

University of Mumbai



क. वि.प्रा.स.से.(युजी)/आयसीसी/२०२४-२५/४

परिपत्रक :-

सर्व प्राचार्य/संचालक, संलग्नित महाविद्यालये/संस्था, विद्यापीठ शैक्षणिक विभागाचे संचालक/विभाग प्रमुख यांना कळविण्यात येते की, राष्ट्रीय शैक्षणिक धोरण २०२० च्या अमलबजावणीच्या अनुषंगाने शैक्षणिक वर्ष २०२४-२५ पासून एक्झिट पर्याय सह पदवी व पदव्युत्तर अभ्यासक्रम विद्यापिठेच्या दिनांक २७ डिसेंबर, २०२३, ३ फेब्रुवारी, २०२४, २० एप्रिल, २०२४ व २४ मे, २०२४ च्या बैठकीमध्ये मंजूर झालेले सर्व अभ्यासक्रम मुंबई विद्यापीठाच्या www.mu.ac.in या संकेत स्थळावर NEP २०२० या टॅब वर उपलब्ध करण्यात आलेले आहेत.

मुंबई - ४०० ०३२

११ जून, २०२४

Baliram

(प्रा. (डॉ.) बळीराम गायकवाड)

प्र. कुलसचिव

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	Faculty of Humanities, Offg. Dean 1. Prof.Anil Singh Dranilsingh129@gmail.com Offg. Associate Dean 2. Prof.Manisha Karne mkarne@economics.mu.ac.in 3. Dr.Suchitra Naik Naiksuchitra27@gmail.com
	Faculty of Commerce & Management, Offg. Dean, 1 Prin.Ravindra Bambardekar principal@model-college.edu.in Offg. Associate Dean 2. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in 3. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 4. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology Offg. Dean 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in Offg. Associate Dean 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, Offg. Dean 1.Dr. Anil K. Singh aksingh@trcl.org.in Offg. Associate Dean 2.Prin.Chadrashekhar Ashok Chakradeo cachakradeo@gmail.com 3. Dr. Kunal Ingle drkunalingle@gmail.com
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW directr@dsd.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

As Per NEP 2020

University of Mumbai



Title of the program

- A-** U.G. Certificate in **Chemistry**
- B-** U.G. Diploma in **Chemistry**
- C-** B.Sc. (**Chemistry**)
- D-** B.Sc. (Hons.) in **Chemistry**
- E-** B.Sc. (Hons. with Research) in **Chemistry**

Syllabus for

Semester – Sem I & II

Ref: GR dated 20th April, 2023 for Credit Structure of UG

**(With effect from the academic year 2024-25
Progressively)**

University of Mumbai



(As per NEP 2020)

Sr. No.	Heading	Particulars	
1	Title of program O: <u>SU-509A</u>	A	U.G. Certificate in Chemistry
	O: <u>SU-509B</u>	B	U.G. Diploma in Chemistry
	O: <u>SU-509C</u>	C	B.Sc. (Chemistry)
	O: <u>SU-509D</u>	D	B.Sc. (Hons.) in Chemistry
	O: <u>SU-509E</u>	E	B.Sc. (Hons. with Research) in Chemistry
2	Eligibility O: <u>SU-510A</u>	A	12 th Science of all recognized Board OR Passed Equivalent Academic Level 4.0
	O: <u>SU-510B</u>	B	Under Graduate Certificate in Chemistry OR Passed Equivalent Academic Level 4.5
	O: <u>SU-510C</u>	C	Under Graduate Diploma in Chemistry OR Passed Equivalent Academic Level 5.0
	O: <u>SU-510D</u>	D	Bachelors of Chemistry with minimum CGPA of 7.5 OR Passed Equivalent Academic Level 5.5
	O: <u>SU-510E</u>	E	Bachelors of Chemistry with minimum CGPA of 7.5 OR Passed Equivalent Academic Level 5.5
3	Duration of program R: <u>SU-521</u>	A	One Year
		B	Two Years
		C	Three Years
		D	Four Years
		E	Four Years
4	Intake Capacity R: <u>SU-522</u>	120	

5	Scheme of Examination R: <u>SU-523</u>	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination	
6	R: <u>SU-524</u> Standards of Passing	40%	
7	Credit Structure Sem. I - R: <u>SU-525A</u> Sem. II -R: <u>SU-525B</u>	Attached herewith	
	Credit Structure Sem. III - R: <u>SU-525C</u> Sem. IV -R: <u>SU-525D</u>		
	Credit Structure Sem. V - R: <u>SU-525E</u> Sem. VI -R: <u>SU-525F</u>		
8	Semesters	A	Sem I & II
		B	Sem III & IV
		C	Sem V & VI
		D	Sem VII & VIII
		E	Sem VII & VIII
9	Program Academic Level	A	4.5
		B	5.0
		C	5.5
		D	6.0
		E	6.0
10	Pattern	Semester	
11	Status	New	
12	To be implemented from Academic Year Progressively	From Academic Year: 2024-25	

Sign of the BOS
Chairman
Prof. Shivram S. Garje
Board of Studies in
Chemistry

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology

Sign of the
Offg. Dean
Prof. Shivram S. Garje
Faculty of Science &
Technology

Preamble

1) Introduction

This program is designed to provide a basic understanding of Chemistry. Through an academic curriculum of theory and practical courses, we aim to provide not only knowledge but to create interest in the subject. The B.Sc (Chemistry) is framed to equip students with a basic theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of the subject. There is continuous evaluation of students based on Quizzes, Class Tests and assignments. Emphasis is given to conceptual understanding of theoretical concepts followed by inclusion of the same in practicals.

