Royal College of Arts Science and Commerce (Autonomous)

Affiliated to University of Mumbai

Program: Batchelor of Science

Course : Chemistry

Syllabus for Semester : I and II

Syllabus for Undergraduate Programme as per

National Education Policy (NEP-2020) with effect from the academic year 2024-2025 Progressively

NEP Credit Structure for Science

Level	Sem	Major		Minor	OE	VSC	SEC	AEC	IKS	VEC	OJT/FP /RP/CC /CEP	Cumulative Credits	
		DSC	DSE										
4.5	I	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2	2		2	2	2		22	UG Certificate Cumulative Credit:44
	II	6 (4Th + 2 Pr)		4+2 (4Th + 2 Pr)	2		2	2		2	2	22	
Exit Option: Award of UG Certiflcate in Major with 40 -44 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5	III	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	UG Diploma Cumulative Credit:88
	IV	8 (6Th + 2 Pr)		4 (2 Th + 2 Pr)	2+2		2	2			2	22	
Exit Option: Award of' UG Diploma in Major and Minor with 80-88 Credits and an Additional 4 Credits Core NSQF Course / Internship OR Continue with Major and Minor													
5.5	V	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22+	UG Degree Cumulative Credit:132
	VI	10 (8Th + 2 Pr)	4 (2Th + 2 Pr)			4					4	22	
	Total	**48**	**8**	**20**	**12**	**10**	**6**	**8**	**2**	**4**	**14**	**132**	

Programme Outcomes (POs) for B.Sc.	
Sr. No.	As a graduate of science faculty a student should have:
PO1	Acquired the basic knowledge related to the subject offered.
PO2	Understood the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life
PO3	Acquired the skills in handling scientific instruments
PO4	Acquired the skills of planning and performing laboratory experiments, recording observations and drawing logical inferences from the scientific experiments
PO5	Developed scientific outlook not only with respect to science subjects but also in all aspects related to life.
PO6	Acquired the basic knowledge related to the subject offered.

Programme Specific Outcomes (PSOs) for B.Sc.	
Sr. No.	The student graduating with the Degree B.Sc Chemistry should be able to acquire
PSO1	Core competency: Students will acquire core competency in the subject Chemistry, and in allied subject areas.
PSO2	A systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, and all other related allied chemistry subjects
PSO3	Students will be able to use the evidence-based comparative chemistry approach to explain chemical synthesis and analysis.
PSO4	Students will be able to characterize, identify and separate components of organic or inorganic origin and will also be able to analyze them by making use of the modern instrumental methods learned.
PSO5	Students will be able to understand the basic principle of equipment and instruments used in the chemistry laboratory.
PSO6	Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry
PSO7	The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.
PSO8	Appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues, and key issues facing our society in terms of energy, health, and medicine.
PSO9	Lifelong learner: The course curriculum is designed to inculcate a habit of learning continuously through the use of advanced ICT techniques and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity.

SEMESTER I

Course/ Paper Title	Paper 1 : MJ 1 : Basics in Physical and Inorganic Chemistry
Vertical	Major
Type	Theory
Course Code	RCUSCHMJ101
Semester	1
No. of Credits	2
Hours Allotted	30 Hours
No. of lecture Hours/week	2
Marks Allotted	50 Marks

Course Objectives (CLO):

CLO 1	To train the learner in the basic knowledge of chemistry for industrial applications
CLO 2	To introduce the knowledge of principles of Viscosity, surface tension, Refractive Index and their measurements
CLO 3	To give an understanding of the principles of chemical kinetics , including reaction rate and rate laws
CLO 4	To acquaint the learner with different concentration units and preparation of solutions
CLO 5	To create an awareness the structure of the atom & the quantum mechanical aspect.
CLO 6	To inculcate a thorough understanding of the periodic table with respect to elements

Course Outcomes (CO) :

	On completing the course, the student will be able to:
CO 1	Calculate properties of liquid state such as Viscosity, surface tension, Refractive Index
CO 2	Derive rate expressions and determine order of reactions.
CO 3	Calculate the concentration of solution in different units
CO 4	Elaborate on the various models of the atomic structure and the quantum mechanical model of atom and the shapes of orbitals.
CO 5	Identify the position of elements in the periodic table

Paper I: MJ1: Basics in Physical and Inorganic Chemistry I

Unit I	Physical Chemistry
1.1	**Liquid State: (5L)** **Surface tension:** Introduction, methods of determination of surface tension by drop number method **Viscosity:** Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer **Refractive index**: Introduction, molar refraction and polarizability, determination of refractive index by Abbe's refractometer.
1.2	**Chemical Calculations: (5L)** Methods of expressing concentration of solutions: Normality, Molarity, Formality, Mole fractions, Weight ratio, Volume ratio, Weight to volume ratio, ppm, ppb, millimoles, milliequivalents, Preparation of solutions. (Numerical problems expected wherever necessary)
Unit II	**Physical Chemistry**
2.1	**Chemical Kinetics: (10L)** Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, Integrated rate equation of first order and Second order reactions (with equal initial concentration of reactants) Determination of order of reaction by a) Integration method b) Graphical method c) Ostwald's isolation method d) Half time method, Effect of temperature on the rate of reaction, Concept of activation energy and its calculation from Arrhenius equation (derivation not expected). (Numerical problems expected wherever necessary).
Unit III	**Inorganic Chemistry**
3.1	**Atomic structure: (8L)** **Historical perspectives of the atomic structure;** J. J. Thomson Model, Rutherford's Atomic Model- alpha particle scattering experiment, Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Structure of hydrogen atom.

