.3.1** Application of VBT to complexes with coordination number 4, 5 & 6, Inner and outer orbital complexes.	**(4L)**

Semester IV
Paper: II (Organic and Inorganic Chemistry)
Course Code: RUSCHE402
Credits: 2

Learning Objectives :

This syllabus stresses on the applications of fundamentals of Organic Reaction Mechanism to various functional groups like carboxylic and sulphonic acids and their derivatives. It also introduces the learner to Nitrogen containing compounds and heterocycles which play a major role in synthesis of biologically active compounds. The nature of the metal-ligand bond is further explored and the applications of metal carbonyls are introduced to the learner. Along with this, the learner also is introduced to the importance of certain essential elements to the living system.

Learning Outcome:

After studying this syllabus, the student will have knowledge of

- Reactions and reactivity of Carboxylic and sulphonic Acids and their derivatives
- Nomenclature, nature, type and reactivity of Amines and Diazonium Compounds
- Preparation and reactions of Heterocyclic Compounds- Furan, Pyrrole and Thiophene
- Fundamentals of Organometallic Chemistry
- Role of essential metal ions in Biological systems
- Chemistry of Inorganic Polymers such as Silicones and their various applications.

Unit I	**Organic Chemistry** **1.1 Carboxylic acids and their derivatives:** 1.1.1. Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids. 1.1.2. Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard reagent and hydrolysis of nitriles. 1.1.3. Reactions: Acidity, salt formation, decarboxylation, reduction of carboxylic acids with $LiAlH_4$, diborane, Hell-Volhard-Zelinsky reaction, conversion to acid chlorides, esters, amides and acid anhydrides and their relative reactivity. 1.1.4. Mechanism of nucleophilic acyl and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution. 1.1.5. Mechanism of Claisen condensation and Dieckmann condensation.	**(11L)**

	1.2 Sulphonic acids: 1.2.1 Nomenclature, preparation of aromatic sulphonic acids by sulphonation of benzene (with mechanism), toluene and naphthalene. 1.2.2 Reactions: Acidity of arene sulfonic acid, comparative acidity of carboxylic acid and sulfonic acids, salt formation, desulphonation reaction with alcohol, phosphorous pentachloride, IPSO substitution.	**(4L)**
Unit II	**Organic Chemistry** **2.1 Amines:** 2.1.1 Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines. 2.1.2. Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCI, Sn-HCl, Zn-acetic acid. Reduction of nitriles, ammonolysis of halides, reductive amination, Hofmann bromamide reaction. 2.1.3 Reactions: salt Formation, N-acylation, N-alkylation, Hofmann's exhaustive methylation (HEM), Hofmann-elimination, carbylamine reaction, reaction with nitrous acid, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation. **2.2 Diazonium Salts**: 2.2.1 Preparation: - Sandmeyer reaction, Gattermann reaction, Gomberg reaction Reactions: Replacement of diazo group by -H,-OH. Azo coupling with phenols, naphthols and aromatic amines, reduction of diazonium salt to aryl hydrazine and hydroazobenzene. Synthetic application. **2.3 Heterocyclic Compounds:** 2.3.1. Classification, nomenclature, electronic structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom. 2.3.2. Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis). 2.3.3. Reactivity of furan, pyrrole and thiophene towards electrophilic substitution reactions on the basis of stability of intermediate and of pyridine on the basis of electron distribution. Reactivity of pyridine towards nucleophilic substitution on the basis of electron distribution. 2.3.4. 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. 2.3.5. Pyridine: Basicity. comparison of basicity of pyridine, pyrrole and piperidine. Reaction: sulphonation (with and without catalyst), Chichibabin reaction.	**(4L)** **(3L)** **(8L)**

Unit III	**Unit III: Inorganic Chemistry** **3.1 Chemistry of Group 15 and 16 Elements** 3.1.1 Trends in physical and chemical properties of Group – 15 and Group – 16 Elements 3.1.2 Study of Compounds such as oxyacids of N and S with respect to preparation, properties and structure. 3.1.3 Physical properties of Hydrides of Group 15 and 16 Elements with respect to H- bonding. **3.2 Organometallic Chemistry** 3.1.1 Introduction, definition, classification based on hapticity and nature of metal-carbon bond. Eighteen electron rule and its applications, exceptions 3.1.2 Importance and few applications of organometallic compounds as catalysts (e.g. Ziegler-Natta catalyst, Wilkinson), reagents in organic synthesis etc. 3.1.3 Metal carbonyls: Bonding, general method of preparation and properties of $Ni(CO)_4$, $Fe(CO)_5$.	**(8L)** **(7L)**

Semester IV
Paper: III (Analytical Chemistry)
Course Code: RUSCHE403
Credits: 2

Learning Objectives:
Analytical Chemistry is of utmost importance since it requires thorough knowledge of all other branches of chemistry. The current syllabus introduces the learner to the basic concepts of Analytical Chemistry and makes the student familiar with various chromatographic techniques and separation methods along with methods of Instrumental Analysis. It also introduces the learner to various industrially important Unit Operations.

Learning Outcome:
After studying the syllabus, the student will be able to understand the following nuances of analytical chemistry:

- Separation and Purification Methods
- Methods of Instrumental Analysis
- Solvent Extraction
- Unit Operations

Unit I	**Analytical Chemistry:** **1.1 Separation Techniques in analytical Chemistry** **1.1.1 Introduction to separation Techniques** **1.1.2** Separation and its importance in analytical chemistry, estimation without separation. **1.1.3** Classification of separation methods physical and chemical **1.1.4** Chemical methods, precipitation, complex formation. **1.1.5** Physical methods of separation, precipitation, fractional precipitation, volatilization, distillation, fractional distillation, vacuum distillation. **1.2 Solvent extraction** **1.2.1** Nernst's distribution law, partition coefficient, distribution ratio, **1.2.2** Percentage extraction, extraction efficiency, percentage extraction for single step and multistep process with the same total volume of the extracting solvent **1.2.3**. Modes of extraction: Chelation, ion-pair formation and solvation. **1.2.4** Batch and continuous extraction, Counter current extraction **1.3 Chromatography** **1.3.1** Introduction, Stationary and mobile phase, common features of all chromatographic techniques, classification of chromatographic methods on the basis of physical state of the two phases. **1.3.2Paper chromatography** **1.3.2.1** Introduction and basic principles. **1.3.2.2** Stationary phase, transfer of the sample, mobile phase. **1.3.2.3** Methods of developing the chromatogram, methods of detection, physical, chemical and enzymatic.	**(8L)** **(07L)**

	1.3.2.4 Applications. **1.3.2.5** Comparison of the paper and thin layer techniques. **1.3.3 Thin layer chromatography** **1.3.3.1** Introduction, mechanism of separation, retardation factor, basic principles. **1.3.3.2** Stationary phase, preparation and transfer of the sample, mobile phases and their nature. **1.3.3.3 Methods** of development of the chromatogram, detection methods, physical and chemical. **1.3.3.4** Applications, for determination of purity, following the course of a chemical reaction.	
Unit II	**2.1 UV- Visible Absorption spectroscopy:** **2.1.1** Recapitulation of basic concept of spectroscopy. **2.1.2** Terms involved in absorption spectroscopy, monochromatic and polychromatic radiation, radiant power, absorbance, transmittance, absorptivity, molar extinction coefficient, wavelength of maximum absorption. **2.1.3** Statement of Beer's law & Lamberts' law combined mathematical expression for Beer- Lambert's Law, deviations from Beer-Lambert's law, types of deviations. **2.1.4** Components of an optical instrument and their functions, photometers and spectrophotometers. 2**.1.5** Photometers: Sources, monochromators, sample containers and detectors, block diagram for a single and double beam photometer. (Numerical problems expected.) **2.2 Photometric titrations** **2.2.1** Basic principles, experimental set up and operational procedures, **2.2.2** Requirements for a photometric titration, types of photometric titration curves, and determination of equivalence point. **2.2.3** Advantages and limitations **2.3 Conductometric titrations** **2.3.1** Conductometry and conductometric titrations, basic principles, operational procedure,determination of the equivalence point., **2.3.2** Conductometric titration curves for the titration of 1] Acid –base titrations of all types 2] Mixture of a weak acid and a strong acid vs strong base and vice versa. 3] Mixture of acid ans salt ag. base 4] Precipitation titrations 5] Complexometric titrations **2.3.3** Advantages and limitations.	**(8L)** **(4L)** **(3L)**
Unit III	**Industrial Chemistry** 3.1 Concept of quality, Quality assurance, Product Development (Formulation), Stability Study, Quality control, Validation System, Audits. 3.2 International Standards and their significance	**(15L)**

	3.3 Unit Operations- Filtration, Distillation, Fractional distillation, Crystallisation	

Semester IV
Chemistry Practicals I, II and III
Credits: 3

Course Code	Experiments
RUSCHEP401	**Chemistry Practicals I** **(Paper-I): Physical Chemistry** 1. To determine order of the reaction between $K_2S_2O_8$ and KI for unequal concentrations. 2. To determine dissociation constant of weak acid by incomplete titration method using pH meter. 3. To determine dissociation constant of weak acid by pH metric titration. 4. To determine the amount of strong acid in the given solution by potentiometric titration 5. To determine standard cell potential (E^{o}_{cell}), standard free energy change (ΔG^{o}) and equilibrium constant (K) for a given galvanic cell. 6. To determine the amount of weak acid in the given solution by conductometric titration. **(Paper-II): Organic Chemistry:** Qualitative Analysis of bi-functional organic compounds (minimum six) on the basis of 1. Preliminary examination 2. Solubility profile 3. Detection of elements C, H, (O), N, S and X. 4. Detection of functional groups 5. Determination of physical constants (M.P/B.P) Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysisto be given: Carboxylic acids, phenol, carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halides.
	Chemistry Practicals II : Inorganic Chemistry **Inorganic preparation –** 1. *Tris* (ethylene diamine) nickel (II) thiosulphate. 2. preparation of Copper DMSO 3. Preparation of magnesium oxalate.

	Chemistry Practicals III **Analytical Chemistry** 1. Chromatography: a) Separation of cations Fe(III), Ni(II) and Cu(II) in a sample by paper chromatography b) Separation of a mixture of o-and p-nitrophenols by thin layer chromatography (TLC) 2. To determine partition coefficient of iodine between water and CCl_4 3. Estimation of Fe(II) in the given solution by titrating against $K_2Cr_2O_7$ potentiometrically. 4. Determination of amount of Fe (III) in the given solution by photometric titration using salicylic acid . 5. To verify Beer Lamberts law. 6. Determination of Calcium and Magnesium in the given sample of Dolomite ore. 7. To determine the purity of the given commercial sample of aspirin using phenol red indicator.

Reference Books for Physical Chemistry:

1) The Elements of Physical Chemistry, P.W. Atkins, Oxford University Press, Oxford.
2) University General Chemistry. By C.N. R. Rao Mc. Millan Publication.
3) Principles of Physical Chemistry. By Maron and Pruton 4th Ed. Oxford and IBH publication.
4) Physical Chemistry, G.M. Barrow, Tata McGraw Hill Publishing Co.Ltd. New Delhi.
5) Physical Chemistry, G.Castellan, Narosa Publishing House.
6) Modern Electrochemistry, J.O'M. Bockris & A.K.N. Reddy, Maria. Gamboa – Aldeco. Springer.
7) Chemical Kinetics. By Keith J. Laidler, G. K. Rollefson, Publisher, Pearson Education
8) Fundamentals of Molecular Spectroscopy by Colin N. Banwell, Elaine M. McCash, McGraw-Hill publishers.
9) Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
10) Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
11) Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
12) Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)

References for Organic Chemistry:

1. Organic Chemistry, F. A. Carey, Tata McGraw-Hill Publishing company Ltd.
2. Paula Y. Bruice, Organic Chemistry, Pearson Education.
3. Organic Chemistry, Finar, I. L. (Volume 1), Dorling Kindersley (India) Pvt. Ltd.
4. Heterocyclic Chemistry, Synthesis reactions and Mechanisms, R.K Bansal, Wiley Eastern Ltd.
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

6. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
8. 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

Reference Books for Inorganic Chemistry

1. *Practical Inorganic Chemistry* by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
2. Inorganic Chemistry – Gary Wulfsberg, Viva Book, First Indian Edition 2002
3. Quantitative Analysis – R.A.Day, A.L. Underwood, sixth edition
4. Vogel's Textbook of quantitative chemical analysis – J Mendham, R C Denny, J D Barnes, M Thomas, B Sivasankar
5. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS, The group III elements Pg. 359-648.
6. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999) page 325-446.
7. CNR Rao edited, University General Chemistry, 513-578.
8. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).
9. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry, page 416-628.
10. Bruce H. Mahan, University Chemistry, Narosa publishing house.
11. *Practical Inorganic Chemistry* by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)

References for Paper III:

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
5. Asim K. Das, 'Environmental Chemistry with Green Chemistry' Books & Allied (P) Ltd.
6. K.A. Gavhane, 'Unit operations-I and II'

Modality of Assessment:

Theory Examination Pattern:

A) Internal Assessment – 40% **40 marks.**

Sr.No	Evaluation type	Marks
1	One Assignment	15
2	One class Test (multiple choice questions / objective/ numerical)	20
3	Active participation in routine class instructional deliveries(case studies/ seminars//presentation)	05

B) External examination – 60 %

Semester End Theory Assessment - 60% **60 marks**

These examinations shall be of **two hours** duration.

There shall be **three** questions each of **20** marks. On each unit there will be one question.

All questions shall be compulsory with internal choice within the questions.