2) Aims and Objectives

The aims and objectives of the B.Sc (Chemistry) course are designed to provide students with a foundational understanding of the principles and applications of chemistry. These aims and objectives align with broader educational goals, focusing on academic, practical, and professional development.

3) Learning Outcomes

To demonstrate an understanding of fundamental principles in inorganic, organic, and physical chemistry. To initiate a process to continuous learning and self-improvement. To cultivate a curiosity-driven approach to scientific inquiry. To identify potential career paths in chemistry-related fields such as pharmaceuticals, materials science, and environmental science. To apply acquired skills to entry-level positions in industries requiring a foundation in chemistry.

4) Any other point (if any)

The skills and knowledge acquired during this program will strengthen the students for basic knowledge of the subject.

5) Credit Structure of the Program (Sem I, II, III, IV, V & VI)

Under Graduate Certificate in Chemistry

Credit Structure (Sem. I & II)

	R: _____ A										
Level	Semester	Major		Minor	OE	VSC, SEC (VSEC)	AE C, VE C, IKS	OJT, FP, CEP, CC, RP	Cum. Cr. / Sem.	Degree/ Cum. Cr.	
		Mandatory	Electives								
4.5	I	6 Paper I: MJ1: Basics in Physical and Inorganic Chemistry I Paper II : MJ2: Basics in Organic and Inorganic Chemistry I MJCHP1: Chemistry Practical 1		-	2+2	VSC:2, VSCCH1: Calibration of Glassware and Instruments SEC:2 Sampling Techniques OR Basic Statistical Tools in Chemistry	AEC: 2, VEC: 2,IKS: 2	CC:2	22	UG Certificate 44	
	R: _____ B										
	II	6 Paper I: MJ3: Basics in Physical and Inorganic Chemistry II Paper II: MJ4: Basics in Organic and Inorganic Chemistry II MJCHP2: Chemistry Practical 2		2	2+2	VSC:2, VSCCH2: Commercial Analysis of Food Samples SEC:2 Data Analysis in Chemistry OR Softwares in Chemistry	AEC: 2, VEC: 2	CC:2	22		
	Cum Cr.	12	-	2	8	4+4	4+4+2	4	44		

Exit option: Award of UG Certificate in Major with 40-44 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Major and Minor

Under Graduate Diploma in Chemistry

Credit Structure (Sem. III & IV)

	R: _____ C										
Level	Semester	Major		Minor	OE	VSC, SEC (VSEC)	AEC, VEC, IKS	OJT, FP, CEP, CC,RP	Cum. Cr. / Sem.	Degree/ Cum. Cr.	
		Mandatory	Electives								
5.0	III	8 Paper I: MJ5: Progressive Physical and Analytical Chemistry I Paper II: Theory MJ6: Progressive Inorganic and Organic Chemistry I Practical I: MJCHP3: Chemistry Practical 3 Practical II: MJCHP4: Chemistry Practical 4		4	2	VSC:2, VSCCH 3: Soil Analysis	AEC:2	FP: 2 CC:2	22	UG Diploma 88	
	R: _____ D										
	IV	8 Paper I: MJ7: Progressive Physical and Analytical Chemistry II Paper II: Theory MJ8: Progressive Inorganic and Organic Chemistry II		4	2	SEC:2	AEC:2	CEP: 2 CC:2	22		

		Practical I: MJCHP5: Chemistry Practical 5 Practical II: MJCHP6: Chemistry Practical 6								
	Cum Cr.	28		10	12	6+6	8+4+2	8+4	88	
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										

B.Sc. (Chemistry)
Credit Structure (Sem. V & VI)

	R: _____ E									
Level	Semester	Major		Minor	OE	VSC, SEC (VSEC)	AEC, VEC, IKS	OJT, FP, CEP, CC,RP	Cum. Cr. / Sem.	Degree/ Cum. Cr.
		Mandatory	Electives							
5.5	V	10	4	4		VSC: 2		FP/CE P:2	22	UG Degree 132
		Paper I: MJ9: Physical and Analytical Chemistry Paper II: MJ10: Organic and Inorganic Chemistry Paper III: MJ11: IKS - Ancient Indian Chemistry Practical I: MJCHP7: Chemistry Practical 7 Practical II: MJCHP8: Chemistry Practical 8				VSCCH4 Comm erc al Analysis of Water Samples				
	R: _____ F									
	VI	10	4	4				OJT :4	22	
		Paper I: MJ12: Physical and Analytical Chemistry Paper II:								

		MJ13: Inorganic Chemistry Paper III: MJ14: Organic Chemistry Practical I: MJCHP9: Chemistry Practical 9 Practical II: MJCHP10: Chemistry Practical 10								
	Cum Cr.	48	8	18	12	8+6	8+4+2	8+6+4	132	
Exit option: Award of UG Degree in Major with 132 credits OR Continue with Major and Minor										

[Abbreviation - OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – on Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