	Hydrogenic atoms: 1. Simple principles of quantum mechanics 2. Atomic orbitals i) Hydrogenic energy levels ii) Shells, subshells and orbitals iii) Electron spin iv) Radial shapes of orbitals v) Angular shapes of orbitals. Aufbau principle, Hund's rule of maximum multiplicity and Pauli exclusion principle
3.2	**Periodic Table and periodicity: (2L)** **Long form of Periodic Table:** Classification for elements as main group, transition and inner transition elements.

Paper II: MJ2: Basics in Organic and Inorganic Chemistry I

Course/ Paper Title	Paper 2 : MJ 2 Basics in Organic and Inorganic Chemistry I
Vertical	Major
Type	Theory
Course Code	RCUSCHMJ102
Semester	1
No. of Credits	2
Hours Allotted	30
No. of lecture Hours/week	2 hours
Marks Allotted	50 Marks

Course Objectives (CLO):

CLO 1	To introduce the rules of nomenclature of organic molecule
CLO 2	To acquaint the learner with the structure and bonding of organic compounds.
CLO 3	To update the learner with stereochemical configuration of an organic molecule
CLO 4	To give an understanding of the chemistry of oxides and hydroxides of main group elements and preparation, properties and applications of some important compounds
CLO 5	To reinforce the environmental aspects of non metallic oxides

Course Outcomes (CO) :

	On completing the course, the student will be able to:
CO 1	Draw a structural formula from the name of a compound and give the name of the compound from the structure
CO 2	Correlate the hybridization, bond formation and structure of molecule
CO 3	Distinguish between different kinds of stereoisomers
CO 4	Summarize the chemistry of oxides and hydroxides of main group elements, preparation and properties of some important compounds
CO 5	Discuss the environmental aspects of non metallic oxides

Paper II : MJ2: Basics in Organic and Inorganic Chemistry

Unit I	Organic Chemistry
1.1	**Classification and Nomenclature of Organic Compounds: (5L)** **Nomenclature of mono and bi-functional aliphatic compounds on the basis of priority order of the following classes of compounds**: Alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines and their cyclic analogues.
1.2	**Bonding and Structure of Organic Compounds: (7L)** **Hybridization**: sp3, sp2, sp hybridization of carbon and nitrogen; sp3 and sp2 hybridizations of oxygen in Organic compounds (alcohol, ether, aldehyde, ketone, carboxylic acid, ester, cyanide, amine and amide) **Overlap of atomic orbitals:** Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules. **Shapes of molecules;** Influence of hybridization on bond properties (as applicable to ethane, ethene, ethyne).
Unit II	**Organic Chemistry**
2.1	**Stereochemistry I: (8L)** Projection formulae: Flying Wedge projection, Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3 -dichlorobutane) and their interconversions; **Geometrical isomerism in alkene**: cis–trans and syn-anti isomerism R/S nomenclature, E/Z notations with C.I.P rules. **Optical Isomerism:** Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two similar and dissimilar chiral-centres, Diastereoisomers, meso structures, racemic mixture and resolution (methods of resolution not expected). **Conformational analysis of alkanes** (ethane, and n-butane)

Unit III	**Inorganic Chemistry**
3.1	**Comparative Chemistry of Main Group Elements: (10L)** Comparative chemistry of oxides and hydroxides of group I and group II elements. Some important compounds- **$NaHCO_3$, Na_2CO_3, CaO, $CaCO_3$**; oxides of carbon, oxides of Sulphur and Nitrogen with respect to environmental aspects like greenhouse effect, photochemical smog and acid rain.

MJCHP1 : Chemistry Practical 1

Course/ Paper Title	Chemistry Practical 1
Course offered as	Major
Type	Practical
Course Code	RCUSCHMJP1
Semester	1
No. of Credits	2
No. of Hours/week	4 hours practical /week
Hours Allotted	60
Marks Allotted	50 Marks

Course Objectives (CLO): To enable the learner to

CLO 1	Perform basic volumetric titration techniques
CLO 2	Handle and measure viscosity with Ostwalds Viscometer
CLO 3	Study reaction rate by classical kinetic method
CLO 4	Conduct qualitative and quantitative chemical analysis
CLO 5	Work on semi-micro scale experiments

Course Outcomes (CO) :

	On completing the course, the student will be able to:
CO 1	Standardise solution using primary standard
CO 2	Determine relative viscosity of solutions
CO 3	Determine rate constant of reaction
CO 4	Perform gravimetric analysis of mixtures
CO 5	To determine nature of organic compounds and physical constant

MJCHP1 : Chemistry Practical 1

Paper I

Physical Chemistry

1) To prepare 0.1 N succinic acid and standardize the NaOH solution of different concentrations.
2) To standardize Sodium thiosulphate solution.
3) To determine the rate constant for the hydrolysis of ester using HCl as catalyst.
4) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature (Any two solutions).