Theory question paper pattern is as follows :-

Questions	Options	Marks	Questions on
Q.1)A)	Any 4 out of 6	16	Unit I
Q.1)B)	Any 4 out of 6	04	
Q.2)A)	Any 4 out of 6	16	Unit II
Q.2)B)	Any 4 out of 6	04	
Q.3)A)	Any 4 out of 6	16	Unit III
Q.3)B)	Any 4 out of 6	04	

Practical Examination Pattern:

(A)Internal Examination:-

	Paper I	**Paper II**	**Paper III**
Journal	05	05	05
Test	10	10	10
Participation	05	05	05
Total	20	20	20

(B) External (Semester end practical examination) **30 Marks Per Section**

Sr.No.	**Particulars**	**Marks**	**Total**
1.	**Laboratory work**	**25 + 25+ 25**	**= 75**
2.	**Viva**	**05 + 05 +05**	**= 15**

PRACTICAL BOOK/JOURNAL

Semester III and IV:

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / Incharge of the department ; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Semester III

Course	301			302			303			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	300
Practicals	20	30	50	20	30	50	20	30	50	150

Semester IV

Course	401			402			403			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	300
Practicals	20	30	50	20	30	50	20	30	50	150

(Total: 900 marks)

S.P. Mandali's
Ramnarain Ruia Autonomous College

Syllabus for T.Y.B.Sc
Programme – B.Sc.
Course: Chemistry (RUSCHE)
Resolution No. AC/II(18-19).2.RUS5

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

SEMESTER V

Paper I : PHYSICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE501	**I**	Molecular spectroscopy	**2.5**	**15**
	II	Electrochemistry-III Classification of galvanic cells		**15**
	III	Colligative properties Chemical kinetics-II		**09** **06**
	IV	Surface chemistry & catalysis Colloids		**08** **07**

PAPER II: INORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE502	**I**	Chemical bonding: Molecular symmetry Molecular orbital theory for polyatomic species Metallic bonding	**2.5**	**07** **05** **03**
	II	Solid state chemistry		**15**
	III	Chemistry of elements: lanthanides & actinides		**15**
	IV	Chemistry of non aqueous solvents, inter-halogen compounds and xenon		**15**

PAPER III: ORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE503	I	Mechanism of organic reactions	2.5	15
	II	Stereochemistry		15
	III	IUPAC nomenclature Polymers		06 09
	IV	Synthesis of organic compounds		15

PAPER IV: ANALYTICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE504	I	Sampling Treatment of analytical data	2.5	15
	II	Titrimetric analysis: Redox titrations Precipitation titrations Complexometric titrations Non-aqueous titrations		15
	III	Atomic absorption spectroscopy Atomic emission methods Fluorescence and phosphorescence spectroscopy Nephelometry and turbidimetry		15
	IV	Thermal methods Radioanalytical techniques Mass spectrometry Method validation		15

PRACTICALS: SEMESTER V

Course Code	UNIT	TOPICS	Credits
RUSCHEP501	**I**	**PRACTICALS OF COURSE RUSCHE501 & RUSCHE502**	**3**
RUSCHEP502	**II**	**PRACTICALS OF COURSE RUSCHE503 & RUSCHE504**	**3**

SEMESTER VI

Paper I: PHYSICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE601	**I**	NMR spectroscopy Polymers	**2.5**	**08** **07**
	II	Electrochemistry-IV: decomposition potential, overvoltage and electroplating renewable sources		**08** **07**
	III	Nuclear chemistry-III		**15**
	IV	Basics of quantum chemistry		**15**

PAPER II : INORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE602	I	Coordination chemistry	2.5	15
	II	Properties of coordination compounds		15
	III	Organometallic chemistry		15
	IV	Nanomaterials Bioinorganic chemistry		08 07

PAPER III: ORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE603	I	Chemistry of carbohydrates Catalysts & reagents	2.5	09 06
	II	Chemistry of amino acids, proteins and nucleic acids Photochemistry		08 07
	III	Spectroscopy –I		15
	IV	Spectroscopy -II		08
		Natural products		07

PAPER IV: ANALYTICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE604	**I**	Separation techniques (GC, HPLC,HPTLC, ion exchange chromatography)	**2.5**	**15**
	II	Electroanalytial techniques: Ion selective electrodes Polarography Amperometric titrations		**15**
	III	**Miscellaneous Methods** Potentiometric Titrations Bi-amperometric titrations Gel electrophoresis Size exclusion chromatography		**15**
	IV	**Applications to different fields**: Food analysis Cosmetic analysis Detergent analysis Water analysis Pharmaceutical analysis		**15**

PRACTICALS :SEMESTER VI

Course Code	UNIT	TOPICS	Credits
RUSCHEP601	**I**	**PRACTICALS OF COURSE RUSCHE601 & RUSCHE602**	**3**
RUSCHEP602	**II**	**PRACTICALS OF COURSE RUSCHE603 & RUSCHE604**	**3**

Detail Syllabus
Academic Year 2019-20

SEMESTER V
Paper-I: Physical Chemistry
Course Code: RUSCHE501
Credits: 2.5

Learning Objectives:

The learner is already introduced to the fundamental concepts of Physical Chemistry in his lower classes. In the current syllabi, he is introduced to the concept of Molecular Spectroscopy whereby he is introduced to the Rotational, Vibrational and Raman Spectra of Molecules. The subject of Electrochemistry is further explored on the basis of the concepts learnt in the lower classes. Advanced applications of Raoult's low to study colligative properties are also studied. The learner is finally introduced to Surface Chemistry and its applications to colloids.

Learning Outcome:

After studying the current syllabi, the student will have detailed knowledge of

- Rotational, Vibrational and Raman Spectra of Molecules.
- Galvanic Cells and Applications of Fundamentals of Electrochemistry
- Application of Raoult's Law and Clapeyron Equation to study Colligative Properties
- Advanced Kinetic Studies
- Surface Chemistry and its application to Colloids

Unit I	**1 MOLECULAR SPECTROSCOPY** 1.1 Rotational Spectrum: Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia, energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of inter-nuclear distance and isotopic shift. 1.2 Vibrational spectrum: Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum. 1.3 Vibrational-Rotational (IR) spectrum of diatomic molecule: vibrating rotor, energy levels, selection rule, nature of spectrum, P and R branch lines, anharmonic oscillator, energy levels, selection rule, fundamental band, overtones. Applications of vibrational- rotational spectrum in determining force constant and its significance infrared spectra of simple molecules like H_2O and CO_2 1.4 Raman Spectroscopy: Scattering of electromagnetic radiation, Rayleigh	**(15L)**

	scattering, Raman scattering, nature of Raman spectrum (Stoke's lines and anti Stoke's lines), Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion (example of CO_2 molecule). Number of modes of vibrations for linear and non-linear molecules	
Unit II	**2 ELECTROCHEMISTRY- III: CLASSIFICATION OF GALVANIC CELLS** 2.1 Lewis concept of Activity and Activity coefficient, Mean ionic activity and mean ionic activity coefficient of an electrolyte, ionic strength of a solution, Debye-Huckel limiting law. 2.2 Classification of galvanic cells: Chemical Cells and concentration cells, Cells with transference and without transference, Expression for EMF of each type of cell. 2.3 Origin of liquid junction potential and its elimination. 2.4 Determination of solubility product and solubility of a sparingly soluble salt by Chemical cell and by Concentration cell. 2.5 Determination of liquid junction potential.	**(15L)**
Unit III	**3.1 COLLIGATIVE PROPERTIES** 3.1.1 Colligative properties, Raoult's law. 3.1.2 Relative lowering of vapour pressure. 3.1.3 Elevation of boiling point – Thermodynamic derivation for relation between elevation of boiling point and molality. 3.1.4 Depression in freezing point- Thermodynamic derivation for relation between depression in freezing point and molality 3.1.5 Osmosis and Osmotic Pressure – Determination of molar mass form Osmotic pressure. Abnormal molar masses of solute, van't Hoff factor (Degree of dissociation and degree of association). Reverse osmosis. **3.2 CHEMICAL KINETICS-II** 3.2.1 Recapitulation, Collision theory of reaction rates, applications of collision theory to bimolecular reaction and unimolecular reaction (Lindemann's theory), Merits and demerits of Collision theory. Steric factor and Probability factor. 3.2.2 Activated complex theory of bimolecular reactions. Merits of Activated complex theory. 3.2.3 Classification of reactions- slow, fast and ultra fast, study of kinetics of fast reactions by STOP FLOW method.	**(9L)** **(6L)**
Unit IV	**4.1 SURFACE CHEMISTRY AND CATALYSIS** 4.1.1 Adsorption: Physical and Chemical Adsorption, Types of adsorption isotherms, Langmuir's adsorption isotherm. B.E.T. equation for multilayer	**(8 L)**

	adsorption, determination of surface area of an adsorbent using B.E.T. equation. 4.1.2 Catalysis: Homogeneous and heterogeneous catalysis, catalytic activity and selectivity, promoters, inhibitors, catalyst poisoning and deactivation. 4.1.2.1 Acid catalysis and Base catalysis, mechanism and kinetics of acid and base catalyzed reactions, effect of pH on acid and base catalyzed reactions. 4.1.2.2 Enzyme catalysis, mechanism and kinetics of reaction (Michaelis-Menten equation). **4.2 COLLOIDS** 4.2.1 Introduction to colloidal state of matter. 4.2.2 Origin of charge on colloidal particles. Concept of electrical double layer, zeta potential, Helmholtz and Stern model, electrokinetic phenomena: electrophoresis, electro-osmosis, streaming potential and sedimentation potential. 4.2.3 Colloidal electrolytes. 4.2.4 Donnan Membrane Equilibrium. **4.2.5** Surfactants, Micelle formation, application of surfactants in detergents, food industry and pesticide formulations.	**(7 L)**

SEMESTER V
Paper-II: Inorganic Chemistry
Course Code: RUSCHE502
Credits: 2.5

Learning Objectives:

Having studied the applications of the Molecular Orbital Theory for Homonuclear and heteronuclear diatomic molecules, it was essential to introduce the learner with heteronuclear polyatomic molecules. Also, the importance of symmetry elements, symmetry operations and concept of point group in chemistry is required to be understood by the learner which is quite important to understand the orientation of molecules in space. The structure of solids and defects in solids have a major application in the study of the physical parameters of compounds. The chemistry of inner transition elements is newly introduced at the TYBSc level which completes the discussion of all the four blocks of elements of the periodic table.

Learning outcome:

After a detailed study of this syllabus, the student will be able to undertand

- Importance of symmetry in chemistry.
- Concept of Point Group
- Correlation between Bond angle and Molecular Orbitals
- Band Theory and its application to metals
- Structure of Solids and their defects
- Comparison between Lanthanides and Actinides.
- Properties and Application of Uranium
- Properties of Xenon and other noble gases

Unit I	**Chemical Bonding** **1.1 Molecular Symmetry** **1.1.1** Introduction and Importance of symmetry in chemistry. **1.1.2** Symmetry elements and symmetry operations. **1.1.3** Concept of a Point Group with illustrations using the following point groups: (i) $C_{\alpha v}$ (HCl), (ii) $D_{\alpha h}$ (H_2), (iii) C2v (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h} (trans – trichloroethylene), and (vi) D_{3h} (BCl_3). **1.2 Molecular Orbital Theory for Polyatomic Species** **1.2.1** Simple triatomic species: H_3^+ and H_3 (correlation between bond angle and Molecular orbitals). **1.2.2** Other molecules (considering only σ-bonding): i) BeH_2, ii) H_2O iii) CH_4 **1.3 Metallic Bonding** Band theory, explanation of electrical properties of conductors, insulators and semi conductors, intrinsic and extrinsic semiconductors.	**(07L)** **(5L)** **(3L)**
Unit II	**Solid State Chemistry** **2.1 Structures of Solids** **2.1.1** Explanation of terms viz.crystal lattice, lattice points, unit cells and lattice constants. **2.1.2** Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc, fcc and hcp lattices (numerical problems expected). **2.1.3** Stoichiometric point defects in solids (discussion on Frenkel and Schottky defects) **2.2 Superconductivity** **2.2.**1 Discovery of superconductivity **2.2.1** Superconductivity,transition temperature and Meissner effect. **2.2.2** Different types of superconductors viz, convential superconductors, , alkali metal fullerides (A3C60) and high temperature Superconductors. **2.2.3** Applications of superconducting materials.	**(11L)** **(04L)**
Unit III	**3 Chemistry of f-block elements** 3.1 Introduction Definition, position in periodic table and electronic configuration of lanthanides and actinides. 3.2 Chemistry of Lanthanides 3.2.1 Lanthanide contraction and its consequences 3.2.2 Oxidation states 3.2.3 Magnetic and spectral properties, 3.2.4 Occurrence, extraction and separation of lanthanides by Solvent extraction. 3.2.5 Applications of lanthanides. **3.3 Chemistry of Actinides** 3.3.1 Comparison between lanthanides and actinides 3.3.2 Chemistry of Uranium and with reference to occurrence and isolation (solvent extraction method) 3.3.2 Properties and applications of Uranium.	**(12L)** **(3L)**

Unit IV	**4.1 Chemistry of Non-aqueous Solvents** Classification of solvents and importance of non-aqueous solvents. **4.1.1** Super critical carbon dioxide and ionic liquids as solvents 4.1.2 Characteristics and study of liquid ammonia, dinitrogen tetraoxide as non-aqueous solvents with respect to i) acid base reactions and ii) redox reactions. 4.2 **Chemistry of Interhalogens**: introduction, preparation, reactions and structures. 4.3 **Chemistry of pseudohalogens** : Intorduction, preparation, reaction and structures 4.4 **Chemistry of Xenon** : Introduction, Compounds of Xenon: Oxides, fluorides, oxyfluorides w.r.t. preparation , properties and bonding.	**(7 L)** **(3L)** **(3L)** **(2L)**

SEMESTER V
Paper-III: Organic Chemistry
Course Code: RUSCHE503
Credits: 2.5

Learning Objectives:

The student at the TYBSc level is expected to apply the fundamentals of Organic Chemistry that he has learnt in the lower classes. The syllabi aims at incorporating these fundamentals to study the advanced concepts in Reaction Mechanism and stereochemistry. The IUPAC rules of nomenclature learnt in the lower classes are applied to Bicyclo and spiro compounds along with heterocycles. The need of the hour of having environmentally safe reactions is understood by the learner on studying the principles of Green Chemistry.

Learning Outcome

After studying this prescribed syllabi, the learner will have profound knowledge of

- Fundamentals of Organic Reaction Mechanisms
- Advanced Concepts in Stereochemistry
- Application of IUPAC nomenclature rules to spiro, bicyclo and heterocyclic compounds.
- Basic Idea of Polymer Chemistry
- Fundamentals of Green Chemistry and their applications to Organic Synthesis.