Syllabus
B.Sc. (Chemistry)
SEMESTER I

Sr.No.	Heading	Particulars
1	Description the course:	This program is designed to provide a basic understanding of Chemistry. Through an academic curriculum of theory and practical courses, we aim to provide not only knowledge but to create interest in the subject. The B.Sc (Chemistry) course is framed to equip students with a basic theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of subject. There is continuous evaluation of students based on Quizzes, Class Tests and assignments. Emphasis is given to conceptual understanding of theoretical concepts followed by inclusion of the same in practicals. B.Sc. (Chemistry) programme offers two majors , one minor, VSCs, SECs, IKS, AECs, OEs VEC and CC. After successful completion of the first year B.Sc. programme the learner will be awarded a UG Certificate in Chemistry.
2	Vertical:	Major
3	Type :	Theory and Practical
4	Credits :	Credits per Semester Theory: 4 Credits (1 Credit = 15 Hours for Theory) Practicals: 2 Credits (1 Credit = 30 Hours for Practical)
5	Hours Allotted :	Hours per Semester Theory: 60 Hrs. Practicals: 60 Hrs.
6	Marks Allotted:	Marks per Semester Theory: 100 Marks Practicals: 50 Marks
7	Course Objectives (CO): CO 1. To apply the principles of Chemistry (viscosity, surface tension, pH etc.) in daily life and their importance. CO 2. To train the students in the basic knowledge of chemistry for industrial applications. CO 3. To understand the basics of atomic structure and the impacts of its compounds on the environment. CO 4. To understand compressive knowledge and coherent understanding of the periodic table with reference to elements and their properties. CO 5. To develop critical thinking about different types of organic compounds with reference to their functional group, physical and chemical properties. CO 6. To apply the knowledge of nomenclature, bonding, reaction mechanism and stereochemistry to solve problems.	
8	Course Outcomes (OC): OC 1 Students will acquire core competency in the subject of Chemistry, and its allied subject areas.	

	OC 2 Acquire a fundamental understanding of Physical Chemistry concepts for industrial applications. OC 3 Students will be able to use the evidence-based comparative approach to explain the impacts on the environment. OC 4 Students will develop an insight into the fundamental reactions among elements to form compounds. OC 5 Students will be able to differentiate/identify organic compounds on the basis of functional groups, physical and chemical properties. OC 6 Develop the concepts of nomenclature, bonding, reaction mechanism and stereochemistry for its applications in research and industry.
9	Modules

Semester	Paper	Unit	Description	Credits
I	Paper I: MJ1: Basics in Physical and Inorganic Chemistry I	I	Physical Chemistry 1.1. Liquid State: 1.2. Chemical Calculations	02
		II	Physical Chemistry 2.1 Chemical Kinetics	
		III	Inorganic Chemistry 3.1 Atomic structure 3.2 Periodic Table and Periodicity	
	Paper II: MJ2: Basics in Organic and Inorganic Chemistry I	I	Organic Chemistry 1.1 Classification and Nomenclature of Organic Compounds 1.2 Bonding and Structure of Organic Compounds	02
		II	Organic Chemistry 2.1 Stereochemistry I	
		III	Inorganic Chemistry 3.1 Comparative Chemistry of Main Group Elements	
	MJCHP1: Chemistry Practical 1		Practical Component	02
II	Paper I: MJ3: Basics in Physical and Inorganic Chemistry II	I	Physical Chemistry 1.1. Gaseous State 1.2. Electrochemistry - I	02
		II	Physical Chemistry 2.1 Chemical Thermodynamics 2.2 Chemical Equilibria	
		III	Inorganic Chemistry 3.1 Periodicity 3.2 Concept of Qualitative Analysis	
	Paper II: MJ4: Basics in Organic and Inorganic Chemistry II	I	Organic Chemistry 1.1. Fundamentals of Organic Reaction Mechanism 1.2. Chemistry of Aliphatic Hydrocarbons	02
		II	Organic Chemistry 2.1 Stereochemistry II 2.2 Aromatic Hydrocarbons	
		III	Inorganic Chemistry	

			3.1 Comparative Chemistry of Main Group Elements 3.2 Chemical Bond and Reactivity	
	MJCHP2: Chemistry Practical 2		Practical Component	02

Sem. - I

Mandatory

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). Classification of reactions as slow, fast and ultra-fast. (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

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: (5L) Hybridization: sp ³ , sp ² , sp hybridization of carbon and nitrogen; sp ³ and sp ² 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: (10L) 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); Relative stability with energy profile diagrams
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- NaHCO₃, Na₂CO₃, CaO, CaCO₃ ; 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

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

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

Gravimetric 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)

Title of the course

VSCCH1: Calibration of Glassware and Instruments

Sr.No.	Heading	Particulars
1	Description the course:	The aim of Vocational Skill Courses (VSC) designed to provide experiential learning for students, which help to develop their technical skill through hands-on training and also developing abilities of critical thinking, analytical skill, collaboration, teamwork, problem-solving and communication which mold their careers.
2	Vertical:	Vocational Skill Course
3	Type:	Theory and Practical
4	Credits:	Credits per Semester Theory: 1 Credits (1 Credit = 15 Hours for Theory) Practicals: 1 Credit (1 Credit = 30 Hours for Practical)
5	Hours Allotted:	Hours per Semester Theory: 15 Hrs. Practicals: 30 Hrs.
6	Marks Allotted:	50 Marks
7	Course Objectives (CO): CO 1. To introduce glassware and instruments used in a Chemistry laboratory. CO 2. To understand the importance of calibration of glassware and instruments in tune with concepts of precision and accuracy. CO 3. To develop awareness about safety measures for handling chemicals. CO 4. To identify and comprehend the major components present in food samples. CO 5. To gain knowledge about various analytical techniques employed in commercial food analysis. CO 6. To develop practical skills for the analysis of food samples.	
8	Course Outcomes (OC): After Completion of the course, the Learner will able to; OC 1 Calibrate glassware and instruments. OC 2 Understand the concept of minimizing errors. OC 3 Handle various chemicals with the necessary care. OC 4 Identify the various components present in food samples. OC 5 Apply analytical techniques for the analysis of food samples. OC 6 Acquire the necessary basic skills for the analysis of food samples.	