Inorganic Chemistry

Quantitative Analysis : Gravimetric and Volumetric analysis

a) To determine the strength of commercial acid sample (HCl).
b) To estimate the content of Na_2CO_3 and $NaHCO_3$ in the given sample using double indicator

Paper II

Organic Chemistry

1. Purification of organic compounds by recrystallization selecting suitable solvent (minimum 2 Organic compounds to be given)
   (Learners are expected to report a) Solvent for recrystallization.
   b) Percentage Yield and the melting points of the purified compound.)
2. Basic principles involved in characterization of Organic compound (minimum 4 Solid Organic compounds)
   (Learners should perform Preliminary Tests, Solubility Test, obtain melting point and recrystallize the compound with given solvent)

Inorganic Chemistry
Quantitative Analysis :

Gravimetric and Volumetric analysis

a) To determine the percent purity of sample of $BaSO_4$ containing NH_4Cl
b) To determine the percent purity of ZnO containing $ZnCO_3$.

VOCATIONAL SKILL COURSE (VSC)

Course/ Paper Title	Calibration of Glasswares , Instruments and Lab safety
Course offered as	Vocational Skill Course
Type	Theory/Practical
Course Code	**RCUSCHVSC1 / RCUSCHVSCP1**
Semester	1
No. of Credits	2
Hours Allotted	45 hours (Theory 1 Credit = 15 Hours, Practical 1 Credit = 30 Hours)
No. of lecture Hours/week	1 hour
No. of Practical Hours/week	2 hour
Marks Allotted	50 Marks

Sr No.	**Course Objectives (CLO)**
CLO 1	To introduce glassware and instruments used in Chemistry laboratory
CLO 2	To give an understanding of the importance of calibration of glassware and instruments in tune with concepts of precision and accuracy.
CLO 3	To develop awareness about safety measures for handling chemicals.

	Course Outcome (CO)
	On completing the course, the student will be able to:
CO 1	Calibrate glassware and instruments.
CO 2	Minimize errors in chemical analysis
CO 3	use various chemicals with the necessary care.

Semester 1 : VSC

Calibration of Glasswares, Instruments and Lab Safety

Unit	Description	Hours
I **Theory Component**	**1.1 Tools of Analytical Chemistry** 1. Introduction to common laboratory glassware and instruments used in practical course 2. SOPs for instruments used in practical course 3. Importance of Calibration with reference to accuracy, precession and minimization of errors	**04**
	1.2 Introduction to Analytical Chemistry & Calibration of Laboratory Instruments 1. Introduction, types of chemical analysis, general analytical method, primary standard and secondary standard substances. 2. Calibration of Laboratory Glassware: Burettes, Pipettes, Volumetric Flask, thermometer etc. 3. Calibration of laboratory instruments: pH meter, conductometer and colorimeter.	**06**
	1.3 Chemicals and Laboratory Safety 1. Personal safety and safety equipments 2. Material Safety Data Sheets with reference to hazardous chemicals like $K_2Cr_2O_7$, Benzene, cadmium nitrate, β-naphthol, CCl_4 and mercury. 3. Chemical storage and transfer . Precautions in handling of hazardous substances like conc. acids, ammonia, organic solvents like ether and alcohol. 4. Accidents, Hazards and First Aid	**05**
II **(Practical Component)**	**2.1 Calibration of Laboratory Glassware** 1. Calibration of Burette 2. Calibration of Pipette 3. Calibration of Standard measuring flask **2.2 Calibration of Laboratory Instruments** 1. Calibration of Conductometer 2. Calibration of Colorimeter 3. Calibration of pH meter 2.3 Quantitative estimation using oxidizing agent and MSDS of chemicals involved. (Minimum 2 chemicals)	**30**

References-

1. Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch (2006)
2. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Hollers'. Crouch (2009)
3. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education (1999)
4. S.M. Khopkar, "Basic Concepts of Analytical Chemistry", IInd Edition New Age International Publisher (2004)
5. Principles of Instrumental Analysis, D. A. Skoog, F. James Holler, Stanley R. Crouch (2007)
6. Vogel's Textbook of quantitative chemical analysis, 5th edition (1989)
7. Instrumental method of analysis, B.K. Sharma, Goel publishing house. Miscellaneous methods (2005

Semester 1 : Open Elective (OE)

Chemistry in Daily Life

Course/ Paper Title	**Chemistry in Daily Life**
Course offered as	**Open Elective (OE)**
Type	Theory
Course Code	**RCUSCHOE1**
Semester	1
No. of Credits	2
Hours Allotted	30 Hours
No. of lecture Hours/week	2 Hour
Marks Allotted	50 Marks

Sr No.	**Course Objectives (CLO)**
CLO 1	Introduce a subject which has importance in everyday life.
CLO 2	Make them aware of the Chemistry of products used in daily life.
CLO 3	Familiarize the learner with the connection between Chemistry and environmental impact, health care, nutrition, etc.