Unit I	**1 Mechanism of Organic Reactions** 1.1 Recapitulation: Curved arrows, intermediates, transition states, Electrophilicity vs acidity and nucleophilicity vs basicity. 1.2 Elimination Reactions: Mechanisms and stereochemistry. 1.2.1 E_1 and E_2 Mechanisms, factors influencing the mechanism: nature of substrate, leaving group, structure of base, solvent; Saytzeff and Hofmann	**(15L)**

	elimination; elimination *vs* substitution. 1.2.2 E_1CB mechanism 1.2.3 Pyrolytic elimination: Cope, Chugaev, pyrolysis of acetates. 1.3 Neighbouring group participation in nucleophilic substitution reactions: partcipation of lone pair of electrons, kinetics and stereochemical outcome. 1.4 Acyl nucleophilic substitution (Tetrahedral mechanism): Acid catalysed esterification of carboxylic acids and base promoted hydrolysis of esters ($B_{AC}2$). 1.5 Mechanism of following rearrangements with examples and stereochemistry wherever applicable. 1.5.1 Migration to electron deficient carbon: Pinacol, Benzylic acid. 1.5.2 Migration to electron deficient nitrogen: Beckmann, Hofmann. 1.5.3 Migration involving a carbanion: Favorski. 1.6 Name reactions: Michael, Wittig (mechanism and examples).	
Unit II	**2. Stereochemistry** 2.1 Molecular chirality and element of symmetry: Mirror Plane symmetry, inversion centre, rotation-reflection (alternating) axis. Chirality of compounds without stereogenic centre: cummulenes, spirans and biphenyls. 2.2 Conformations of cyclohexane, mono, disubstituted cyclohexanes and their relative stabilities 2.3 Stereo selectivity and Stereo specificity: Idea of enantioselectivity (ee) and diastereoselectivity (de). Topicity- enantiotopic and diastereotopic atoms, groups and faces. 2.4 Stereochemistry of: 2.4.1 Substitution reactions- S_N1, S_N2, S_Ni (reaction of alcohol with thionyl chloride). 2.4.2 Elimination reactions: E_2-Base induced dehydrohalogenation of 1-bromo-1,2-diphenylpropane. 2.4.3 Addition reactions to olefins- i) catalytic hydrogenation ii) bromination (electrophilic anti addition) (iii) synhydroxylation with OsO_4 and $KMnO_4$. iv) epoxidation followed by hydrolysis.	**(15L)**
Unit III	**3.1 IUPAC Nomenclature** IUPAC systematic nomenclature of the following classes of compounds (including substituted ones up to two substituents/ functional groups): **3.1.1** Bicyclic compounds- spiro, fused, and bridged (upto 11carbon atoms) - saturated and unsaturated compounds. **3.1.2** Biphenyls. **3.1.3** Cummulenes upto three double bonds. **3.2 Polymers** 3.2.1 Introduction: Review of terms: monomer, polymer, homopolymer,	**(6L)**

	copolymer, thermoplastics and thermosets. 3.2.2 Addition polymers: polyethylene, polypropylene, Teflon, PVC and polystyrene. Uses, recycling 3.2.3 Condensation polymers: polyesters, polyamides, polyurethans, polycarbonates and phenol-formaldehyde resins. Uses 3.2.4 Mechanism of free radical addition polymerization. 3.2.5 Stereochemistry of polymers: Tacticity. Mechanism of stereochemical control of polymerization using Ziegler-Natta catalyst 3.2.6 Natural and synthetic rubbers: polymerization of isoprene: 1,2- and 1,4-addition (cis and trans), styrene- butadiene copolymer. 3.2.7 Additives to polymers: Plasticizers, stabilizers and fillers. 3.2.8 Biodegradable polymers: Classification and uses. Polylactic acid- structure, properties and use for packaging and medical purposes. (Note: Identification of monomer in a given polymer and the structure of a polymer from given monomer(s) is expected. Conditions for isomerisation not expected).	**(9L)**
Unit IV	**Synthesis of Organic compounds** **4.1 Introduction**: Criteria for ideal organic synthesis. Calculaton of yields. Concept of selectivity with examples Linear and convergent synthesis with one example each Multi-component reactions: Mannich reaction, Hanztsch synthesis. 4**.2 Introduction to retrosynthesi**s: Analysis and synthesis, technical terms: target molecules (TM), retrosynthetic analysis, FGA, FGI, Disconnection, synthon and reagent. Retrosynthtic analysis of Limonene, Salbutamol and Proparacaine. **4.3 Green chemistry and synthesis:** 4.3.1 Introduction to green chemistry: definition, need for and importance of green synthesis. Twelve principles of green chemistry with examples. Atom economy and E-factor, calculations and their significance. Examples of reactions with low and high atom economy. 4.3.2 Green synthesis in industry: Green starting materials: D-glucose to adipic acid. Green reagents: Selective methylation of active methylene using dimethyl carbonate. Green solvent: Supercritical CO_2, deep eutectic solvents (DES). Green catalyst: Heterogeneous catalysis using tellurium, biocatalysis. Green synthesis of paracetamol **4.4 Other methods of organic synthesis** Microwave assisted organic synthesis (Using organic solvents and in solid state). Ultrasound in organic synthesis, Phase transfer catalysis. Polymer supported synthesis: Merrifield polypeptide synthesis.	**(15L)**

SEMESTER V
Paper-IV: Analytical Chemistry
Course Code: RUSCHE504
Credits: 2.5

Learning Objectives:

Learner in his lower classes, has encountered with classical techniques such as volumetric analysis and gravimetric analysis. He is familiar with Acid-Base titrations. At the TYBSc level, the learner should know the advanced titrimetric methods such as redox, precipitation, complexometric and non-aqueous titrations. Also, the need and importance of sampling and the different methods of sampling are elaborately introduced at this level. Concept of Quality and different standards and their utility is of utmost importance for them which will enable them to attain industrial readiness. Different optical methods, thermal methods, Radioanalytical techniques and Mass Spectrometry are the advanced instrumental methods which a learner should know prior to enrolling for higher studies or going ahead for industrial jobs.

Learning Outcome:

At the end of this course, the student will know

- Concept of Sampling and various methods of sampling.
- Importance of Quality Control
- Basic Principles of Redox, Precipitation, Complexometric and Non-Aqueous titrations.
- Applications of Advanced Instrumental methods

Unit I	**1.1 Sampling:** **1.1.1** Sampling, need and importance, terms involved, sampling techniques, non-random and random sampling, sequential sampling, **1.1.2** Sampling of gases, precautions, methods used, pressure and temperature sampling **1.1.3** Sampling of liquids, sample thief, homogeneous and heterogeneous liquids, stationary and flowing liquids, **1.1.4** Sampling of solids, bulk ratio, size to weight ratio, **1.1.5** Sampling and equipment for sampling of compact solids, sampling and equipment for sampling of powdered solids, sampling and equipment foe sampling of flowing solids, sampling of particulate solids, **1.1.6** Methods of reduction of the size of the sample **1.1.7** Preservation of sample, dissolution of the samples use of fluxes. **1.2 Treatment of analytical data** **1.2.1** Collection and processing of data, concept of classes, and class frequencies, histogram and frequency polygon. **1.2.3** Distribution of random errors, Gaussian distribution curve and its salient features. **1.2..4** Concept of confidence limits and confidence interval, computation of both by using range, student's t and population standard deviation. **1.2.5** Criterion for the rejection of a result, empirical methods like 2.5 d and 4.0 d rule, statistical approach. **1.2..6** Testing for significance, null hypothesis, variance ratio test.	**(15L)**

	1.2.7 Graphical presentation of results, scatter diagram, regression analysis, method of averages, least square method for line of the type y – mx + c and y - mx **1.2.8** Significant figures and their use in data treatment.	
Unit II	**Titrimetric analysis** **2.1 Redox Titrations** **2.1.1** General introduction, theory of redox indicators, **2.1.2** criterion for choosing an indicator for a redox titration, **2.1.3 C**onstruction of the titration curves in the case of i) Fe(II) vs Ce(IV), ii) Fe(II) vs CrO_7^{2-}, **2.1.4** Use of diphenyl amine and ferroin as redox indicator. **2.2 Precipitation titrations** **2.2.1** Basic principles of precipitation titrations **2.2.2** Argentimetric titrations, construction of the titration curve for the titration of sodium chloride with silver nitrate. **2.2.3** Mohr's method **2.2.4** Volhard's method **2.2.5** Adsorption indicators, examples and uses. **2.3 Complexometric titrations** **2.3.1** General introduction of complexometric titrations **2.3.2** EDTA titrations **2.3.2.1** EDTA as a chelating agent, structure of the chelate, characteristic features of the metal EDTA complexes. **2.3.2.2** Stability constant of the EDTA complexes, conditional stability constants, construction of the titration curve in the titration of a metal ion with EDTA with the example of Ca^{2+} . **2.3.2.3** Types of EDTA titrations. **2.3.2.4** Methods of improving the selectivity of EDTA titrations. **2.3.2.5** Metallochromic indicators. **2.4 Nonaqueous titrations** **2.4.1** Need for nonaqueous titrations, **2.4.2** Types of solvents, choice of the solvent for the nonaqueous titrations, **2.4.3** Acid base titrations in nonaqueous media, **2.4.4** Use of glacial acetic acid as the solvent in nonaqueous titrations, nonaqueous titrations with a visual indicator using an instrument **2.4.5** Advantages and limitations	**(15L)**
Unit III	**Optical Methods** **3.1 Atomic Absorption Spectroscopy** **3.1.1** Atomic energy level diagram, basic principles, characteristic features of atomic spectra **3.1.2** Basic principles of atomic absorption spectroscopy, steps involved in the process of atomization	**(6L)**

	3.1.3 Instrumentation: components-hollow cathode lamp, chopper, types of burners, premix and total consumption, electrothermal atomizers, **3.1.4** Qualitative and quantitative analysis, calibration curve and standard addition method. **3.1.5** Applications of atomic absorption spectroscopy. **3.2 Atomic Emission Methods** **3.2.1** Flame emission: basic principles of flame photometry **3.2.2** Instrumentation, flames and burners, detectors, **3.2.3** Qualitative and quantitative analysis, calibration curve, standard addition and internal standard method **3.2.4** Applications of flame photometry; comparison of atomic absorption and flame emission methods. **3.3 Fluorescence and phosphorescence spectroscopy** **3.3.1** Basic principles of fluorescence and phosphorescence, Jablonski diagram and its utility, factors affecting fluorescence and phosphorescence, **3.3.2** Relation between fluorescence intensity and concentration **3.3.3** Instrumentation: fluorimetry and phosphorimetry **3.3.4** Applications of fluorimetry and phosphorimetry **3.3.5** Comparison of fluorimetry and phosphorimetry , **3.3.6** Comparison of absorption and fluorimetric techniques. **3.4 Nephelometry and turbidimetry** **3.4.1** Scattering of radiation, basic principles of nephelometry and turbidimetry, **3.4.2** Factors affecting scattering of radiation, particle size, wavelength, concentration, refractive index **3.4.3** Instrumentation in nephelometry and turbidimetry **3.4.4** Applications of both techniques	**(9L)**
Unit IV	**Miscellaneous Methods** **4.1 Thermal Methods** **4.1.1** Introduction to thermal methods, classification of thermal methods, **4.1.2** Thermo gravimetric analysis, thermogram, factors affecting the thermogravimetric curve, **4.1.3** Instrumentation, components, thermo balance, furnace, sample holder, recorder, measurement of temperature **4.1.4** Applications, limitations. **4.2 Radioanalytical techniques** **4.2.1** Neutron activation analysis, **4.2.1.1** Basic principles, characteristic features, operational procedure, **4.2.1.2** Applications. **4.2.1.3** Advantages and limitations **4.2.2** Isotope dilution analysis, **4.2.2.1** Basic principles, operational procedure, **4.2.2.2** Applications, advantages and limitations	**(15L)**

	4.3 Mass spectrometry **4.3.1** Basic principles, **4.3.2** Instrumentation, components, sources, analysers, detectors **4.4 Method validation** **4.4.1** Need and significance of method validation **4.4.2** Parameters chosen for method validation **4.4.3** Procedure for method validation	

PRACTICALS

RUSCHEP501	**Physical Chemistry** 1. To study the effect of ionic strength on the rate of reaction between $K_2S_2O_8$ and KI using KCl. 2. To study the rate of adsorption of acetic acid on activated charcoal. 3. To study the relative strength of acetic acid and monochloroacetic acid. 4. To determine the amount of oxalic acid and its dissociation constants by pH-metry. 5. To determine the amount of oxalic acid by conductometric titration. 6. To determine the standard reduction potential of Cu^{2+}/Cu electrode at room temperature.
	Inorganic preparations 1. Potassium diaquo bis- (oxalate)cuprate(II)$K_2[Cu(C_2O_4)_2.(H_2O]$ 2. Bis(ethylenediamine)iron(II)sulphate$[C_2H_4(NH_2)_2FeSO_4.4H_2O]$. **Volumetric analysis** 1. Determination of magnesium from the supplied commercial sample of Milk of magnesia tablet 2. Estimation of Nickel(II) complexometrically using murexide indicator (Students are expected to standardize supplied EDTA solution using ZnSO4.7H20) 3. Estimation of copper(II) complexometrically using fast sulphon black-F indicator (Students are expected to standardize supplied EDTA solution using ZnSO4.7H20)
RUSCHEP502	**I) Binary Mixture Separation: Separation of mixture containing (VL + NVL) & (VL+ S) components.** 1. Minimum Six mixtures to be completed by the students. 2. Components of the liq-liq mixture should include volatile liquids like acetone, methylacetate, ethylacetate, isopropylalcohol, methyl alcohol, ethyl alcohol, chloroform and non- volatile liquids like chlorobenzene, bromobenzene, aniline, N,N-dimethylaniline, acetophenone, nitrobenzene, ethyl benzoate. 3. Components of the liq- solid mixture should include volatile liquids like acetone, methylacetate, ethylacetate, ethyl alcohol, methyl alcohol, isopropylalcohol, chloroform and solids such as water insoluble acids, phenols, bases, neutral.

	4. A sample of the mixture one ml to be given to the student for detection of the physical type of the mixture. 5. After correct determination of physical type, separation of the binary mixture to be carried out by distillation method using microscale technique. 6. After separation into component A and component B, the physical constants and the yield of the separated components is to be determined. **II) Organic Preparations:** 1. Acetylation of hydroquinone. 2. Bromination of acetanilide. 3. Hydrolysis of ethyl benzoate. 4. Nitration of acetanilide. 5. Microwave assisted synthesis of Schiff's base from aniline and p-anisaldehyde. 6. Microwave assisted synthesis of coumarin by Knoevenagel reaction from salicylaldehyde and ethylacetoacetate in presence of a base.
	Analytical Chemistry: 1. Determination of the amount of fluoride in the given solution colorimetrically. 2. Estimation of Vitamin C content of a given tablet by titration with sodium hydroxide pH metrically 3. To determine potassium content of a commercial salt sample by flame photometry. 4. To determine the amount of chloride in the given sample using Mohr's method. 5. To determine the amount of persulphate in the given sample by back titration with standard Fe(II) ammonium sulphate solution. 6. To estimate Fe(II) in a tablet using diphenylamine as an indicator.