Semester	Unit	Description	Credits
I	I (Theory Component)	Calibration of Glassware and Instruments	
		1.1 Tools of Analytical Chemistry 1.2 Introduction to Analytical Chemistry and Calibration of Laboratory Instruments 1.3 Chemicals and Laboratory Safety	01
		2.1 Calibration of Laboratory Glassware 2.2. Calibration of Laboratory Instruments	01
	II (Practical Component)		
II	I (Theory Component)	Commercial Analysis of Food Samples	
		1.1 Importance of Food Analysis and Nutrients 1.2 Food Quality and Safety 1.3 Importance of Food Analysis with reference to Important Case Study	01
	II (Practical Component)	Practical Component	01

Semester I
Calibration of Glassware and Instruments

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 and 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, potentiometer and colorimeter.	08
	1.3 Chemicals and Laboratory Safety 1. Introduction to pictogram of chemical used. (Acids, Bases, Solvents and Salts) 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. Precautions in handling of hazardous substances like conc. acids, ammonia, organic solvents like ether and alcohol.	03
II (Practical Component)	2.1 Calibration of Laboratory Glassware 1. Calibration of Burette 2. Calibration of Pipette 3. Calibration of Standard Measuring Flask 4. Calibration of Thermometer (Demonstration) 2.2 Calibration of Laboratory Instruments 1. Calibration of pH meter 2. Calibration of Conductometer 3. Calibration of Colorimeter 4. Calibration of Potentiometer (Demonstration)	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).

Skill Enhancement Course (SEC)

Semester I

Title of the course Sampling Techniques

Sr. No.	Heading	Particulars
1	Description the Course	The aim of Skill Enhancement Courses (SECs) is to introduce the students with opportunities to develop required skills in Chemistry
2	Vertical	Skill Enhancement Course (SEC)
3	Type	Theory and Practical
4	Credits	2 Credits (1 Credit = 15 Hours for Theory) (1 Credit = 30 Hours for Practical)
5	Hours Allotted	45 Hours
6	Marks Allotted	50 Marks
7	Course Objectives (CO)	
	CO 1	To understand the fundamentals of sampling including its importance, terms involved, the concept of sample size and types of sampling techniques
	CO 2	To gain knowledge of traditional and modern preservation methods of liquid and solid samples, their storing and handling so as to maintain their integrity and obtain accuracy in further analysis
	CO 3	To design a sampling plan tailored to the specific objective
	CO 4	To develop practical skills for implementing sampling techniques in real-world settings
	CO 5	To understand the fundamentals of sampling including its importance, terms involved, the concept of sample size and types of sampling techniques
8	Course Outcomes (OC) The student will be able to-	
	OC 1	Conducting sampling procedures in Chemistry, including selecting appropriate methods and equipment for different sample types
	OC 2	Handling solid and liquid samples according to established protocols to ensure accurate analysis and reliable results
	OC 3	Critically analyze case studies related to soil and water pollution, applying Chemical principles to identify causes, effects, and remedial measures, and proposing effective solutions and prevention strategies
9	Modules	

Semester	Module	Description	Credits
I	I (Theory Component)	1.1 Sampling	01
		1.2 Storage, Preservation and Handling of Solid and Liquid Samples	
		1.3 Case Study	
	II (Practical Component)	Practicals	01

Module	Description	Hours
I (Theory Component)	Sampling • Introduction to sampling • Importance and problems involved in sampling • Terms involved: Sample, universe, increment, gross sample, sub sample, analysis sample • Concept of sample size: Macro, semi-micro, micro, ultra micro • Types of sampling: Random and non-random sampling • Methods and equipments used in sampling of homogeneous, heterogeneous and flowing liquids • Methods and Equipments used in sampling of solids	09
	Storage, Preservation and Handling of Solid and Liquid Samples • Need of preservation • Traditional and modern methods of preservation • Methods of handling of solid and liquid samples	03
	Case Study Discussion on the case study related to soil and water pollution and its remedial measures	03
II (Practical Component)	Practicals (i) Demonstration of sampling techniques for water samples (ii) Demonstration of sampling techniques for soil samples (iii) Collection of soil samples (minimum three) from nearby area and determine pH from the same (iv) Collection of soil samples (minimum three) from nearby area and determine Conductance from the same (v) Collection of water sample from nearby area and determine chloride content from the same (vi) Collection of water sample from nearby area and determine the hardness of the same (vii) Collection of water sample from nearby area and determine the alkalinity of the same (viii) Collection of Water sample from nearby area and determine TDS and TSS from the same	30

10. References

1. B. Schrader, ed., Infrared and Raman Spectroscopy: Methods and Applications, Wiley, Chichester, West Sussex, England, 1995.
2. J.J. Laserna, Modern Techniques in Raman Spectroscopy, Wiley, Chichester, West Sussex, England, 1996.
3. N. Bloembergen, Pure Appl. Chem., 59, 1229 (1987).