	Course Outcome (CO)
	On completing the course, the student will be able to:
CO 1	Elaborate on the Chemistry of the products used in daily life OC 2:
CO 2	Distinguish between the advantages and disadvantages of the products used in daily life
CO 3	Select appropriate household products

Semester 1 : Open Elective (OE) - Chemistry in Daily Life

	Description	Hours
Module I	**Chemistry in Household Activities**	
1.1	**Chemistry in the Kitchen :**	**07**
	Chemistry of Cooking: Physical and chemical changes, stability of nutrients during cooking, Microwave and conventional cooking Butter and Cooking Oil: Saturated and unsaturated fatty acids, hydrogenation of oil, trans and cis fatty acids Water Purification: RO and UV-light treatment	
1.2	**Chemistry of the Cleaning Agents**	**08**
	Soaps: Basic chemical compositions of soap, hard and soft soaps, laundry detergents (Classification as organic and inorganic builders), Difference between soaps and detergents Kitchen Utensils Cleaning Agents: Dry Cleaning: Chemical agents used and their environmental significance Shampoos: Different kinds of shampoos (Antidandruff, anti-lice, herbal and baby shampoos) and their main active compounds Toothpaste: Composition and health effects Shaving Creams and Foams: Composition and health effects	
Module II	**Chemistry of the Personal Care Products & Food Products**	
2.1	**Chemistry in the Cosmetics** Compositions ofSunscreen and suntan lotions, Deodorants, Talcum powder, Lipsticks, Face creams, Baby care products, Hair products for bleaching and colouring, Moisturizers, Eyebrow pencils and eye-liners	**07**
2.2	**Chemistry in the Food Products (08L)** Common Adulterants in Different Foods: Milk and milk products, Vegetable oils, Cereals, Tea and Coffee powder, Chilly powder, Beverages Food Additives: Food preservatives like benzoates, Sorbates, Commonly used permitted and non-permitted food colours, Artificial sweeteners like aspartame, saccharin, sucralose	**08**

Reference Books:

1. B. K. Sharma, Industrial Chemistry, Krishna Prakashan Media, 1991.

2. M. S. R. Winter, A Consumer's Dictionary of Cosmetic Ingredients, 7th Edn., Three Rivers Press, New York, 2009.

3. Drugs and Pharamaceutical Sciences Series, Marcel Dekker, Vol. II, INC, New York.

4. Analysis of Foods – H.E. Cox: 13. Chemical Analysis of Foods – H.E.Cox and pearson.

5. Foods: Facts and Principles. N. Shakuntala Many and S. Swamy, 4th ed. New Age International (1998) 6

6. Handbook on Feritilizer Technology by Swaminathan and Goswamy, 6th ed. 2001, FAI.

7. Lillian Hoagland Meyer, Food Chemistry, 1st Edn., CBS Publishers & Distributors, New Delhi, 2004.

8. B. A. Fox, A. G. Cameron, E. Arnold, Food Science, Nutrition and Health,

6th Edn., Edward Arnold, London, 1995.

9. H. S. Ramaswamy, M. Marcotte, Food Processing: Principles and Applications, CRC Press, 2005.

10. A. F. Smith, Encyclopedia of Junk Food and Fast Food, Greenwood Publishing Group, 2006.

11. T. A. M. Sagati, The Chemistry of Food Additives and Preservatives, John Wiley & Sons, 2012.

12. S. N. Mahindru, Food Additives, APH Publishing, 2009. 8. Biju Mathew, Anchor India, Info Kerala Communications Pvt. Ltd., 2015.

SEMESTER 2

SEMESTER 2

Course/ Paper Title	**Paper 1 : MJ 3 Basics in Physical and Inorganic Chemistry II**
Course offered as	Major
Type	Theory
Course Code	**RCUSCHMJ201**
Semester	1
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50

Course Objectives (CLO):

CLO 1	To enable learners to have comprehensive knowledge and understanding of the gaseous state
CLO 2	To reinforce the terms related to conductance and Galvanic cells
CLO 3	To introduce the construction an electrochemical cell and apply Nernst equation for calculating the emf of galvanic cell
CLO 4	To give an understanding of the basic thermodynamic terminology and Thermodynamics laws
CLO 5	To appraise the learner about the general trends in the variation of periodic properties in the periodic table
CLO 6	To update about the various tests for the evolution of gaseous evolutes and the role of common ion effect, precipitation equilibria in qualitative analysis

Course Outcomes (CO) :

	On completing the course, the student will be able to:
CO 1	Elaborate on the concepts of gaseous state
CO 2	Define various terms of electrochemistry
CO 3	Calculate electrode/cell potential by Nernst equation
CO 4	Explain the basic terms of thermodynamics
CO 5	Predict the variation in the periodic trends and calculate effective nuclear charge and electronegativity
CO6	Predict the various tests for detection of gaseous evolutes and the role of precipitation equilibria and common ion effect in qualitative analysis