SEMESTER VI
Paper-I: Physical Chemistry
Course Code: RUSCHE601
Credits: 2.5

Learning Objectives:

As the student approaches the end of his Graduation studies, he needs to have the idea of applications of the fundamentals of physical chemistry. Hence this syllabi incorporates the understanding of Nuclear Magnetic Resonance for structure determination and Polymer chemistry. With basic understanding of fundamentals of Electrochemistry in lower classes, the learner is introduced to advanced applications of electrochemical phenomenon. Nuclear Chemistry is a major arena for research in the medical field and hence the learner is introduced to the basic concepts in Nuclear Chemistry. Basics of quantum chemistry are also introduced to the learner.

Learning Outcome:

After taking this course, the learner will have decent control on the following areas of Physical Chemistry:

- Nuclear Magnetic Resonance and Its applications
- Polymer Chemistry
- Renewable Energy Sources
- Basic Nuclear Chemistry
- Basics of Quantum Chemistry.

Unit I	**1.1 NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY** 1.1.1. Nuclear spin, magnetic moment, criteria for nuclei to be NMR active, energy levels, Larmor precession, Relaxation processes in NMR (spin-spin relaxation and spin-lattice relaxation). 1.1.2. NMR Spectrometer, chemical shift, shielding and deshielding of protons, low resolution NMR spectrum, high resolution NMR spectrum. **1.2 POLYMERS** 1.2.1 Classification of polymers based on 1) source, 2) structure, 3) thermal response, 4) Physical properties 1.2.2 Molar mass of polymers: 1) Number average molar mass, 2) Weight average molar mass, 3) Viscosity average molar mass, monodispersity, polydispersity, polydisperity index 1.2.3 Methods of determining molar mass of polymers: 1) Ultracentrifugation method 2) Viscosity method of Viscosity average molar mass, Mark-Houwink equation.	**(08L)** **(07L)**
Unit II	**2.1 ELECTROCHEMISTRY- IV: DECOMPOSITION POTENTIAL, OVERVOLTAGE AND ELECTROPLATING** 2.1.1 Polarization, concentration polarization and its elimination.	**(08L)**

	2.1.2 Decomposition potential and its experimental determination, factors affecting decomposition potential. 2.1.3 Over voltage and its experimental determination, factors affecting overvoltage. 2.1.4 Tafel's equation for hydrogen overvoltage 2.1.5 Electroplating – Objectives and process. **2.2 RENEWABLE ENERGY SOURCES** 2.2.1 Lithium ion cell, 2.2.2 Hydrogen - fuel of future, Advantages and limitations of hydrogen as a universal energy medium, Production of hydrogen by electrolysis of water. 2.2.3 Fuel cells: Bacon's H_2 and O_2 fuel cell. 2.2.4 Solar energy: Photovoltaic effect, P-type and N- type of semiconductors, PN-Junction, Silicon solar cell.	**(7L)**
Unit III	**3. NUCLEAR CHEMISTRY** 3.1 Structure of Nucleus. 3.2 Nuclear disintegration/ Nuclear radioactivity, Types of nuclear radiations (α-ray, β-ray and γ-ray). 3.3 Nuclear transmutation and Artificial radioactivity, Nuclear transmutation with different types of projectiles. 3.4 Kinetics of radioactivity: units of radioactivity, expression of decay constant and its units, half life of nuclear reactions. 3.5 Radioactive Equilibrium- 1) Secular 2) Transient; Differences between chemical and radioactive equilibrium. 3.6 Mode of decay of radioactive elements: 1) emission of positrons 2) emission of electrons 3) K-electron capture. 3.7 Energy involved in Nuclear reactions: Q-value and Threshold energy. 3.8 Nuclear Fission process and its Characteristics features of nuclear fission process, Factors affecting Nuclear Fission: 1) Multiplication Factor 2) Critical Mass 3.9 Fertile and fissile materials, conversion of fertile material to fissile material. 3.10 Basic components of Nuclear Reactors, Types of Nuclear Reactors: 1) Power Reactor 2) Breeder Reactor. 3.11 Nuclear Fusion - Characteristics; Mechanism of nuclear fusion: 1) Carbon cycle 2) Proton cycle 3.12 Detection and measurement of radioactivity – GM Counter and Scintillation Detector	**(15L)**
Unit IV	**4.0 BASICS OF QUANTUM MECHANICS** 4.1 Classical mechanics: limitations of classical mechanics: 1) Black body radiation 2) photoelectric effect 3) Compton Effect. 4.2 Introduction to quantum mechanics, Planck's theory of quantization, wave	**(15L)**

	particle duality, de-Broglie equation, Heisenberg's uncertainty principle. 4.3 The Schrodinger wave equation 4.3 Postulates of quantum mechanics 1) State function and its significance 2) Concept of operators: definition, addition, subtraction and multiplication of operators, commutative and non- commutative operators, linear operator, Hermitian operator 3) Eigen function and eigen value, eigen value equation. 4) Wave mechanical operator for evaluating various classical properties. 5) Expectation value. 4.4 Solution of the Schrodinger wave equation for a simple system: Particle in one dimensional box	

SEMESTER VI
Paper-II: Inorganic Chemistry
Course Code: RUSCHE602
Credits: 2.5

Learning objectives:

The student has learnt the applications of Valence Bond Theory and Molecular Orbital Theory so far. The Crystal Field theory and the important parameters associated with Crystal Field Theory were introduced to give the evidences of covalence in metal complexes. Also, the applications of MOT to octahedral complexes have been discussed in the current syllabi. With the same flow, the properties of the co-ordination compounds such as their spectral data and stability and reactivity of metal complexes is required to be understood by the learner. The principles of Organometallic chemistry have been further explored in Metallocenes. The learner is made familiar with industrially relevant topics such as Nanomaterials – their characterization and properties and medicinal chemistry.

Learning outcome:

Towards the end of the year, the learner will have good knowledge of

- Advantages of Crystal Field Theory over Valence Bond Theory
- Calculations of CFSE and its applications
- Applications of MOT to octahedral complexes
- Spectral Analysis of Inorganic Compounds- Determination of terms, term symbols and Orgel Diagrams
- Thermodynamic and Kinetic Stability of Complexes.
- Types of Reactions shown by Metal complexes.
- General Characteristics of Organometallic Compounds
- Synthesis of Nanomaterials and their properties
- Inorganic Compounds showing medicinal properties.

Unit I	**1. Coordination Chemistry** **1.1 Theories of metal-ligand bond** **1.1.1** Limitations of VBT **1.1.2** Crystal field theory and effect of crystal field on central metal valence orbitals in various geometries, **1.1.3** Splitting of d orbitals in octahedral, square planar and tetrahedral crystal fields **1.1.4** Distortions from the octahedral geometry : i) effect of ligand field and ii) Jahn- Teller distortions **1.1.5** Crystal field splitting parameter , its calculation and factors affecting it in octahedral complexes, Spectrochemical series. **1.1.6** Crystal field stabilization energy (CFSE), calculation of CFSE, for octahedral and tetrahedral complexes with *d1* to *d10* metal ion configurations. **1.1.7** Consequences of crystal field splitting on various properties such as inic radii, hydration, energy, lattice energy, enthalpies of formation, colour and magnetic properties. **1.1.8** Limitations of CFT **1.1.9:** Evidences for covalence in metal complexes: i) intensities of d-d transitions, ii) ESR specftrum of $[IrCl_6]^{2-}$ iii) Nephelauxetic effect . **1.2 Molecular Orbital Theory (MOT) of Coordination Complexes** **1.2.1** Application to octahedral complexes in case of (i) $[Ti(H_2O)]^{3+}$, (ii) Fluoro complexes of Fe(II) and Fe (III) and (iii) Cyano complexes of Fe(II) and Fe (III).	**(11L)** **(4L)**
Unit II	**Properties of Co-ordination Compounds:** **2.1 Electronic Spectra** **2.1.1 O**rigin of electronic spectra **2.1.2** Types of electronic transitions in coordination co0mpounds: intra- ligand, charge transfer and intra-metal transitions. **2.1.3** Electronic configuration and electronic micro states, Term symbols, coupling of spin momenta (Ms),orbital momenta (Ml)and spin- orbit coupling or Russell-Saunders coupling. **2.1.4** Determination of Terms for *p2 and d2* electronic configuration **2.1.5** Terms and micro-states for transition metal atoms/ions. **2.1.6** Orgel diagrams for D and F terms (i.e. d1 to d9 electronic configurations in octahedral crystal fields) **2.1.7** Selection rules for electronic transitions : Spin and orbital forbidden transitions (Laporte selection rules) **2.2 Stability of Metal Complexes** **2.2.1** Thermodynamic stability and kinetic stability of complexes with examples. **2.2.2** Stability constants: Stepwise and overall constants and their interrelationship. **2.2.3** Factors affecting thermodynamic stability (Factors related to nature of central metal atom, nature of ligand, chelate effect to be discussed)	**(07L)** **(04L)**

	2.3 : Reactivity of Metal Complexes : **2.3.1** Comparison between inorganic and organic reactions **2.3.**2 Types of reactions in metal complexes **2.3.3** Inert and labile complexes: Correlation between electronic configuration and lability of Complexes **2.3.4** Ligand substitution reactions: Associative and Dissociative mechanisms **2.3.5** Acid hydrolysis, base hydrolysis and anation reaction	**(04L)**
Unit III	**Organometallic Chemistry** 3.1 Organometallic Compounds of main group metals 3.1.1 General characteristics of various types of Organometallic compounds, viz., ionic, sigma bonded and electron deficient compounds 3.1.2 General synthetic methods: (i) Oxidative addition, (ii) Metal-Metal exchange (Transmetallation), (iii) Carbanion-Halide exchange, (iv) Metal Hydrogen exchange and (v) Methylene insertion reactions. **3.1.3** Chemical reactions: (i) Reactions with oxygen, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents and (iv) Complex formation reactions. **3.2 Metallocenes** Introduction, Ferrocene; Synthesis, properties, structure and bonding on the basis of VBT. d- bonding in rhenium and molybdenum halide complexes.	**(9L)** **(06L)**
Unit IV	**Some Selected Topics** **4.1 Nanomaterials** 4.1.1Introduction and importance of nanomaterials 4.1.2 Chemical methods of synthesis of nanomaterials 4.1.3 Characterisation of Nanomaterials (UV and XRD techniques) 4.1.4 Dimensions and forms of Nanomaterials : Nano films , nano layers , nano tubes , nanowires and nano particles. 4.1.5 Properties (comparison between bulk and nano materials) : 1. Optical 2. Electrical and 3. Mechanical properties **4.2.Bio-inorganic and Medicinal Chemistry** 4.2.1 Metal Co-ordination in biological system: Enzymes, apoenzymes and Coenzymes . 4.2.2 Metal complexes in medicine: cis- platin and gold complexes 4.2.3 Inorganic pharmaceuticals.	**(15L)**

SEMESTER VI
Paper-III: Organic Chemistry
Course Code: RUSCHE603
Credits: 2.5

Learning Objectives:

Along with basics of mechanism, the learner is expected to have basic understanding of biologically active molecules. This is introduced in the chapters of Carbohydrates, Amino Acids, Nucleic Acids and Natural Product Chemistry. So also, it is of utmost importance that the student has knowledge of structure determination using the advanced spectral techniques like UV-VIS spectroscopy, IR Spectroscopy, NMR Spectroscopy and Mass Spectrometry.

Learning Outcome:

At the end of the course, the student will have knowledge about

- Carbohydrates and their structures
- Reactions shown by Glucose
- General applications of various catalysts and Reagents
- Basic Fundamentals of Photochemistry
- Basics of Natural Product chemistry- Including Amino acids, nucleic acids etc
- Applications of Spectral techniques to Structure Determination

Unit I	**1.1 Chemistry of Carbohydrates:** 1.1.1 Introduction: Classification, reducing and non-reducing sugars, DL notation. 1.1.2 Structures of monosaccharides: Fischer projection (4-6 carbon monosaccharides) and Haworth formula (Furanose and pyranose forms of pentoses and hexoses). Interconversion: open and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with stereochemistry of D-glucose. Stability of chair forms of D- glucose. 1.1.3 Stereoisomers of D-glucose: Enantiomers and diastereomers, anomers and epimers. 1.1.4 Mutarotation in D-glucose with mechanism. 1.1.5 Chain lengthening and shortening reactions: Modified Kiliani-Fischer synthesis (D- arabinose to D-glucose and D-mannose), Wohl method (D-glucose to D-arabinose). 1.1.6 Reactions of D-glucose and D-fructose: (a) osazone formation (b) reduction- H_2/Ni, $NaBH_4$ c) oxidation: bromine water, HNO_3, HIO_4 d) acetylation e) methylation (d and e with cyclic pyranose forms). 1.1.7 Glycosides: general structure, formation of alkyl glycosides and anomeric effect. 1.1.8 Disaccharides: Structures of sucrose and maltose (cyclic forms: Haworth/chair). **1.2 Catalysts and Reagents :** Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism) 1.2.1 **Catalysts:** Catalysts for hydrogenation: Raney Ni, Pt and PtO_2: C=C, CN, NO_2, aromatic ring; Pd/C: C=C, COCl → CHO (Rosenmund); Lindlar catalyst: alkynes; Wilkinson's catalyst: olefins.	**(09L)** **(6L)**