4. A.B. Harvey, ed., Chemical Applications of Non-linear Raman Spectroscopy, Academic Press, New York, 1981.
5. A. Zumbusch, G. R. Holtom, and X. S. Hie, Phys. Rev. Lett., 82, 4142 (1999).
6. S. A. Asher, C. H. Munro, and Z. Chi, Laser Focus World, 33, 99 (1997).
7. R. L. McCreery, in J. J. Laserna, ed., Modern Techniques in Raman Spectroscopy, Wiley, Chichester, West Sussex, England, 1996.
8. G. J. Puppels, F. F. M. D. Mul, C. Otto, J. Greve, M. Robert-Nicoud, D. J. Arndt-Jovin, and T. Jovin, Nature, 347, 301 (1990). 9. C. J. H. Brenan and W. Hunter, Appl. Opt., 33, 7520 (1994).

Skill Enhancement Course (SEC)

Semester I

Title of the course

Basic Statistical Tools in Chemistry

Sr. No.	Heading	Particulars
1	Description the Course	The aim of Skill Enhancement Courses (SECs) is to introduce the students with opportunities to develop required skills in Chemistry
2	Vertical	Skill Enhancement Course (SEC)
3	Type	Theory and Practical
4	Credits	2 Credits (1 Credit = 15 Hours for Theory) (1 Credit = 30 Hours for Practical)
5	Hours Allotted	45 Hours
6	Marks Allotted	50 Marks

7	Course Objectives (CO)	
	CO 1	To understand the significance of data and its types
	CO 2	To learn methods to assess precision and accuracy using statistical measures
	CO 3	To gain proficiency in analyzing data dispersion using statistics
8	Course Outcomes (OC)	
	The student will be able to-	
	OC 1	Ability to critically evaluate and categorize different types of data sets, distinguishing between them
	OC 2	Proficiency in utilizing various measures of precision and accuracy to analyze and interpret data
	OC 3	Competence in assessing data dispersion and variability through the application of statistical measures

9	Modules
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Semester	Module	Description	Credits
I	I (Theory Component)	1.1 Introduction, Types and Variables of Data	01
		1.2 Precision and Accuracy	
	II (Practical Component)	Practicals	01

Module	Description	Hours
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
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 and 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 $\text{Na}_2\text{S}_2\text{O}_3$ by using 0.05N $\text{K}_2\text{Cr}_2\text{O}_7$. (The readings of all students of the batch shall be used for calculation and also expert reading shall be provided)	30

10. 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)

Sem. – II

Syllabus B.Sc. (Chemistry)

SEMESTER II

Paper I: MJ3: Basics in Physical and Inorganic Chemistry II

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, Critical phenomena, Relation between critical constants and van der Waals constants. (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. Reversible and irreversible reactions, equilibrium constants (K_c and K_p), relationship between K_c and K_p . Thermodynamic derivation of equilibrium constant (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 nuclear charge (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 BaSO ₄ effect of common ions, uncommon ions, oxidation states, buffer action.

Paper II: 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: (5L) Cycloalkanes and Conformational Analysis Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagram.
2.2	Aromatic Hydrocarbons: (5L) 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 AB_n type molecules with and without lone pair of electrons, applications and limitations of VSEPR theory.

Semester II Practical

MJCHP2: Chemistry Practical 2

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 (K_a) using Henderson's equation and the method of incomplete titration pH metrically.
- 3) To determine enthalpy of dissolution of salt (KNO_3)
- 4) 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)

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^+ , NH_4^+

Anions (from amongst): CO_3^{2-} , SO_4^{2-} , NO_2^- , NO_3^- , Cl^- , Br^- , I^- , SO_4^{2-} , PO_4^{3-}

(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)

(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)

Cations (from amongst): Pb^{2+} , Cu^{2+} , Cd^{2+} , Fe^{2+} , Ni^{2+} , Mn^{2+} , Cr^{3+} , K^+ , NH_4^+

Anions (from amongst): CO_3^{2-} , SO_4^{2-} , NO_2^- , NO_3^- , Cl^- , Br^- , I^- , SO_4^{2-} , PO_4^{3-}

(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) $PbSO_4 / PbCl_2 + KCl / KNO_3$
- 3) $Cu(NO_3)_2 / CuSO_4 + ZnCl_2 / Zn(NO_3)_2$
- 4) $NiSO_4 / NiCl_2 + CrCl_3 + CrSO_4$

10. Reference Books:

Physical Chemistry

- 1) Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
- 2) Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
- 3) Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- 4) Keith J. Laidler & John H. Meiser, Physical Chemistry, 2nd Ed. (2004)
- 5) Puri B. R., Sharma L. R. & Pathania M. S. Principles of Physical Chemistry, Vishal Publishing Company, 2008
- 6) Ball, D. W. Physical Chemistry Thomson Press, India (2007).
- 7) Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
- 8) Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
- 9) McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
- 10) Levine, I. N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
- 11) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
- 12) Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).
- 13) Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
- 14) Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
- 15) 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.
8. Advanced Inorganic Chemistry, 17th Edition, by Satyaprakash, G.D.Tuli and R. D. Madan, 2022.