Semester 2 : Paper 1 : MJ3 : Basics in Physical and Inorganic Chemistry

Unit I	**Physical Chemistry**
1.1	**Gaseous State (5L)** Kinetic theory of gases, Maxwell-Boltzmann's distribution of velocities (Qualitative discussion), Ideal gas laws, Deviation from ideal gas laws, Ideal and real gases, Reasons for deviation from ideal gas laws, Compressibility factor, Boyle's temperature, van der Waals equation of state. **Joule-Thomson Effect :** Qualitative discussion, Experimentation and Inversion temperature. **(Numerical problems expected wherever necessary)**
1.2	**Electrochemistry - I (5L)** Conductance, specific conductance, equivalent conductance, molar conductance, Variation of molar conductance with concentration of strong and weak electrolyte. Reversible electrodes, Electrode potential, standard electrode potential, Galvanic cells, Conventions to represent the galvanic cells, Concept of emf of cell. **(Numerical problems expected wherever necessary)**
Unit II	**Physical Chemistry**
2.1	**Chemical Thermodynamics (5L)** **Thermodynamic terms;** System, surrounding, boundaries, types of system, Intensive and Extensive properties, State functions and path functions, Thermodynamic processes. **First law of thermodynamics:** Concept of heat (q), work (w), internal energy (U), enthalpy,-heat capacity, relation between heat capacities, sign conventions, calculations of heat, work, internal energy and enthalpy (H), Second law of thermodynamics, concept of entropy, Physical significance of entropy. **(Numerical problems expected wherever necessary)**

2.2	**Chemical Equilibria (5L)** Concept of free energy, Helmholtz and Gibbs free energy, Variation of free energy with temperature and pressure, Spontaneity and Physical significance of free energy. Re Reversible and irreversible reactions, equilibrium constants (Kc and Kp), relationship between Kc and Kp. **(Numerical problems expected wherever necessary)**
Unit III	**Inorganic Chemistry**
3.1	**Periodicity in the Following Properties (4L)** Atomic and ionic size, electron gain enthalpy, ionization enthalpy, effective nuclearcharge (Slater's rule), electronegativity, Pauling and Mulliken methods. (Numerical problems expected, wherever applicable.)
3.2	**Concept of Qualitative Analysis: (6L)** Testing of Gaseous Evolutes, Role of Papers impregnated with Reagents in qualitative analysis (with reference to papers impregnated with starch iodide, potassium dichromate, lead acetate, dimethylglyoxime and oxine reagents). Precipitation equilibria, Formation of precipitates like AgCl, AgBr, AgI and BaSO4 effect of common ions, uncommon ions, oxidation states, buffer action .

Semester 2

Paper 2 : MJ4 :Basics in Organic and Inorganic Chemistry II

Course/ Paper Title	**Paper 1 : MJ 4 Basics in Organic and Inorganic Chemistry II**
Course offered as	Major
Type	Theory
Course Code	**RCUSCHMJ202**
Semester	1
No. of Credits	2
No. of lecture Hours/week	2 hours
Hours Allotted	30
Marks Allotted	50

Course Objectives (CLO):

CLO 1	To introduce the knowledge of reagent in organic reactions
CLO 2	To acquaint the learner with the principle of functional group interconversion during organic reaction
CLO 3	To reinforce the concept of the acidity of hydrocarbon based on hybridization and specific reaction
CLO 4	To update the learner with reactions of carbon-carbon bond formation
CLO 5	To educate about the trends in general properties of main group elements
CLO 6	To appraise the learner about the various types of chemical bonds and structure of covalent molecules on the basis of Sidgwick Powell theory and VSEPR

Course Outcomes (CO) :

	On completing the course, the student will be able to:
CO 1	Classify the molecule as aromatic, antiaromatic and non aromatic
CO 2	Correlate the directive influence of substituents towards electrophile substitution reaction
CO 3	Write fundamentals organic reactions and their mechanisms
CO 4	Differentiate different carbon intermediate
CO 5	Review the general trends in the general properties of main group elements
CO6	Differentiate between the different types of chemical bonds and predict the structure of covalent molecules on the basis of Sidgwick Powell theory and VSEPR

Semester 2 : Paper 2 : MJ4 : Basics in Organic and Inorganic Chemistry II

Unit I	**Organic Chemistry**
1.1	**Fundamentals of Organic Reaction Mechanism: (5L)** **Basic terms & concepts**: Homolytic and Heterolytic fission with curly arrows with suitable examples. Electrophiles and Nucleophiles. **Types (primary, secondary, tertiary, allyl, benzyl), shape and their relative stability of the following reactive intermediates**: i. Carbocations ii. Carbanions and iii. Free radicals **Introduction to types of organic reactions:** Addition, Elimination and Substitution reaction. With one example of each)
1.2	**Chemistry of Aliphatic Hydrocarbons** **a. Carbon - Carbon sigma bonds: (1L)** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig reaction **b. Carbon - Carbon pi bonds (4L):** **Formation of alkenes and alkynes by elimination reactions**: Mechanism of E1, E2, Saytzeff and Hofmann eliminations **Reactions of alkenes**: Electrophilic additions with mechanisms (Markownikoff / Anti Markownikoff addition), Ozonolysis, reduction (catalytic and chemical), syn- and anti-dihydroxylation (oxidation) **Reaction of alkynes**: Acidity, Electrophilic and Nucleophilic additions with mechanisms.
Unit II	**Organic Chemistry**
2.1	**Stereochemistry II: (3L)** **Conformational analysis of alkanes** Relative stability with energy diagrams

2.2	**Aromatic Hydrocarbons: (7L)** **Aromaticity:** Hückel's rule, anti-aromaticity, aromatic character of arenes and cyclic carbocations/carbanions with suitable examples. **Electrophilic Aromatic Substitution:** Halogenation, Nitration, Sulphonation and Friedel-Crafts alkylation/acylation with their mechanism, Directing effects of the groups.
Unit III	**Inorganic Chemistry**
3.1	**Comparative Chemistry of Main Group Elements (4L)** Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behavior of second period elements, allotropy, catenation, diagonal relationship.
3.2	**Chemical Bond and Reactivity: (6 L)** Types of chemical bond, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick Powell Theory, basic VSEPR theory for ABn type molecules with and without lone pair of electrons, applications and limitations of VSEPR theory.