	1.2.2 **Reagents**: (a) LiAlH4 and Red-Al: reduction of CO, COOR, CN, and NO_2. (b) $NaBH_4$: reduction of CO (c) SeO_2: hydroxylation of allylic and benzylic positions, oxidation of CH_2 to CO (d) *m*-CPBA epoxidation of C=C. (e) NBS: allylic and benzylic bromination.	
II	**2.1 Chemistry of Amino acids, Proteins and Nucleic acids:** 2.1.1 α-Amino acids: General structure, configuration, essential (valine, leucine, phenylalanine), neutral (glycine, alanine), acidic (glutamic acid) and basic (lysine) amino acids (systematic names with abbreviations). pH dependency of ionic structure and isoelectric point. 2.1.2 Polypeptides and Proteins: Nature of Peptide bond. Nomenclature and representation of peptides (di and tripeptides) 2.1.3 Proteins: general idea of primary, secondary, tertiary and quartenary structures. 2.1.4 **Nucleic acids:** Controlled hydrolysis of nucleic acids. Sugars and bases in nucleic acids. Structures of nucleosides and nucleotides in DNA and RNA. Structure of nucleic acids (DNA and RNA including base pairing). **2.3 Photochemistry:** 2.3.1 Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triple states, allowed and forbidden transitions, fate of excited molecules, photosensitization. 2.3.2 Photochemical reactions of olefins: photoisomerisation, photochemical rearrangement of 1,4-dienes (di π methane) 2.3.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages, photoreduction (e.g. benzophenone to benzpinacol).	**(08L)** **(07L)**
III	**3. Spectroscopy-I (UV-Visible, IR and ^{1}H NMR)** 3.1 Introduction: Electromagnetic spectrum, units of wavelength and frequency. 3.2 UV- Visible spectroscopy: Basic theory, solvents, nature of UV-VIS spectrum, concept of Chromophore, auxochrome,bathochromic shift, Hypsochromic shift, hyperchromic and hypochromic effects, chromophore- chromophore and chromophore -auxochrome interactions. calculation of absorption maxima by Woodward-Fischer Rule for conjugated polyenes. Applications of UV-Visible spectroscopy. 3.3 IR Spectrocopy: Basic theory, selection rule, nature of IR spectrum, characteristic vibrational frequencies of functional groups, fingerprint region. Applications IR Spectrocopy. 3.4 ^{1}H NMR Spectroscopy: Basic theory of ^{1}H NMR, nature of ^{1}H NMR spectrum, chemical shift (∂ unit), standard for ^{1}H NMR, solvents used. Factors affecting chemical shift: inductive effect and anisotropic effect (with reference to C=C, C≡C, C=O and benzene ring). Spin- spin coupling and coupling constant. Application of deuterium exchange technique. Application of ^{1}H NMR in structure determination.	**(15L)**

IV	**4.1 Spectroscopy-II** 4.1.1 Mass Spectrometry: Basic theory. Nature of mass spectrum. General rules of fragmentation. Importance of molecular ion peak, isotopic peaks, base peak, Nitrogen rule. Fragmentation of alkanes and aliphatic carbonyl compounds including Mclafferty rearrangement. 4.1.2 Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes with respect to UV-VIS, IR, ^{1}H NMR: (1) alkanes (2) alkenes and polyenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) carboxylic acids (9) esters (10) amines (11) amides (broad regions characteristic of different groups are expected). 4.1.3 Problems of structure elucidation of simple organic compounds using individual or combined use of the UV-VIS, IR, ^{1}H NMR and Mass spectroscopic techniques. (index of hydrogen deficiency expected). **4.2 Natural Products :** 4.2.1 Introduction, sources, classification and functions to the following natural products (Structures of the compounds specified are expected) (a) Terpenoids: (isoprene rule). citral, α-terpeniol, camphor and α-pinene. (b) Alkaloids: nicotine, atropine. (c) Vitamins: vitamin A and vitamin C. (d) Hormones: adrenaline, thyroxine. (e) Steroids: cholesterol, progesterone. 4.2.2 Structure determination of natural products: (a) Ozonolysis in terpenoids: Examples of open chain and monocyclic monoterpenoids. (b) Hofmann exhaustive methylation and degradation in alkaloids: simple open chain and monocyclic amines. 4.2.3 Commercial synthesis: (a) camphor from α-pinene (b) α- and β- ionones from citral. 4.2.4 Introduction to primary and secondary metabolites and broad classification of natural products based on biosynthesis.	**(8L)** **(07L)**

SEMESTER VI
Paper-IV: Analytical Chemistry
Course Code: RUSCHE604
Credits: 2.5

Learning Objectives:

Having introduced chromatographic techniques at the SYBSc level, the learner is exposed to sophisticated chromatographic methods such as GC, HPLC, HPTLC etc. Also, the electroanalytical techniques such as DC-Polarography and Amperometric and Bi-Amperometric Titrations are introduced. The importance of Size-Exclusion Chromatography, Gel Electrophoresis and Method Validation is stressed upon. The commercial applications of Analytical chemistry are also explored through food, cosmetic, detergent, water and pharmaceutical analysis.

Learning Outcome:

At the end of the course, the student will know:

- Basic Principles and Applications of Advanced sophisticated techniques.
- Advantages and limitations of these techniques.
- Industrial relevance of these techniques
- Basic Principles, Applications and comparison of Electroanalytical Methods
- Applications of Analytical methods to day-to-day life.

Unit I	**Separation Techniques.** **1.1 Gas Chromatography** **1.1.1** Introduction, basic principles, terms involved, **1.1.2** Rate theory and plate theory of chromatography **1.1.3** Instrumentation, components of the instruments, Types of columns, packing materials, **1.1.4**Types of detectors, TCD, FID, ECD, their relative advantages and imitations **1.1.5** Qualitative and quantitative analysis, **1.1.6** Applications of GC **1.2 High Pressure Liquid Chromatography** **1.2.1** Introduction, basic principles. **1.2.2** Instrumentation and its components. **1.2.3**Solvent reservoirs, degassing system, **1.2.4**Types of pumps, pneumatic, reciprocating, syringe type, their advantages and limitations, **1.2.5**Pre-column, types of columns, packed and capillary, sample injection systems **1.2.6**Detectors, UV-Visible, refractive index, **1.2.7** Applications of HPLC **1.3 High Performance Thin Layer Chromatography** **1.3.1** Introduction, Choice of stationary and mobile phases, sample application, **1.3.2** Development and recording in HPTLC, **1.3.3** Detectors used, single beam and double beam detectors, fluorometric detector, **1.3.4** Quantitative determination,	**(15L)**

	1.3.5 Applications of HPTLC **1.3.6** Advantages and limitations **1.3.7** Comparison between TLC and HPTLC **1.4 Ion Exchange Chromatography** **1.4.1** Introduction, types of ion exchangers, synthetic and natural, cation and anion, properties of resins **1.4.2** Ion exchange equilibria, selectivity coefficient, separation factors, factors affecting separation of ions **1.4.3** Ion exchange capacity and its determination **1.4.4** Applications of ion exchange chromatography, preparation of demineralized water, separation of amino acids, separation of lanthanides, preparation of exact concentration of acids or bases	
Unit II	**Electroanalytial Techniques** **2.1**: Introduction and classification of electroanalytical methods and specific features of each of the major category. **2.2 Ion Selective Electrodes:** **2.2.1** Ion selective and ion specific electrodes, components of ion selective electrode, properties of membrane in ion selective electrode, classification of ion selective electrodes **2.2.2** Solid membrane electrodes: Fluoride ion selective electrode, Glass membrane electrode, Glass electrode. **2.2.3** Liquid membrane electrode: Calcium ion electrode **2.3 Polarography** **2.3.1** Basic principles, polarizable and nonpolarizable electrodes, supporting electrolyte, its function, selection of supporting electrolyte **2.3.2** The polarogram, terms involved, residual current, limiting current, diffusion current, half wave potential, , **2.3.3** Oxygen interference and its removal, polarographic maxima and use of maxima suppressors, **2.3.4** Equation of polarographic wave,determination of half wave potential and diffusion current from the polarogram **2.3.5** Ilkovic equation, terms involved and their explanation **2.3.6** DME, Construction, working, advantages and limitations; **2.3.7** Instrumentation, H- shaped polarographic cell , Qualitative and quantitative analysis, calibration curve method, standard addition method. **2.3.8** Applications of polarography. **2.4 Amperometric titrations** **2.4.1** Basic principles: construction of the titration curve, Different types of amperometric titration curves, **2.4.2** Rotating platinum electrode, construction, working, advantages and limitations. **2.4.3** Applications of amperometric titrations, **2.4.4** Comparison of amperometry and polarography	**(15L)**

Unit III	**Miscellaneous Methods** **3.1 Potentiometric titrations** **3.1.1** Potentiometry and potentiometric titrations, basic principles, indicator and reference electrode, types of titrations and indicator electrodes used for each type. **3.1.2** Experimental set up & procedures for the potentiometric titrations, **3.1.3** Determination of equivalence point in potentiometric titrations, use of E vs.V, first and second derivative plots vs. V for the determination of the equivalence point. **3.1.4** Advantages and limitations. **3.2 Biamperometric titrations,** **3.2.1** Basic principles, experimental set up, **3.2.2** Biamperometric titration curves, determination of the equivalence point **3.2.3** Determination of water content by Karl Fischer method. **3.3 Gel electrophoresis** **3.3.1** Basic principle, **3.3.2** Factors affecting migration rate, supporting media, SDS page, Isoelectric focussing **3.3.3** 2D gel support, application of the sample, procedure. **3.3.4** Separation and identification methods **3.3.5** Applications **3.4 Size exclusion Chromatography** **3.4.1** Introduction, principles, **3.4.2** Operational procedures, **3.4.3** Applications of size exclusion chromatography	**(15L)**
Unit IV	**Applications to different fields** **4.1 Food analysis** **4.1 .1 Milk powder** **4.1.1.1** Determination **of lactose** **4.1.1.2** Determination of calcium and iron **4.1.2 Honey** **4.1.2.1** Total reducing sugars in honey **4.2 Cosmetic analysis** **4.2.1** Talcum powder **4.2.2** Analysis of face powder **4.3 Detergent analysis** **4.3.1** Determination of active anionic matter **4.3.2** Determination of alkalinity **4.3.3** Determination of oxygen releasing capacity.	**(15L)**

	4.4 Water analysis **4.4.1** Determination of dissolved oxygen **4.4.2** Determination of chemical oxygen demand **4.5 Pharmaceutical Analysis** **4.5.1** Determination of drugs by non-aqueous titration	

Semester-VI
Practicals

RUSCHEP601	**Physical Chemistry** 1. To determine the energy of activation for the acid catalyzed hydrolysis of methyl acetate. 2. To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement. 3. To determine acidic and basic dissociation constant of amino acid and hence calculate isoelectric point. 4. To determine the amount of weak acid and strong acid in the given mixture by conductometric titration. 5. To determine the solubility and solubility product of AgCl potentiometrically using chemical cell. 6. To determine Critical Micelle Concentration (CMC) using conductometer.
	Inorganic preparations 1. Mercury tetrathiocyanato Cobaltate (II) $Hg[Co(SCN)_4]$ 2. Magnesium oxinate$[Mg(Ox)_2]$ 3. Tris-acetyl acetonato iron(III) $[Fe(AcAc)_3]$ 4. Tetrammine copper(II) sulphate. $[Cu(NH_3)_4]SO_4.H_2O$ **Inorganic estimations/ Analysis** 1. Estimation of copper iodometrically using sodium thiosulphate. 2. Estimation of lead by complexometrically using EDTA solution.
RUSCHEP602	**Binary Mixture Separation & identification (Solid + Solid)** (2.0 g mixture to be given) 1. Minimum six mixtures to be completed by the students. 2. Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols (α-naphthol, β- naphthol), water insoluble bases (nitroanilines), water soluble (urea and thiourea) and water insoluble neutrals (Aromatic hydrocarbons, m-dinitrobenzene, anilides, amides) 3. A sample of binary mixture to be given (<1.0 gram) to the students for detection of chemical type of mixture. After correct determination of the chemical type, the fixing reagent should be decided by the students for separation. 4. Follow separation scheme with the bulk sample of the binary mixture.

	5. After separation of the components into independent components A and B, a. One component (decided by the examiner) is to be analyzed and identified by chemical method with melting point and also by IR spectroscopy. (This component is not to be weighed). b. The other component is to be purified, dried, weighed and melting point is to be determined**.**
	Analytical Chemistry: 1. Estimation of Chromium in water sample by using diphenylcarbazide spectrophotometrically. 2. Determination of acetic acid content in vinegar sample by using quinhydrone electrode potentiometrically. 3. Determination of phosphoric acid in cola sample pH metrically. 4. Estimation of calcium and magnesium content in Talcum powder. 5. Estimation of reducing sugar in honey by Wilstatter method. 6. Separation and estimation of Mg(II) and Zn(II) from given sample solution using an anion exchanger.

References for Paper-I (Physical Chemistry)

1. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
2. Physical Chemistry, P.C. Rakshit, 6th Edition, 2001, Sarat Book Distributors, Kolkota.
3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3rd edition , John Wiley & Sons, Inc [part 1]
4. Physical Chemistry, G. Castellan, 3rd edition, 5th Reprint, 1995 Narosa Publishing House.
5. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2nd Edition, 1st Indian reprint,2006 Springer
6. Visible & U.V. Spectroscopy, Analytical Chemsitry by Open Learning R. Demny and R. Sinclair M 1991 John Wiley & Sons
7. Classical Methods , Vol 1 Analytical Chemistry by Open Learning D. Cooper & C. Devan,1991 John Wiley & Sons
8. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
9. The Elements of Physical Chemistry, P.W. Atkins, 2nd Edition, Oxford Universtity Press Oxford
10. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.

References for Paper-II.(Inorganic Chemistry).

1. D. Banerjea, *Coordination chemistry,* Tata McGraw Hill, New Delhi, (1993).
2. D. F. Shriver and P. W. Atkins, *Inorganic chemistry,* 3rd Ed., Oxford University Press, (1999).
3. K. F. Purcell and J. C. Kotz, *Inorganic chemistry,* Saunders, Hongkong, (1977).
4. N. N. Greenwood and E. Earnshaw, *Chemistry of elements,*Pergamon Press, Singapore, (1989).
5. W. L. Jolly, *Modern inorganic chemistry,* 2nd Ed. McGraw Hill Book Co., (1991).
6. B. E. Douglas and H. McDaniel, *Concepts and models in inorganic chemistry,* 3rd Ed., John Wiley & Sons, Inc., New York, (1994).
7. G. N. Mukherjee and A. Das, *Elements of bioinorganic chemistry,* Dhuri and Sons, Calcutta, (1988).

8. R. W. Hay, *Bioinorganic chemistry,* Ellis Harwood, England, (1984). 9. R. C. Mehrotra and A. Singh, *Organometallic chemistry: A unified approach,* Wiley Eastern, New Delhi, (1991).
10. For synthesis of iron ethylenediamine sulphate refer Practical Inorganic Chemistry by G. Marr and B. W. Rockett,Van Nostrand Reinhold Company London1972. P 34.
11. For preparation of CuCl2.2DMSO Refer Microscale Inorganic Chemistry by Z. Szafran, Ronald M. Pike and Mono M. Singh. Pub. John Wiley and Sons1991.p.218.