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).
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
5. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994
6. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
7. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
8. Paula Y Bruice, Organic Chemistry, 7th Ed, Pearson education, Asia.2014
9. Graham Solomon, Fryhle, Snyder, Organic Chemistry, Wiley publication. 12 th Ed,2016
10. Bahl and Bahl, Advanced Organic chemistry by S. Chand publication.2010
11. Peter Sykes. Guidebook to the mechanism in Organic chemistry ,6th edition
12. D. Nasipuri. Stereochemistry of Organic Compounds, Principles and Applications, Second Edition
13. Organic Chemistry: A problem solving approach by Lakshmi Ravishankar and Gomathi Shridhar, Narosa Publisher, 2023.
14. Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
15. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
16. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
17. 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
Vocational Skill Course (VSC)

Title of the course
VSCCH2: Commercial Analysis of Food Samples

Unit	Description	Hours
I (Theory component)	1.1 Importance of Food Analysis and Nutrients Importance of food analysis and basic principles. Nutrients and their nutritional value in food composition, macronutrients and micronutrients	04
	1.2 Food Quality and Safety Principles of food safety and quality assurance. Types of additives, their functions and safety considerations. Importance of pH and use of chemical preservatives (Boric acid, Sodium Benzoate) Introduction to foodborne illnesses and prevention methods.	05
	1.3 Importance of Food Analysis with reference to Important Case Study Case Study (Any One) – Brominated Vegetable Oil (Soft drink) / Nickel in Chocolate / Oxytocin in Milk Applications of Chemical and instrumental methods in food analysis 1. Estimation of Vitamin C in lemon squash by redox titration 2. Estimation of Calcium in milk powder by complexometric titration 3. Estimation of Acetic acid in vinegar by potentiometry 4. Estimation of Iron in the given food sample by colorimetry using KSCN.	06
II (Practical Component)	1. Measure the pH of given food sample (acidic/basic) using pH meter. 2. Estimation of Vitamin C (Ascorbic Acid) in lemon squash sample by using 2,4-Dichlorophenol indicator 3. Qualitative analysis of macronutrients (two samples each) proteins (Biuret test) Carbohydrates (Benedict's Test) 4. Estimation of Calcium in milk powder by complexometric titration 5. Estimation of acetic acid in preservative (Vinegar) potentiometry. 6. Detection of contaminants or adulterants in the following food samples (Any one adulterant) i). Milk ii). Tea Powder iii). Turmeric powder iv). Chili Powder	30

10. References

1. "Food Analysis Laboratory Manual" by S. Suzanne Nielsen
2. "Food Analysis" by James G. Brennan
3. Vogel's Textbook of Quantitative Chemical Analysis, Fifth Edition, G H Jeffery and J Bassett.
4. 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.
5. FSSI MANUAL OF METHODS OF ANALYSIS OF FOODS: FOOD ADDITIVES

Skill Enhancement Course (SEC)

Semester II

Title of the course Data Analysis in Chemistry

Sr. No.	Heading	Particulars
1	Description the Course	The aim of Skill Enhancement Courses (SECs) is to introduce the students with opportunities to develop required skills in Chemistry
2	Vertical	Skill Enhancement Course (SEC)
3	Type	Theory and Practical
4	Credits	2 Credits (1 Credit = 15 Hours for Theory) (1 Credit = 30 Hours for Practical)
5	Hours Allotted	45 Hours
6	Marks Allotted	50 Marks
7	Course Objectives (CO)	
	CO 1	To understand the significance of SI units in Chemistry and their role in standardizing measurements
	CO 2	To recognize the importance of statistical data analysis in Chemistry for drawing meaningful conclusions from experimental data
	CO 3	To apply rounding off techniques and determine significant figures to ensure accuracy and precision in reporting experimental results
	CO 4	To develop skills in selecting and applying appropriate statistical tests for data analysis
8	Course Outcomes (OC) The student will be able to-	
	OC 1	Apply SI units correctly for precise measurement and communication of chemical quantities and properties
	OC 2	Conduct statistical data analysis in Chemistry experiments, enabling informed decision-making and drawing reliable conclusions
	OC 3	Select the appropriate statistical test for analysis and interpret the results correctly

9	Modules
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Semester	Modules	Description	Credits
I	I (Theory Component)	Data Analysis in Chemistry	01
	II (Practical Component)	Practicals	01

Module	Description	Hours
I (Theory Component)	• SI units and its uses • Importance and need of statistical data analysis in Chemistry • Concept of rounding off an observation from the given data • Concept of significant figures and its importance • Selection and application of statistical tests w.r.t. 2.5d, 4.0d, Q-Test and F-Test • Concept of Student's t • Concept of confidence limits and confidence interval	15
II (Practical Component)	1. Application of 2.5d rule for a Redox Titration of Ferrous sulphate against $K_2Cr_2O_7$. 2. Application of 4.0d rule for standardization of NaOH by using succinic acid as primary standard. 3. Application of Q-Test for the provided data in the gravimetric estimation Ni^{+2} as Ni-DMG. 4. Determination of confidence limit and confidence interval from the given data. 5. Determination of significant figures from the given data of any experiments of Chemistry.	30

10. References

1. https://www2.chemistry.msu.edu/courses/cem434/Lecture%20Statistics_Total.pdf
2. <https://sites.chem.utoronto.ca/chemistry/coursenotes/analsci/stats/BasicStats.html>
3. R.K. Burdick, D. LeBlond, D. Sandell, H. Yang, Statistical methods for validation of procedure accuracy and precision, Pharmacopeial Forum 39 (3) (2013)
4. P. Nethercote, J. Ermer, Quality by design for analytical methods: implications for method validation and transfer, Pharm. Technol. 36 (10), 74–79 (2013)
5. Analytical Chemistry by Cary D. Christian, John Wiley and sons.
6. Basic Concepts of Analytical Chemistry by S.M. Khopkar, New Age International Publishers.
7. 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)

8. Modern Analytical Chemistry, David Harvey (page numbers 53-84)
9. Fundamentals of analytical chemistry –Skoog and West