Semester II Practical : MJP2 : Chemistry Practical 2

Course/ Paper Title	**Chemistry Practical 2**
Course offered as	Major
Type	Practical
Course Code	RCUSCHMP2
Semester	1
No. of Credits	2
No. of lecture Hours/week	4 hours practical /week
Hours Allotted	60
Marks Allotted	50

Course Objectives (CLO): To enable the learner to:

CLO 1	Gain knowledge of the advanced concepts in pH metry and conductometry experiments.
CLO 2	Identify the acidic and basic radical from the given salt
CLO 3	Detect functional group and characterization of given organic compound

Course Outcomes (CO) :

	On completing the course, the student will be able to:
CO 1	Use equipments like conductivity meter and pH meter for quantitative analysis
CO 2	Classify ions in different group and detect ions from the given salt mixture
CO 3	Characterize solid and liquid organic compouunds

RCUSMJCHP2 : Chemistry Practical 2

Paper I

Physical Chemistry

1) To determine the amount of strong acid in the given solution by titrating against strong base conductometrically.
2) To determine the dissociation constant of weak acid (Ka) using Henderson's equation and the method of incomplete titration pH metrically.
3) To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.

Inorganic Chemistry

Qualitative analysis of simple salts: (3 mixtures to be analyzed)

4 mixtures

Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions (from amongst):

Cations (from amongst): Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Mg^{2+}, K^{+}, $NH4^{+}$

Anions (from amongst): CO_3^{2-}, $^{2}SO^{2-}$, NO^{-}, NO^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, PO_4

(Scheme of analysis should avoid use of sulphide ion in any form for precipitation/ separation of cations.)
Below are the representative mixture combinations, besides these any other combination will also be taken.

Probable mixture combination:

1) $MgSO_4$ + KCl
2) $CaCl_2$ + KNO_3
3) $CaCO_3$ + $Mg(NO_3)_2$
4) $BaSO_4$ + NH_4Cl

Paper II

Organic Chemistry

Characterization of organic compounds containing C, H, (O), N, S, X elements (6 solid/liquid Organic compounds) 5 compounds

(Preliminary Tests, Solubility/Miscibility Test, Detection of Elements, Detection of functional group and determination of Physical constant)

Inorganic Chemistry :

Qualitative analysis of complex salts (3 mixtures to be analyzed)

2 mixtures

Cations (from amongst): Pb^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Cr^{3+}, K^{+}, $NH4^{+}$

Anions (from amongst):CO_3^{2-}; SO_4^{2-}, NO^{-}, NO^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, PO_4

(Scheme of analysis should avoid use of sulphide ion in any form for precipitation/ separation of cations.)
Below are the representative mixture combinations, besides these any other combination will also be taken.

Probable mixture combination:

1) $MnSO_4$ / $MnCl_2$ + NH_4Cl
2) PbSO4 / PbCl2 + KCl /KNO3
3) $Cu(NO_3)_2$ / $CuSO_4$ + $ZnCl_2$ / $Zn(NO_3)_2$
4) $NiSO_4$ / $NiCl_2$ + $CrCl_2$ +$CrSO_4$

Reference Books :

Physical Chemistry :

1) Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
2) Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
3) Keith J. Laidler & John H. Meiser, Physical Chemistry, 2nd Ed. (2004)
4) Puri B. R., Sharma L. R. & Pathania M. S. Principles of Physical Chemistry, Vishal Publishing Company, 2008
5) Ball, D. W. Physical Chemistry Thomson Press, India (2007).
6) Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
7) Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
8) McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
9) Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
10) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
11) Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).
12) Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
13) Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
14) Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Inorganic Chemistry

1. Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
3. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970
4. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India
6. Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
7. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

Organic Chemistry

1. Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education).2012
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).

   Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
4. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
6. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
7. Paula Y Bruice, Organic Chemistry, 7th Ed, Pearson education, Asia.2014
8. Graham Solomon, Fryhle, Dnyder, Organic Chemistry, Wiley publication. 12 th Ed,2016
9. Bahl and Bahl, Advanced Organic chemistry by S. Chand publication.2010
10. Peter Sykes. Guidebook to the mechanism in Organic chemistry ,6th edition
11. D. Nasipuri. Stereochemistry of Organic Compounds, Principles and Applications, Second Edition
12. Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
13. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
14. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
15. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

Semester II : SKILL ENHANCEMENT COURSE (SEC)

Course/ Paper Title	**Basic Statistical Tools in Chemistry**
Course offered as	Skill Enhancement Course
Type	Theory and Practical
Course Code	**RCUSCHSEC1**
Semester	2
No. of Credits	2 (1 credit = 15 Hours for Theory) (1 Credit = 30 Hours for Practical)
No. of lecture Hours/week	1 hour per week for Theory 2 hour per week for Practical
Hours Allotted	45 Hours
Marks Allotted	50 Marks