References For Paper-III (Organic Chemistry)

1. Organic Chemistry, Francis A Carey, Pearson Education, 6th Edition, Special Indian Edition 2008.
2. Organic Chemistry, R.T. Morrison and R.N. Boyd, 6th Edition, Pearson Edition.
3. Organic Chemistry, T.W.G. Solomon and C.B. Fryhle, 8th Edition, John Wiley & Sons, 2004.
4. A guide to mechanism in Organic Chemistry, 6th Edition, Peter Sykes, Pearson Education.
5. Fundamentals of Organic Chemistry, G. Marc Loudon, 4th Edition Oxford.
6. Organic Chemistry, L.G. Wade Jr and M.S. Singh, 6th Edition,2008.
7. Organic Chemistry Baula Y. Bruice, Pearson Edition, 2008.
8. Organic Chemistry, J.G. Smith, 2nd Editionm Special Indian Edition, Tata. McGraw Hill.
9. Organic Chemistry, S.H. Pine, McGraw Hill Kogakusha Ltd.
10. Stereochemistry, P.S. Kalsi, New Age International Ltd. 4th Edition,2006
11. Furniss, B. S.; Hannaford, A. J.; Rogers, V.; Smith, P. W. G.; Tatchell, A. R. Vogel's Textbook of Practical Organic Chemistry, ELBS.

Reference List for Paper-IV (Analytical Chemistry)

1. D. Harvey, Modern Analytical Chemistry, The McGraw-Hill Pub. 1st Edition (2000)
2. H.S. Ray, R Sridhar and K.P. Abraham, Extraction of Nonferrous Metals, AffiliatedEast-West Press Pvt. Ltd. New Delhi (1985) reprint 2007.
3. G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney , Vogel's Textbook of Qunatitative Chemical Analysis, Fifth edition, ELBS Publication (1996)
4. D.A. Skoog D.M. West and F.J. Holler, Fundametals of Analytical Chemistry, 7thEdition (printed in India in 2001) ISBN Publication.
5. Analytical Chemistry, J.G. Dick,1973 Tata McGraw Hill Publishing Co. Ltd. New Delhi.
6. Quantitative analysis, Dey & Underwood, Prentice Hall of India, Pvt. Ltd. New Delhi
7. Fundamentals of Analytical Chemistry, Skoog etal 8th edition, Saunders college publishing.

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment - 40% of total marks:

(40 marks)

Sr No	Evaluation type	Marks
1	One Assignment	10
2	One class Test (multiple choice questions / objective)	20
3	Active participation in routine class instructional deliveries (seminars//presentation)	05
4	Overall conduct, participation in co-curricular activities of the department.	05

B) External examination – 60 %

Semester End Theory Assessment - 60% **60 marks**

These examinations shall be of **two hours** duration.

There shall be **Four** questions each of **15** marks. On each unit there will be one question.
All questions shall be compulsory with internal choice within the questions.

Theory question paper pattern is as follows :-

Questions	Options	Marks	Questions on
Q.1)A)	Any 3 out of 5	12	Unit I
Q.1)B)	Any 3 out of 5	03	
Q.2)A)	Any 3 out of 5	12	Unit II
Q.2)B)	Any 3 out of 5	03	
Q.3)A)	Any 3 out of 5	12	Unit III
Q.3)B)	Any 3 out of 5	03	
Q.4)A)	Any 3 out of 5	12	Unit IV
Q.4)B)	Any 3 out of 5	03	

Practical Examination Pattern:

(A)Internal Examination: -				
	RUSCHEP501/601		RUSCHEP502/602	
	Paper I	Paper II	Paper III	Paper IV
Journal	05	05	05	05
Tests	10	10	10	10
Active Participation	05	05	05	05
Total	20	20	20	20
(B) External (Semester end practical examination):-				
Laboratory work	25	25	25	25
Viva	05	05	05	05
Total	30	30	30	30
Grand Total	100		100	

PRACTICAL JOURNAL

Semester V and VI:

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal, Certificate from from Head/ Co-ordinator should be submitted, failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Semester V

Course	501			502			503			504			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	20	30	50	20	30	50	20	30	50	20	30	50	200

Semester VI

Course	601			602			603			604			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	20	30	50	20	30	50	20	30	50	20	30	50	200

(Total: 1200 marks)

S.P. Mandali's
Ramnarain Ruia Autonomous College

Syllabus for T.Y.B.Sc
Programme – B.Sc.
Course: Drugs and Dyes (RUSACDD)
Resolution No. AC/II(18-19).2.RUS5

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

Learning Objectives:

- To make the learner capable of applying principles of basic chemistry and biology in the area of medicinal chemistry and dyestuff chemistry.
- To impart basic knowledge in classifying drugs in various categories on the basis of their activity.

- To inculcate the understanding of principles and theory involved in drug design and development.
- To make the learner understand the mechanism of drug action.
- To give general idea of methods used in estimating and synthesizing drugs and drugs intermediates.
- To give general idea of methods used in estimating and synthesizing dye and dye intermediates.
- To understand the effect of toxicity of dyes on ecology.

Learning Outcome: The student will -

- Understand various pharmacodynamic agents with respect to their chemical structure, chemical class, therapeutic uses, and side effects.
- Understand different routes of drug administration.
- Understand the metabolism of drugs inside the human body.
- Classify dyes based on their constitution and application.
- Understand relation between color and chemical constitution.

RAMNARAIN RUIA AUTONOMOUS COLLEGE
TYBSc
CHEMISTRY – APPLIED CHEMISTRY 2019-20
SEMESTER V
Course Code: RUSACDD501
Drugs and Dyes

UNIT	TOPICS	Credits	Lectures
I	General Introduction to Drugs Routes of Drug Administration and Dosage Forms Pharmacodynamic agents	2.0	15
II	Anti-Neoplastic Drugs Anti HIV Drugs Cardiovascular Drugs Antidiabetic Agents Antiparkinsonism Drugs Drugs for Respiratory System		15
III	Introduction to Dyestuff Chemistry Classification of dyes based on constitution Classification Based on Application		15
IV	Intermediates Preparation of intermediates Dyeing method of cotton fibres		15

PRACTICALS: SEMESTER V

UNIT	TOPICS	Credits	Lectures
I	PRACTICALS OF COURSE RUSACPDD501	2	04/ WEEK

Detail Syllabus:

COURSE CODE: RUSACDD501

UNIT	TOPIC	LECTURES
I	**1.1 General Introduction to Drugs** **1.1 .1** Definition of a drug, Requirements of an ideal drug, Classification of drugs (based on therapeutic action). **1.1.2** Nomenclature of drugs: Generic name, Brand name, Systematic name **1.1.3** Definition of the following medicinal terms; Pharmacon, Pharmacophore, Prodrug, Half-life efficiency, LD50, ED50, Therapeutic Index. **1.1.4** Brief idea of the following terms: Receptors, Drug-receptor interaction, Drug Potency, Bioavailability, Drug toxicity, Drug addiction, Spurious Drugs, Misbranded Drugs, Adulterated Drugs, Pharmacopoeia. **1.2. Routes of Drug Administration and Dosage Forms** **1.2.1** Oral and Parenteral routes with advantages and disadvantages. **1.2.2** Formulations, Different dosage forms (emphasis on sustained release formulations.) **1.3. Pharmacodynamic agents** A brief introduction of the following pharmacodynamic agents and the study with respect to their chemical structure, chemical class, therapeutic uses, and side effects **1.3.1 CNS Drugs:** Classification based on pharmacological actions, Concept of sedation and hypnosis, anaesthesia. Phenobarbitone (Barbiturates – mode of action), Phenytoin (Hydantoins), Trimethadione (Oxazolidinediones), Piracetam (Pyranones), Midazolam, Alprazolam (Benzodiazepines) Methylphenidate (Piperidines) Chlorpromazine (Phenothiazines) Fluoxetine (Phenyl propyl amines) Synthesis of Trimethadione, Methylphenidate, Phenytoin. **1.3.2 Analgesics and Antipyretics** Morphine (Phenanthrene alkaloids), Tramadol (Cyclohexanols), Aspirin (Salicylates), Paracetamol (p-Aminophenols), Synthesis of Tramadol, Paracetamol.	**(6L)** **(2L)** **(5L)** **(2L)**

II	**2.1 Anti-Neoplastic Drugs** **2.1.1.** Idea of malignancy; Types of Cancer, Causes of cancer, Treatment of cancer (surgery, radiation therapy, chemotherapy). **2.1.2.** Chemotherapeutic agents used in the treatment (Structures not expected):Lomustine (Nitrosoureas), Mitomycin C (Antibiotics), Vincristine; vinblastine; (mechanism of action), Cisplatin (mechanism of action), Fluorouracil (Pyrimidines) **2.1.3.** Synthesis of 5-Fluorouracil from urea. **2.2 Anti HIV Drugs** **2.2.1.** Introduction of AIDS and HIV, pathogenecity, Symptoms of AIDS, mode of transmission, prevention, Diagnosis and treatment **2.2.2.** Reverse transcriptase inhibitors (AZT, Stavudine (Pyrimidines), DDI (Purines) **2.3 Cardiovascular drugs** **2.3.1.** Introduction, Classification based on pharmacological action **2.3.2.** Enalapril (-amino acids), Isosorbide dinitrate (Nitrates), Atenoldol (Aryloxy propanol amines), Nifedipine (Pyridines), Furosemide (Sulfamyl benzoic acid), Synthesis of Furosemide, Atenolol **2.3.3.** Drug Therapy and Renin-Angiotensin System **2.4 Antidiabetic Agents** **2.4.1.** Introduction and types of diabetes; Insulin therapy **2.4.2.** Antidiabetic agents - Glibenclamide (sulphonyl ureas – mode of action), Metformin (Biguanides) **2.5 Antiparkinsonism Drugs** **2.5.1.** Introduction **2.5.2.** Procyclidine hydrochloride (Pyrrolidines), Ethopropazine hydrochloride (Phenothiazines) Laevodopa (alpha-amino acids) Synthesis of Levodopa from Vanillin. **2.6 Drugs for Respiratory System** **2.6.1.** General idea of Expectorants; Mucolytes; Bronchodilators Decongestants and Antitussives **2.6.2.** Bromhexine hydrochloride (Phenyl methyl amines), Salbutamol, Pseudo-ephedrine (Phenyl ethyl amines) Oxymetazoline (Imidazolines) Codeine Phosphate (Opiates) Synthesis of Salbutamol	**(3L)** **(2L)** **(3L)** **(2L)** **(2L)**

		(3L)
III	**3.1 Introduction to Dyestuff Chemistry** **3.1.1** Important landmark in the history of dyes **3.1.2**. Natural colouring matter and their limitations:e.g,; Heena, Turmeric, kesar, Chlorolphyll, Indigo, Alizarine from roots of madder plants, Logwood. Tyrian Purple. **3.1.3.** Synthetic Dyes: Important milestones, i.e. Mauve, Diazotization, aniline Yellow, Congo Red, Synthesis and structure of Indigo, disperse Dye, fluorescent Brighteners, procion reactive Dyes, Remazole Dyes. (Emphasis on Name of the Scientist and dyes and the year of the discovery is required and structure is not expected. **3.1.4.** Defination of dyes, Properties i.e. colour, Chromophore and Auxochrome, Solubility, Linearity, Coplanarity, fastness properties, substantivity, Economic viability. **3.1.5.** Explanation of nomenclature of commercial dyes with at least one example. Suffixes-G, O, R, B, 6B, GK, 3GK, 6GK, L, S Explanation: naming of dyes by colour index(two examples) **3.2. Classification of dyes based on constitution** (Examples are mentioned below with structures) Nitro Dyes-Napyhol yellow S, Nitroso Dye-Gambine Y, Azo Dyes- (a) Monoazo Dyes- Metanil yellow (b) DiazoDyes- Napthol Blue Black (c) Triazodyes -Chloroamine Green B, Diphenymethane Dyes-Auramine G, Triphenyl methane Dyes- (a) Malachite Green Series- Naphthalene green V (b) Magenta Series- Acid Magenta (c) Rosolic acid series-Chrome Violet, Heterocyclic Dyes, Xanthene-Rhodamine 6G, Acridines-Acriflavine, Azines- Safranine B, Oxazines-Capri blue, Thiazines-Methylene Green, Quiolines-Quinoline Yellow, Thiazoles-Primuline, Benzoquinones and naphthaquinones – Napthazarin, Anthraquinone Dyes- Indanthrene, Turquoise Blue 3GK, Indigoids-Indigo Caramine, Pthacyanines-Sirius Light green FFGL **3.3 Classification Based on Application** Definition, fastness properties & applicability on substrates examples with structures (a) Acid Dyes- Orange II, (b) Basic Dyes-methyl violet, Victoria Blue B (c) Direct cotton Dyes- Benzofast Yellow 5GL (d) Azoic Dyes-Diazo components; Fast yellow G,Fast	**(5L)** **(5L)**

	orange R. Coupling components. Naphthol AS, Naphthol ASG (e) Mordant Dyes-Erichrome Black A, Alizarin. (f) Vat Dyes-Indanthrene brown RRD, Indanthrene Red 5GK. (g) Sulphur Dyes-Sulphur Black T (no structure) (h) Disperse Dyes-Celliton Fast brown 3R, perlon fastblue FFR (i) Reactive Dyes- cibacron Brillant Red B,procion briilant Blue HB.	**(5L)**
IV	**4.1 Intermediates** 4.1.1. A brief idea of Unit processes 4.1.2. Introduction of primary intermediates, unit processes 4.1.3. Nitration, Sulphonation, Halogenation, Diazotization : 3 different methods, importance, Ammonolysis , Oxidation N.B.: Definition, Reagents Examples with reaction conditions (mechanism is not expected) **4.2 Preparation of the following Intermediates**. 4.2.1 Benzene derivatives: Benzenesulphonic acid; 1,3-Benzenedisulphonic acid; phenol; resorcinol; sulphanilic acid; o-,m-,p-chloronitrobenzenes; o-,m-,p-nitroanilines; o-,m-p- phenylene diamines; Naphthol ASG. 4.2.2 Naphthalene derivatives: α,β-Naphthols; α,β-Naphthylamines; Schaeffer acid, Tobias acid; Naphthionic acid; N.W. acid; Clev-6-acid; H acid; Naphthol AS. 4.2.3 Anthracene derivatives: 1-Nitroanthraquinone; 1-Aminoanthraquinone; 2-Aminoanthraquinone; 2-Methylanthraquinone; anthraquinone-1-sulphonic acid; Anthraquinnone-2-sulphonic acid; 1-Chloroanthraquinone; Chloroanthraquinone; Benzanthrone. **4.3 Dyeing Method of Cotton Fibres** 4.3.1 Direct dyeing, Vat dyeing , Mordant dyeing , Disperse dyeing 4.3.2 Forces binding of dyes to the fibres: Ionic forces, Hydrogen bonds, Van-der-Wall's forces, Covalent linkages.	**(5L)** **(7 L)** **(3L)**

Practicals

Course Code: RUSACPDD501

Dyes Preparation 1. Preparation of Orange-II 2. Preparation of p-Nitroacetanilide from Acetanilide
Dye Estimation: 1. Estimation of Primary amino group by diazotization
Drug Estimation 1. Estimation of Ibuprofen 2. Estimation of Acid neutralizing capacity of antacid
Drug Preparation: 1) Preparation of Methyl Salicylate from Salicylic Acid **5.** To write the monograph of Paracetamol and Aspirin from I.P.