Skill Enhancement Course (SEC)

Semester II

Title of the course Softwares in Chemistry

Sr. No.	Heading	Particulars
1	Description the Course	The aim of Skill Enhancement Courses (SECs) is to introduce the students with opportunities to develop required skills in Chemistry
2	Vertical	Skill Enhancement Course (SEC)
3	Type	Theory and Practical
4	Credits	2 Credits (1 Credit = 15 Hours for Theory) (1 Credit = 30 Hours for Practical)
5	Hours Allotted	45 Hours
6	Marks Allotted	50 Marks
7	Course Objectives (CO)	
	CO 1	To develop proficiency in utilizing MS-office and other softwares for precise representation of chemical formulae, equations and experimental data and use them to solve chemical equations.
	CO 2	To use online platforms for literature survey
	CO 3	To gain competence in using specialized Chemistry software tools
	CO 4	To enable students to understand MSDS
8	Course Outcomes (OC) Students will be able to-	
	OC 1	Proficiently use of MS-Word and MS-Excel for accurately documenting chemical formulae, equations and experimental data, ensuring clarity and precision in scientific communication
	OC 2	Utilization of online platforms to conduct comprehensive literature surveys, and stay updated with advancements in Chemistry
	OC 3	Gain mastery of specialized Chemistry software tools such as ChemDraw/ChemSketch etc.

9	Modules
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Semester	Modules	Description	Credits
I	I (Theory Component)	1.1 ICT Tools in Chemistry	01
		1.2 Online Platforms for Literature Survey	
		1.3 Chemistry Softwares	
	II (Practical Component)	Practicals	01

Module	Description	Hours
I Theory Component	1.1 ICT Tools in Chemistry Use of MS-WORD in writing chemical formulae and equations Use of MS-Excel in treatment of experimental data: Basic functions and formulae, creating charts and graphs, etc.	05
	1.2 Online Platforms for Literature Survey Google Scholar, Sci-Finder, Scopus and Web of Science	02
	1.3 Chemistry Softwares ChemDraw / ChemSketch: Introduction, Drawing of chemical structures and reactions, Chemical structure to name conversion, chemical name to structure conversion and other related features Origin Software: Introduction, graphs, 2D and 3D graphs and other related features	08
II (Practical Component)	1. Writing of chemical equations and formulae using MS Word. 2. Use of Excel sheets in calculation and plotting of graph of rate constants for the given data of hydrolysis of methyl acetate. 3. Drawing of chemical structure of organic compounds (acyclic, cyclic, polycyclic, heterocyclic) by using ChemSketch / Chem Draw. 4. Use of Origin software for plotting of graphs for the given data of potentiometric titration of weak acid against strong base. 5. Drawing of chemical structure of simple organic compounds and determination of molecular weight, molecular formula, refractive index, bond angles, bond lengths by using ChemSketch / Chem Draw 6. Demonstration of Chemistry Experiments using Virtual Laboratory (http://www.chemcollective.org/vlab/vlab.php) (Minimum 3 Experiments)	30

10. References

1. “Research Methodology – Methods and Techniques” by C.R. Kothari.
2. “Excel 2019 Charts (Easy Excel Essentials 2019)” by M L Humphrey
3. “Tutorial to ChemDraw: For beginner” by Juhn Morton

4. https://www.chem.uzh.ch/bienz/lecture/gpc/Files/Intro_cdrow.pdf
5. “Origin Software Complete Usage Instruction and Graph Representation: A complete Guide for new users” by Muhammad Arsalan, Azka Awais
https://d2mvzyuse3lwjc.cloudfront.net/pdfs/Origin2022b_Documentation/English/Origin_User_Guide_2022b_E.pdf

**QUESTION PAPER PATTERN
(External and Internal)**

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

Evaluation Pattern for semester I and II:

Theory Paper

Internal Continuous Assessment: 40% (20 Marks)	Semester End Examination: 60% (30 Marks)	Duration for End semester examination
Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.	As per paper pattern	1 h

Paper Pattern for 30 marks :

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

Internal Continuous Assessment: 40% (20 Marks)	Semester End Examination: 60% (30 Marks)	Duration for End semester examination
Viva/ assignment/ objective question test (15 Marks), Overall performance (5 Marks) = 20 Marks	One experiment (25 marks for experiment and 5 Marks for Journal = 30 Marks)	3 h 30 minutes

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. 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.

Evaluation Pattern for VSC Courses

The Scheme of Examination

Internal Continuous Assessment: 40% (20 Marks)	Semester End Examination: 60% (30 Marks)	Duration for End semester examination
Viva / Assignments / Objective Question Tests (15 Marks), Overall Performance (5 Marks) = Total 20 Marks	Theory (10 Marks) and Practical (20 Marks) = Total 30 Marks	3 hr 30 minutes

Semester End Examination (30 Marks)

Duration - This examination shall be of **3 hours and 30 minutes** duration to be taken in laboratory (**1 hour for Theory and 2 hours 30 minutes for Practicals**).

Question	Option	Marks	Questions Based on
Q.1	Based on Theory Attempt any two out of three questions (5 marks each)	10	Unit I (Theory Component)
Q.2	One Experiment (15 marks for Experiment and 5 Marks for Journal = 20 Marks)	20	Unit II (Practical Component)
Total		30	---

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. 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.