Sr No.	**Course Objectives: (CHSEC1) : To enable the learner to**
CLO 1	Understand the significance of data and its type
CLO 2	Use methods to assess precision and accuracy using statistical measures
CLO 3	Analyze data dispersion using statistics

	Course Outcome (CHSEC1)
	On completing the course, the student will be able to:
CO 1	Critically evaluate and categorize different types of data sets.
CO 2	Demonstrate proficiency in utilizing various measures of precision and accuracy to analyze and interpret data
CO 3	Assess data dispersion and variability through the application of statistical measures

Semester II : Basic Statistical Tools in Chemistry (SECCH1)

Unit	Description	Hours
Unit I Theory Component	**1.1 Introduction, Types and Variables of Data** • Introduction and importance • Data: Meaning and Types- Primary data and secondary data, Discrete data and continuous data Variables and their types	**07**
	1.2 Precision and Accuracy • Concept of Precision: Mean, median, mode, range, absolute deviation, average deviation, relative average deviation, standard deviation, variance • Concept of Accuracy: Absolute and relative error **Measures of Dispersion:** Percentiles, Mean deviation, Standard deviation (S.D.) Coefficient of variation	**08**
Unit II **(Practical Component)**	**1)** Determination of mean, median and mode of titre values of acid base titration (Minimum number titre values = 10) **2)** Determination of standard deviation and variance of titre values of any complexometric titration (Minimum number titre values = 10) **3)** Determination of acetic acid in vinegar by potentiometry & calculate absolute and relative error **4)** Determination of Absolute deviation, average deviation and relative average deviation from the given data of any experiments of Chemistry. **5)** Determination of absolute and relative error in standardization of $Na_2S_2O_3$ by using 0.05N $K_2Cr_2O_7$. (The readings of all students of the batch shall be	**30**

	used for calculation and also expert reading shall be provided)	

References

1. Analytical Chemistry by Cary D. Christian, John Wiley and sons
2. Basic concepts of Analytical Chemistry by S.M. Khopkar, New Age International Publishers
3. Vogel's Textbook of Quantitative Chemical Analysis by J. Menham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th Edn, Low Price Edition, Pearson Education Ltd, New Delhi (2000)

Semester 2 : Open Elective (OE)

Food Safety and Hygiene

Course/ Paper Title	**Food Safety and Hygiene**
Course offered as	**Open Elective (OE)**
Type	Theory
Course Code	**RCUSCHOE2**
Semester	1
No. of Credits	2
Hours Allotted	30 Hours
No. of lecture Hours/week	2 Hour
Marks Allotted	50 Marks

Sr No.	**Course Objectives (CLO)**
CLO 1	To give an understanding of fundamental aspects of food safety and hygiene
CLO 2	To update the learner with information on common contaminants in food
CLO 3	To appraise the learner on importance of foodborne diseases
CLO 4	To create awareness on food safety management systems and its regulations

Sr No.	**Course Outcomes (CO)**
	On completing the course, the student will be able to:
CO 1	Demonstrate their understanding of good systems for food safety and hygiene
CO 2	Elaborate the sources of food contamination and will be able to take preventive measures to avoid contamination
CO 3	Describe the signs and causes of foodborne diseases
CO 4	Explain strategies of perishable food supply chain management

Semester 1 : Open Elective (OE) - Food Safety and Hygiene

	Description	Hours
Module I	**Food Safety (15L)**	
1.1	**Introduction to Food Safety and Hygiene**	**07**
	□ Overview of food safety principles and importance (01L) □ Types of food hazards (01L) □ Introduction to food hygiene (01L) □ Personal hygiene in food handling (01L) □ Food storage and temperature control (01L) □ Reading and interpreting food labels (02L)	
1.2	**Food Contamination and Food Adulteration**	**08**
	Food Contamination (04L) □ Organisms responsible for food contamination (E.coli, Penicillium spp, Amoeba) (01L) □ Factors influencing microbial growth in food and sources of contamination in the food supply chain (03L) Food **Adulteration (04L)** □ Concept of food adulteration and types of adulterants (chemical, biological and physical) (02L) □ Commonly adulterated foods and their methods of detection (Milk, Turmeric and Tea) (02L)	
Module II	**Food Storage, Transportation and Food Safety Management Systems**	**15**
2.1	**Food Storage and Transportation**	**07**
	□ Overview of production, processing and perishable supply chain of milk and milk products (03L) □ Temperature control and cold chain management (02L) □ Best practices for storage, transportation and handling of perishable goods (02L)	

2.2	**Food Safety Management Systems**	**08**
	• Introduction to food safety management systems (FSMS) (02L) • Implementation of HACCP in the food industry (02L) • ISO 22000 standards and their application in ensuring food safety (02L) • Auditing and certification of food safety management systems (02L)	

References books and Articles:

1. Ronald H. Schmidt and Gary E. Rodrick. 2002. “Food Safety Handbook”, Wiley; 1st edition.

2. Norman G. Marriott and Robert B. Gravani. 2006. “Principles of Food Sanitation”, Springer; 5th edition

3. Haji, M.; Kerbache, L.; Muhammad, M.; Al-Ansari, T. Roles of Technology in Improving Perishable Food Supply Chains. Logistics 2020, 4, 33. https://doi.org/10.3390/logistics4040033