REFERENCE

Medical Chemistry by V K Ahluwalia, Madhu Chopra, Ane's Books Pvt. Ltd.

SEMESTER VI
Course Code: RUSACDD601

UNIT	TOPICS	Credits	Lectures
I	**Drug Discovery, Design and Development** **Drug Metabolism** **Chemotherapeutic Agents** **Antibiotics** **Antimalarials**	**2.0**	**15**
II	**Anti-inflammatory Drugs** **Antiamoebic Drugs** **Antitubercular Drugs** **Antileprotic Drugs** **Drug Intermediates** **Nano particles in Medicinal Chemistry**		**15**
III	**Colour and chemical constitution of dyes** **Non-textile Uses of Dyes** **Optical brighteners** **Organic Pigments**		**15**
IV	**Synthesis of specific dyes and their uses** **Types of fibres and classes of dyes applicable to them** **Ecology and toxicity of dyes**		**15**

PRACTICALS :SEMESTER VI
Course Code: RUSACPDD601

TOPICS	Credits	Lectures
PRACTICALS OF COURSE	**2**	**04/WEEK**

RUSACDD601		

SEMESTER VI
Theory Course Code: RUSACDD601
Detail Syllabus:

Unit	Topic	Lectures
I	**1.1 Drug Discovery, Design and Development** 1.1.1 Discovery of a Lead compound: Screening, drug metabolism studies and clinical observation. 1.1.2 Drug development from Natural Sources: Anti infective agents Anti cancer agents CNS agent 1.1.3 Development of drug: The Pharmacophore identification, modification of structure or functional group, Structure activity relationship (Benzodiazepines, Sulphonamides). 1.1.4 Structure modification to increase potency: Homologation, Chain branching, Ring-chain transformation, Extension of the structure. 1.1.5 Computer assisted drug design. **1.2 Drug Metabolism** 1.2.1. Introduction, Absorption, Distribution, Bio-transformation, Excretion. 1.2.2. Different types of chemical transformation of drugs with specific example 1**.3 Chemotherapeutic Agents** Study of the following chemotherapeutic agents with respect to their chemical structure, chemical class, therapeutic uses, and side effects. **1.3.1 Antibiotics** Definition, Characteristics and properties of : Amoxicillin; Cloxicillin (lactum antibiotics) Cephalexin (Cephalosporins), Doxycycline (Tetracyclines), Gentamycin (Aminoglycosides), Ciprofloxacin (Quinolones) Synthesis of Ciprofloxacin **1.3.2 Antimalarials** Types of malaria: Symptoms; pathological detection during window period (Life cycle of the parasites not o be discussed) Chloroquine (3-Amino quinolines) Paludrine (Biguanides) Pyrimethamine (Diamino pyrimidines) Artemether (Benzodioxepins) Following combination to be discussed (i) Sulfadosine-Pyrimethamine (ii) Atremether-Lumefantrine (no structure) Synthesis of Paludrine.	**(5L)** **(4L)** **(3L)** **(3L)**

II	**2.1 Anti-inflammatory Drugs** 2.1.1. Mechanism of inflammation and various inflammatory conditions. 2.1.2. Prednisolone, Betamethasone (Steroids), Aceclofenac (N- Aryl anthranilic acids), Mefanic Acid (N-Aryl anthranilic acids). Synthesis of Aceclofenac. **2.2 Antiamoebic Drugs** 2.2.1. Types of Amoebiasis 2.2.2.Metronidazole; Diloxamide furoate (Furans) 2.2.3. Following combination therapy to be discussed: Ciprofloxacin-Tinidazo Synthesis of Metronidazole **2.3 Antitubercular Drugs** 2.3.1. Types of Tuberculosis; Symptoms and diagnosis of Tubeculosis. 2.3.2. General idea of Antibiotics used in their treatment. 2.3.3. Streptomycin, Rifampin, PAS (Aminosalicylates), Isoniazide (Hydrazides), Pyrazinamide (Pyrazines), (+) Ethambutol (Aliphatic diamines) Synthesis of Ethambutol. **2.4 Antileprotic Drugs** 2.4.1. Introduction, Types 2.4.2 Classification of anti-leprotic agents Ethionamide (Thioamides), Dapsone (Sulfonamides), Clofazimine (Phenazines) Synthesis of Dapsone 2.4.3. Following combination therapy to be discussed for the treatment of Tuberculosis and Leprosy: (i) Rifampin + Ethambutol + Pyrazinamide (ii) Rifampin + Isoniazide + Pyrazinamide (iii) Rifampin + Clofazimine + Ethionamide. **2.5 Drug Intermediates: Synthesis and uses** (i) 2,4,5-Triamino-6-hydroxypyrimidine from Guanidine. (ii) 3-Chloro-5-sulphonyl amino anthranilic acid from 3-Chloro-2-toludine (iii) p-[2'-(5-Chloro-2-methoxy benzamido) ethyl]-	**(2L)** **(3L)** **(2L)** **(3L)**

	benzenesulphonamide from Methyl-5-chloro-2-methoxybenzoate (iv) 4-(p-Chlorophenyl)-4-hydroxypiperidine from 4-Chloroacetophenone. (v) p-Acetyl amino benzenesulphonyl chloride from Aniline (vi) Epichlorohydrine from propene. **2.6 Nano particles in Medicinal Chemistry** 2.6.1. Introduction, Carbon nano particles (structures), Carbon nano tubes: Functionalisation for Pharmaceutical applications. Targeted drug delivery in vaccine (Foot and mouth disease) Use in Bio-physical treatment. 2.6.2 Gold nano particles in treatment of cancer, Parkinsonism, Alzheimer. 2.6.3. Silver nano particles: Antimicrobial activity.	**(2L)** **(3L)**
III	**3. 1 Colour and chemical constitution of dyes** 3.1 .1 Absorption of visible light, colour of wavelength absorbed, complementary colour. 3.1.2 Relation between colour and chemical constitution.(i) Armstrong theory (quinonoid theory) and its limitations (ii) Valence Bond theory; Comparative study and relation of colour in the following classes of compounds/dyes: Benzene, Nitrobenze, Nitroanilines, Nitrophenols, Benzoquinones, Azo, Triphenyl methane, Anthraquinones. (iii) Molecular Orbital Theory. **3.2. Non-textile Uses of Dyes** Structural features of the substrate, fastness and other property requirements and main classes of dyes used to be mentioned as applicable. (Two examples with structures for each of the following.) . 1. Leather 2. Paper 3. Foodstuff 4. Cosmetics 5. Medicinal 6. Biological Stains 7. Indicator & Analytical Reagents 3. Coloured Smokes & Camouflage colours 3. Laser Dyes **3.3 Optical Brighteners** General idea and important characteristics of optical brighteners, one example eachwith structure of the following classes: Stilbene,	**(5L)** **(6L)**

	Coumarin,Heterocyclic vinylene derivatives, Diaryl pyrazolines, Naphthalimide derivatives. **3.4 Organic Pigments** General idea, distinguish between dyes and pigments, important characteristics of organic pigments, Toners, Lakes, Classification of organic pigments with suitable examples, i.e. Ionic pigments-Lake of acid and basic dyes. Nonionic pigments-Azo, Indigoid, Anthraquinone, Quinacridone, Phthalocyanine (Copper phthalocyanine).	**(2L)** **(2L)**
IV	**4.1 Synthesis of Specific Dyes and their Uses** (i) Orange IV from sulphanilic acid (ii) Eriochrome Black T from β-naphthol (iii) Eriochrome Red B by using ethyl aceto acetate and 1-amino-2-naphthol-4-sulphonic Acid. (iv) Direct Deep Black EW by using benzidine, H acid, aniline, and m-phenylen diamine. (v) Congo Red from nitrobenzene vi) Diamond Black F by using 5-amino salicylic acid, N.W. acid and α-naphthylamine. (vii) Malachite Green by using benzaldehyde and N,N-dimethylaniline. (viii) Auramine O from dimethylaniline (ix) Methylene Blue by using 4-amino-N,N-dimethylaniline and N,N-dimethylaniline (x) Safranine T by using o-toluidine and aniline (xi) Pararosaniline by using p-toluidine and aniline (xii) Alizarine Cyanine Green G by using phthalic anhydride and p-cholorophenol (xiii) Indanthrene from anthraquinone (xiv) Disperse Yellow 6G from benzanthrone (xv) Indigo from aniline (xvi) Eosine by using phthalic anhydride and resorcinol (xvii) Bismark Brown from m-phenylenediamine. **4.2 Types of Fibres and Classes of Dyes Applicable to them** Introduction to the following types of fibres with structures and classes of dyes applicable to it. Cotton, Wool, Silk, Polyester. **4.3 Ecology and Toxicity of Dyes**	**(12L)**

	With reference to the textile dyes, food colours, benzidine etc.	**(1L)** **(2L)**

Practicals

Course Code: RUSACPDD601

1. Dyes Preparation 1. Preparation of m-dinitrobenzene 2. Preparation of m-nitroaniline
2. Dye Estimation: Estimation of Methyl Orange/ Eriochrome Black T/Eosin/Congo Red by colorimetry
3. Drug Estimation Estimation of Tincture of Iodine
4. Drug Preparation: Preparation of Aspirin from Salicylic Acid
5. Dyeing of fabric (cotton)by Direct Dyeing or by Vat Dyeing.

REFERENCE:

Medical Chemistry by V K Ahluwalia, Madhu Chopra, Ane's Books Pvt. Ltd.

Modality of Assessment

Theory Examination Pattern:

A) Internal Assesment 40% **40 Marks**

Sr No	Evaluation type	Marks
1	One Assignment	10
2	One class Test (multiple choice questions / objective/ drawing structure of drugs and dyes)	20
3	Active participation in class	05
4	Overall conduct, participation in curricular and co-curricular activities.	05

B) External Assesment - 60%

Semester End Thory Assesment- 60 Marks

i. Duration - These examinations shall be of **two hours** duration.
ii. Theory question paper pattern: - There shall be **four** questions each of **15** marks, one on each unit. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions on
Q.1) a)	Any 3 out of 5	12	Unit I

Q.1) b)	Any 3 out of 5	03	
Q.2) a)	Any 3 out of 5	12	Unit II
Q.2) b)	Any 3 out of 5	03	
Q.3) a)	Any 3 out of 5	12	Unit III
Q.3) b)	Any 3 out of 5	03	
Q.4) a)	Any 3 out of 5	12	Unit IV
Q.4) b)	Any 3 out of 5	03	

Practical Examination Pattern:

A) Internal Examination: -

Activity	Marks
Journal	10
Tests	20
Active Participation	10
Total	40

B) External Examination
(Semester end practical examination):- 30 Marks per Section

Sr. No.	Particulars	Marks	Total
1)	**Laboratory Work**	25 + 25	50
2)	**Viva- Voce**	05 + 05	10

PRACTICAL BOOK / JOURNAL

Semester I and II:

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / In charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Course	501			601		
	Internal	**External**	**Total**	**Internal**	**External**	**Total**

Theory	**40**	**60**	**100**	**40**	**60**	**100**
Practicals	**40**	**60**	**100**	**40**	**60**	**100**

S.P. Mandali's
Ramnarain Ruia Autonomous College

Syllabus for T.Y.B.Sc
Programme – B.Sc.
Course: Nonconventional Energy Sources and Waste Recycling (RUSACNCE)
Resolution No. AC/II(18-19).2.RUS5

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

T. Y. B. Sc. Applied component NCE-WR
Preamble

The purpose of including applied component subject at the graduation level, along with the core subject, was to make the students aware of the peripheral topics associated with the core subject but which could not be included at the core level. In many situations, it increased the reach of the core subject, in others it acted as a complementary subject to the core.

Chemistry is an application based science. The properties of the material synthesized are in accordance with the requirement. Chemistry becomes interesting because of the interactions that many of the material existing in nature or that has been synthetically prepared. Applications of these materials will involve interaction. One of the most important interactions of these materials is with the environment for which chemistry has not only been accused but has been made a culprit as well.

With increasing demand for the diverse materials, with different physical and chemical properties introduced in to the environment, the interactions have become more and more important for our survival. The increasing production of materials of diverse nature both in quality and quantity has not only depleted the natural resources, produced all kinds of waste but also severely affected our environment. A student graduating in chemistry cannot afford to miss all these important consequences of use of chemistry. Hence the necessity to make the student familiar with the problems of resource depletion, increasing energy requirements, generation of all types of wastes in increasing quantity and the methods of their disposal .It is not only the chemistry aspect of the problem but the socio economic political part of which is the part to which the student should be familiarized with as it is this part which is well understood by the laypersons as well.

Finally as it is often said, we are the trustees of this beautiful entity called as mother earth and it is our responsibility to transfer it in robust health to the future generations. If the study of this applied component can inculcate the above mentioned feeling and the awareness that solution to each and every problem begins with oneself in the mind of the graduate student then we feel that the purpose of introducing this as an applied component will be served.