Evaluation Pattern for SEC Courses

Theory	Credit	No. of Hours	Marks
	02	30	50

Internal Continuous Assessment: 40% (20 Marks)	External, Semester End Examination Individual Passing in Internal and External Examination: 60% (30 Marks)
Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.(at least 3)	As per the Format of Question Paper
Format of Question Paper: for the final examination	

Paper Pattern for 30 Marks

A. Semester End Theory Examination of 20 Marks

1. Duration - These examinations shall be of **one-hour** duration
2. Theory question paper pattern:
 - a. There shall be **02** questions, Question 1 carries 04 Marks and Question 2 carries 16 Marks on Unit I (Theory)
 - b. All questions shall be compulsory with internal choice within the questions

Question	Particulars	Marks	Questions Based on
Q.1	Objective Questions 04 out of 07	04	Unit I
Q.2	Subjective Questions 04 out of 07	16	
Total		20	---

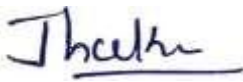
B. Semester End Practical Examination of 10 Marks

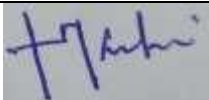
1. Duration - These examinations shall be of **One and half hour** duration
2. Give any one Experiment from Unit II for 10 Marks

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 - 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Signatures of Team Members

Name	College Name	Sign
Dr. Kalpana Patankar Jain	Principal, Royal College of Arts, Science & Commerce Mira road Email: knjc00@gmail.com Contact no.: 8806474000	
Dr. Sunil Patil	Coordinator, Board of Studies in Chemistry	
Dr. Jayashree Thakre	Assistant Professor and Head, Department of Chemistry KME G. M. Momin Women's College Bhiwandi Email: jayashree.thakre@gmail.com Contact no.: 9869137416	
Dr. Kiron Jathar	Associate Professor, Vice Principal, R. D. and SH National College, Bandra, Mumbai 400050 Email: kiron.jathar@rdnational.ac.in Mobile: 9969065969	
Dr. Rupesh Hiranman Gaikwad	Assistant Professor, Department of Chemistry, Maharshi Dayanand College of Arts Science and Commerce, Parel, Mumbai - 400012 Email: rupeshhgaiikwad@gmail.com Contact no.9867879484	
Dr. Ganesh Ramdas Bhagure	Principal, Satish Pradhan Dnyanasadhana College Thane Email: grbhagure69@gmail.com Contact no.8451845615	
Dr. Santosh WamanKulkarni	K.M. Agrawal College, Kalyan. Email – kulkarnisantosh17055@gmail.com Mobile – 9930897130	
Dr Nandkishor Chandan	Department of Chemistry, Siddharth College of Arts, Science and Commerce, Buddha Bhavan Fort Mumbai 400001 Email: nschandan2020@gmail.com	
Prof. Dr. Anil Mahadeo Palve	Mahatma Phule Arts, Science and Commerce College Panvel, Dist-Raigad Email: palve_anil@yahoo.com	

	Mobile: 9137936470	
Dr. Sandip D. Maind	Associate Professor Bhavans H. Somani College of Arts and Science, Chowpatty, Mumbai 400007 Email- sandipmaind@bhavanschowpatty.ac.in Contact: 8425916377	
Dr. Aparna Milind Kulkarni	Vice Principal Associate Professor Gogate-Joglekar College Ratnagiri Email draparna.gjc@gmail.com aparna.kulkarni@gjcrt.ac.in	
Dr. Bhushan Langi	Vice-Principal Assistant Professor, Department of Chemistry, Satish Pradhan Dnyanasadhana College, Thane Mobile: 9867125723	
Prof.Dr.Dinesh Vasant Bhagat	Head, Department of Chemistry, KES Anandibai Pradhan Science College Nagothane, District -Raigad Email: bhagat.dinesh72@gmail.com Mobile: 9284052390	
Dr. Suresh T. More	Assistant Professor Department of Chemistry VPMK'S Art's Commerce and Science College Kinhavali 421403 Email - stm.vpmkchem@gmail.com Contact - 9096232365	
Dr. Aqeela A. S. Qureshi	Associate Professor, Department of Chemistry, Royal College, Mira Road East, Dist. Thane 401107 Email. : aqeela@royalcollegemiraroad.edu.in Contact : 9594383614	
Dr. Vishwanath R. Patil	Department of Chemistry, University of Mumbai Santacruz (E), Mumbai – 400098 Email: vrpatil@chem.mu.ac.in Mobile: 9821013703	

Justification for B.Sc. (Chemistry)

1.	Necessity for starting the course:	The necessity for starting the B.Sc. (Chemistry) course lies in its role as a foundational, interdisciplinary, and practical program that prepares students for higher education, diverse career opportunities, and active participation in addressing scientific and societal challenges.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	The course has already commenced in the university and in the academic year 2023-24 it is restructured under NEP 2020
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	This course is aided / self-financed based on the sanction given by University of Mumbai to affiliated colleges time to time.
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	The duration of the program is three years (6 semesters). It is not possible to compress the course.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	The intake capacity is variable from college to college based on sanctions received from the University.
7.	Opportunities of Employability / Employment available after undertaking these courses:	B.Sc. (Chemistry) graduates are versatile and can adapt their skills to various industries, making them valuable assets in the workforce. Additionally, continuous learning and staying updated on industry trends can enhance career prospects and open up new opportunities.

**Sign of the BOS
Chairman
Prof. Shivram S. Garje
Board of Studies in
Chemistry**

**Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science &
Technology**

**Sign of the
Offg. Dean
Prof. Shivram S. Garje
Faculty of Science &
Technology**