4. Zhong, R., Xu, X. and Wang, L. (2017), "Food supply chain management: systems, implementations, and future research", Industrial Management & Data Systems, Vol. 117 No. 9, pp. 2085-2114.

https://doi.org/10.1108/IMDS-09-2016-0391

Evaluation Pattern for Major Theory Course

MAJOR: 6 credits

Semester I

Theory/Practical	Credits	No. of Hours	Marks
Theory: **Paper I: MJ1:** Basics in Physical and Inorganic Chemistry I	2	30	50
Theory: **Paper II : MJ2:** Basics in Organic and Inorganic Chemistry I	2	30	50
Practical : **MJCHP1:** Chemistry Practical 1	2	60	50

Semester II

Theory/Practical	Credits	No. of Hours	Marks
Theory: **Paper I: MJ3:** Basics in Physical and Inorganic Chemistry II	2	30	50
Theory: **MJ4:** Basics in Organic and Inorganic Chemistry II	2	30	50
Practical : **MJCHP2:** Chemistry Practical 2	2	60	50

Theory Examination Pattern for

(Major)

I	Internal Assessment	
a	One class test (Short answers/Objectives/ Multiple Choice)	**10**
b	Assignment/ Project/ Presentation/Book or research paper Review	**10**
	Total	**20 Marks**
II	Semester End Examination	**30 Marks**

Question Paper Pattern (Major)

30 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of **one hour** duration.
2. Theory question paper pattern:

a. There shall be **03** questions each of **10 marks** on each unit

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

Question	Option	Marks	Questions Based on
Q.1	A) Objective questions 4 out of 6	04	Uni I
	B) Subjective questions 2 out of 3	06	
Q.2	A) Objective questions 4 out of 6	04	Unit II
	B) Subjective questions 2 out of 3	06	
Q.3	A) Objective questions 4 out of 6	04	Unit III
	B) Subjective questions 2 out of 3	06	
	Total	**30**	

Evaluation Pattern for Major Practical Course

Duration for End semester examination	External Assessment for Practical	50 Marks
3 hours 30 minutes	**Experiment**	**30**
	Viva	**10**
	Journal	**10**

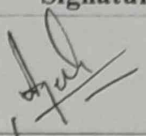
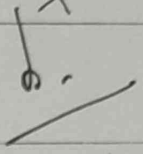
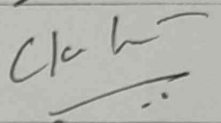
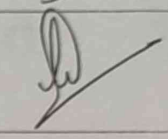
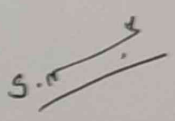
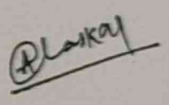
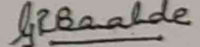
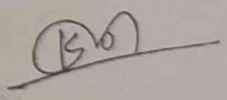
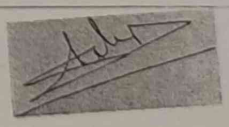
Examination Pattern for (SEC/ Open Elective)

	Continuous Internal Assessment	Marks
a	One class test (Short answers/Objectives/ Multiple Choice)	25 (45 minutes duration)
b	Project	20
c	Attendance	05
	Total	50 marks

Examination Pattern for (VSC)

I	**Continuous Internal Assessment**	Marks
a	One class test based on based on theory	15 (20 minutes duration)
b	Assignment	5
	Total	20 marks
II	**External Examination**	
a)	Theory	10 marks
b)	Practical experiment	15 marks
c)	Journal	5 marks
	Total	30 marks

Board of studies in Chemistry

	Category	Name and Designation	Affiliation	Signature
1	Chairperson (Head of Department)	Dr. Aqeela A. S. Qureshi, Associate Professor	Royal College of Arts, Science and Commerce. Mira Road	
2	Internal BOS Members	Prof. Kalpana Patankar Jain. Principal	Royal College of Arts, Science and Commerce. Mira Road	
		Dr. Chitralekha Kotian Associate Professor		
		Dr. Gunwanti ~~Negi~~ Sinwal Assistant Professor		
		Dr. Vibha Bhagat Assistant Professor		
		Dr. Mustaqeem Mohammed - Assistant Professor		
3	External Subject Expert	Prof. Atul Chaska - Professor	Institute of Chemical Technology, Matunga , Mumbai.	
		Prof. Gayatri Barabde - Professor	**The Institute of Science, Mumbai** [Dr. Homi Bhabha State University (HBSU)]	
4	Vice-Chancellor Nominee	Prof. Krishnakant T. Waghmode	Ruparel College of Arts, Science & Commerce,	
5	Industry Representative	Shailesh G. Poojary - Chief Manager, Parle Quality Systems,Parle Products	Parle Products VS Khandekar Marg,Vile Parle East Mumbai-400057	
6	Postgraduate meritorious alumnus	Ms. Pratima Rajesh Yadav PhD. Scholar from ICT, Mumbai.	Institute of Chemical Technology , ,Nathalal Parekh Marg, Matunga, Mumbai – 400019