RUSACNCE501
SEMESTER V

UNIT	TOPICS	Credits	Lectures
I	**NON-CONVENTIONAL SOURCES OF ENERGY:** **Perspectives on Energy Sources and Utilization:**	2.0	15
II	**Study of the following non conventional energy sources with respect to scope, present scenario, applications, limitations and future prospects:** • **Solar Energy** • **Wind Energy** • **Tidal energy** • **Geothermal Energy:**		15

III	**WASTE RECYCLING:** **Introduction to waste management.** **Management of gaseous waste**		**15**
IV	**Introduction to liquid waste** **Particulate matter and its management**		**15**

PRACTICALS :SEMESTER V

Course Code	UNIT	TOPICS	Credits	Lectures
RUSACNCEP501	**I**	**PRACTICALS OF COURSE RUSACNCE501**	**2**	**04/ WEEK**

RUSACNCE601
SEMESTER VI

UNIT	TOPICS	Credits	Lectures
I	**Ocean Thermal Energy Conversion** **Fuel Cells**	**2.0**	**15**
II	**Biomass**		**15**
III	**Solid Waste Management**		**15**
IV	**Liquid Waste Management**		**15**

PRACTICALS :SEMESTER VI

Course Code	UNIT	TOPICS	Credits	Lectures
RUSACNCE P601	**I**	**PRACTICALS OF COURSE RUSACNCE601**	**2**	**04/ WEEK**

SEMESTER V

Learning Objectives:

The prescribed syllabus aims at familiarizing the learner with the concept of energy and its types, its consumption rates and a comparative study for developed and underdeveloped nations. So also, waste disposal and its environmental hazards, which is an alarming condition is also introduced to the learner.

Learning Outcome:

After studying this prescribed syllabus, the student will know -

- Concept of Energy – Its types, sources and its comparative utilization
- Solar Energy – Concepts and Applications and Relevance
- Wind and Geothermal Energy
- Concept of Waste and its disposal

Detail Syllabus

Semester - V
Course Code: RUSACNCE501
Credits: 2
NON-CONVENTIONAL SOURCES OF ENERGY AND WASTE RECYCLE

Unit	TOPIC	LECTURES
I	**NON-CONVENTIONAL SOURCES OF ENERGY.** **1.1 Perspectives on Energy Sources and Utilization:** **1.1.1**: Definitions, units and concept. **1.1.2**: Need for energy, energy requirements of a society: developed and underdeveloped, wants and needs with respects to energy, unequal distribution of energy, factors governing the energy consumption pattern, energy consumption and depletion of resources, and Energy needs for the domestic, industrial and agricultural and transport sector, energy utilization and sustainable development, local and global patterns of energy consumption. Depletion of energy sources. **1.1.3** Various types of energy sources, conventional/ non conventional, renewable / non renewable, fossil fuels: coal, oil, natural gas; thermal, hydroelectric and nuclear. **1.1.4** Energy, development and environment, concept of sustainable development and its execution, need of conservation of energy storage and conservation, Environmental implications of energy usage, energy storage and conservation, Role of Government and non government organization, socio-economic aspects, Government policies. **1.1.5** Entrepreneurship opportunities in the energy sector.	**(15L)**
II	**Study of the following non conventional energy sources with respect to scope, present scenario, applications, limitations and future prospects:** **2.1 Solar Energy** **2.1.1** Solar spectrum and its relevance as the energy source, solar radiation, conversion of solar energy into heat energy in solar collectors, Fresnel lenses, parabolic reflectors. **2.1.2** Photovoltaic effect, semi-conductors as solar energy converters, different materials used, factors affecting photovoltaic efficiency, effect of temperature, solar cells. **2.1.3** Photo-electrochemical process for the conversion of solar energy; **a**pplications of solar energy for different purposes. **2.1 .4 Scope, relevance in the present scenario: local and global. Applications, limitations and future prospects.** **2.2 Wind Energy** **2.2.1** Wind velocity and generation of wind energy **2.2.2** Types of wind mills and their working, rotor with blades, gear generator, vertical and horizontal axis of rotation. **2.2.3 scope, relevance in the present, local and global scenario: environmental impact,, applications, limitations and future prospects:** **2.3 Tidal Energy:** **2.3.1**: Tide height and its potential for power generation. **2.3.2:** Construction of dam across sea basin, installation of the turbine, specification of the basin. **2**.3.3 **scope, relevance present, local and global scenario: applications, limitations and future prospects** **2.4 Geothermal Energy:** **2.4.1**: Origin of geothermal heat, temperature gradient, geothermal steam and hot spring, geysers. **2.4.2:** Power production from geysers, mantle as heat source.	**(7L)** **(3L)** **(2L)**

	2.4.3 Relevance to the present, local and global scenario: environmental impact, viability, market economics , applications, limitations and future prospects:	**(3L)**
III	**WASTE RECYCLING:** **3.1 Introduction to waste management**: **3.1.1**Definition of waste, types of waste, changing trends in waste generation, resources, development, population and waste generation, concept of waste management and approaches to it: end of the pipe treatment, in plant treatment, goal of zero waste and its feasibility, introduction to green chemistry. **3.1.2** waste disposal and its three 'R"s Recovery, reuse, recycle and disposal of waste, economic viability of each of the above, waste audit. **3.1.3** waste generation: Types of waste on the basis of usage, sources, physical state, feasibility with respect to three Rs. domestic, industrial, agricultural and commercial waste; gaseous, solid and liquid waste. **3.2 Management of gaseous waste:** **3.2.1**: Generation of gaseous waste, smoke, fog mist, emission of gases, Sources, contribution of different sources to total waste. Effects: vehicular and chimney exhaust **3.2.2** Treatment methods, adsorption, absorption, catalytic conversion, their feasibility cost and regulation **3.2.3** Minimization methods, economic viability of reuse.	**(9L)** **(6L)**
IV	**4.1 Introduction to liquid waste** **4.1.1**: liquid waste: Generation, local and global sources, variation in the amount generated. **4.1.2** Characterization of liquid waste **4.1.3** Physical parameters; colour, odour, turbidity, TSS. TDS, TS **4.1.4** Chemical parameters: pH, acidity, alkalinity, hardness, DO, COD, **TOC**, THOD and BOD, chemical composition , classification. **4.2 Particulate matter and its management:** **4.2.1:** Particulate matter: sources, relation to energy comsumption, characterization, effects. **4.2.2** Disposal methods, cyclone separator, wet scrubber, electrostatic precipitator, fabric filter. **4.2.3 regulations and their implementation in case of waste disposal, Role of the government.**	**(8 L)** **(7 L)**

Semester-V
Practicals of NCEWR
Course Code: RUSACNCEP501
Credits: 2

(a) The practicals to be carried out by each student

1. Determination of acidity , alkalinity and hardness of the given water sample.
2. Construction of the breakthrough curve and determination of breakthrough capacity of the given ion exchanges resin..
3. Determination of TS , TSS and TDS present in the given water sample.

4. Estimation of chloride in water sample by argentometric method
5. Determination of nitrite colorimetrically from the waste water sample.
6. Determination of sulphate in the given water sample by benzidine sulphate method.
7. Determination of Cr (VI) spectrophotometrically in the given water sample.
8. Determination of phosphates in water by stannous chloride method.

(2 experiments to be done at the time examination)

Semester - VI
Course Code RUSACNCE601
Credits: 2
NON-CONVENTIONAL SOURCES OF ENERGY AND WASTE RECYCLE

Learning Objectives:
Towards the end of the course, the learner has been made familiar with various concepts in sources of energy and waste management. This syllabus aims at introducing the learner with concepts behind Ocean Thermal Energy, application of electrochemical principles to Fuel Cells. Along with this, the learner is introduced to a hot field of research namely hydrogen fuel cells. Along with that, this syllabi explores the uses of Biomass as a source of energy.

Learning Outcome:
Towards the end of the syllabus, the learner will have sufficient knowledge about the following aspects:

- Ocean Thermal Energy
- Fuel Cells: Study of Thermodynamic and Kinetic Parameters and their applications.
- Hydrogen as a fuel
- Biomass and its applications
- Solid Waste Management- Its sources, characterization and disposal methods.

- Various Treatment methods used for three step treatment of liquid Waste in general and their applications in specific industries like fertilizer, food & beverage, petrochemical industry.

Unit	TOPIC	L
I	**NON-CONVENTIONAL SOURCES OF ENERGY.** **1.1 Study of the following non conventional energy sources** **1.1. Ocean Thermal Energy Conversion** **1.1.1.1** Difference in surface temperatures and at a depth in ocean, its use as a source for power generation **1.1.1.2**Requirements for a practical OTEC plant, different working fluids. **1.1.1.3** Relevance to the present scenario, feasibility and future projection. **1.2 Study of the following energy sources** **1.2.1Fuel Cells:** **1.2.1.1** Electrochemical energy conversion, basic principle of fuel cells, advantages of energy conversion in fuel cells, distinction between fuel cell and battery. **1.2.1.2** Thermodynamic and kinetic effects of the fuel cell. **1.2.1.3** Hydrogen – oxygen fuel cell, organic oxygen fuel cell **1.2.1.4** Applications of fuel cells. **1.2.1.5** scope, present scenario, limitations and future prospects. **1.3 Use of hydrogen as a potential fuel:** availability, generation and use , feasibility and economic viability, advantages **1.3.2** Economically viable hydrogen production, photolysis of water	**(3L)** **(9L)** **(3L)**
II	**2.1 Biomass:** **2.1.1** Solar energy and generation of biomass, energy from plants, types and energy value, utilization with and without conversion. **2.1.2** Feasible biomass conversion technologies, thermo chemical combustion, pyrolysis, gasification. **2.1.3.** Alcohol from fermentation of sugars, enzyme reactor for continuous production of alcohol. Biodiesel, biofuels. **2.1.4** Fuel from farm and animal waste: economically viable technologies and their availability and production of methane in the biogas plant, domestic and industrial use of bio gas. **2.1.5** Municipal and industrial solid waste as heat source. **2.1.6** Potential of biomass as an energy source, actual utilization on the local and global scale, awareness creation, role of government and NGOs, regulations.	**(15L)**

III	**WASTE RECYCLING:** **3.1 Solid Waste Management**: **3.1.1** Solid waste, sources and their characterization. **3.1.2** classification of solid waste: chemical nature, biodegradable and non biodegradable, their feasibility with respect to the use of three 'R's. **3.1.3** Feasibility of recycling : metal, paper, plastic rubber and glass, costs and economic viability, need of the treatment at the source level, role of the government and awareness in citizens. **3.1.4:** Methods of disposal of solid waste: 3.1.4.1 Dumping of garbage, 3.1.4.2 Sanitary landfills, 3.1.4.3 Composting, soil conditioning, vermi- composting. 3.1.4.4 Incineration; **3.1.5** Hazardous and toxic waste, definition, classification, difference between the hazardous and toxic waste, methods of minimization/ **3.1.6** Radioactive waste: sources, effects on plants, animal and man, activity level and its management, minimization and treatment. **3.1.7:** e-waste, types. **3.1.8** Hospital and medical waste, disposal and preventive measures. **3.1.9** Disaster management and risk analysis, restriction of hazardous substances.	**(15L)**
IV	**Liquid Waste Management:** **4.1** Waste water, industrial effluent, need for the treatment**. sources,** **4.2**Use of COD, BOD and TOC for deciding the treatment process . **4.3**:Pre-primary treatment: neutralization, equalization **.** **4.4**Primary treatment: screening, sedimentation, coagulation, filtration **4.5** Secondary treatment: principles of the biological treatment of liquid waste, **4.6** Various processes used : aerobic and anaerobic process. **4.6.1** Aerobic process, oxidation ponds, oxidation ditch, Aerated lagoons, activated sludge process and trickling filter process. **4.6.2** Anaerobic processes, anaerobic contact process **4.7** Tertiary treatment: reverse osmosis, ultra filtration, electrodialysis, ion exchange, ozone treatment. **4.8 Government regulations, permissible levels for drinking water and for other uses.** **4.9 Attempts for end of the pipe and at source treatment.** **4.10** Characterization of effluent from i) Petrochemical ii) food and beverage iii) Fertilizer industry.	**(15L)**

Semester-VI
Practicals of NCEWR
Course Code: RUSACNCEP601
Credits: 2

The practicals to be carried out by each student **30 Marks**

1. Determination of COD of the waste water sample.
2. Determination of dissolved oxygen present in the given water sample.
3. Determination of dosage of coagulant by Jar Test.
4. Estimation of nitrate in waste water using phenoldisulphonic acid method.
5. Determination of iron in water sample by phenanthroline method / AAS method

Group Activities:

1. Preparation of Biofuel from waste oil
2. Soil analysis.

REFERENCE BOOKS

1 Solar energy: principles of thermal collection and storage – S.P. Sukhatme, Tata Mcgraw Hill, New Delhi 1990

2 Fuel Cell Will Mitchell, Academic Press 1963.

3 Photo electrochemical Cells: Studies in Physical and theoretical Chemistry, Vol.50 K.V.S.Santham & M.Sharma, Elsevier Publishing Company, Amsterdam, 1988.

4 Wastewater Treatment and pollution control : S.A.Arsewala, Tata Mcgraw Hill, New Delhi 1990.

5 Pollution Control in Process Industries: S.P.Mahajan, Tata Mcgraw Hill, New Delhi 1990.

6 Waste Water Treatment: M.N. Rao and A.K. Datta, Oxford and IBH Publishing

Modalities of Assessment

Theory Examination Pattern:

A) Internal Assessment - 40 marks.

Theory **40 marks**

Sr No	Evaluation type	Marks
1	One class Test (multiple choice questions / objective)	20
2	Seminar Presentations/ Assignments	15
3	Active participation in routine class .	05

B) External examination - 60 %

Semester End Theory Assessment - 60% **60 marks**

i. Duration - These examinations shall be of **two hours** duration.

ii. Theory question paper pattern: -There shall be **four** questions each of **15** marks, one on each unit. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions on
Q.1) a)	Any 3 out of 5	12	Unit I
Q.1) b)	Any 3 out of 5	03	
Q.2) a)	Any 3 out of 5	12	Unit II
Q.2) b)	Any 3 out of 5	03	
Q.3) a)	Any 3 out of 5	12	Unit III
Q.3) b)	Any 3 out of 5	03	
Q.4) a)	Any 3 out of 5	12	Unit IV
Q.4) b)	Any 3 out of 5	03	

Practical Examination Pattern for RUSACPNCE :

A) Internal Examination: - 501 and 601

Activity	Marks
Internal of Practical Test	10
Biogas Plant Maintenance	30
Total	**40**

B) External Examination 501
(Semester end practical examination):- 60 Marks

Sr. No.	Particulars	Marks
1	Laboratory Work	25 + 25
2	Viva and Journal	5+ 5
Total		**60**

C) External Examination 601
(Semester end practical examination):- 60 Marks

Sr. No.	Particulars	Marks
1	Laboratory Work	25

2	Journal + Viva	5+5
3	Project work	25
Total		60

Overall Examination and Marks Distribution Pattern

Course	**501**			**601**		
	Internal	**External**	**Total**	**Internal**	**External**	**Total**
Theory	**40**	**60**	**100**	**40**	**60**	**100**
Practicals	**40**	**60**	**100**	**40**	**60**	**100**