

University of Mumbai

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विद्याविषयक प्राधिकरणे
सभा आणि सेवा विभाग(ए.ए.एम.एस)
कम नं. १२८ एम.जी.रोड, फोर्ट,
मुंबई - ४०० ०३२
टेलिफोन नं - ०२२ - ६८३२००३३

(नॅक पुनर्मूल्यांकनाद्वारे ३.६५ (सी.जी.पी.ए.) सह अ++ श्रेणी
विद्यापीठ अनुदान आयोगाद्वारे श्रेणी १ विद्यापीठ दर्जा)


क.वि.प्रा.स.से./आयसीडी/२०२५-२६/३७

दिनांक : २७ मे, २०२५

परिपत्रक:-

सर्व प्राचार्य/संचालक, संलग्नित महाविद्यालये/संस्था, विद्यापीठ शैक्षणिक विभागांचे संचालक/ विभाग प्रमुख यांना कळविण्यात येते की, राष्ट्रीय शैक्षणिक धोरण २०२० च्या अमलबजावणीच्या अनुषंगाने शैक्षणिक वर्ष २०२५-२६ पासून पदवी व पदव्युत्तर अभ्यासक्रम विद्यापरिषदेच्या दिनांक २८ मार्च २०२५ व २० मे, २०२५ 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
२७ मे, २०२५


(डॉ. प्रसाद कारडे)
कुलसचिव

क.वि.प्रा.स.से.वि/आयसीडी/२०२५-२६/३७ दिनांक : २७ मे, २०२५
Desktop/ Pritam Loke/Marathi Circular/NEP Tab Circular



As Per NEP 2020

University of Mumbai



Syllabus for Major Vertical – 1 & 4 (Scheme – III)

Name of the Programme – B.Sc. (Chemistry)

Faculty of Science

Board of Studies in Chemistry

U.G. Second Year Programme

**Exit
Degree**

U.G. Diploma in Chemistry

Semester

III & IV

From the Academic Year

2025-26

University of Mumbai



(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O: _____	B.Sc. (Chemistry)
2	Exit Degree	U.G. Diploma in Chemistry
3	Scheme of Examination R: _____	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination
4	Standards of Passing R: _____	40%
5	Credit Structure R: SU - 525 C (III) R: SU - 525 D (III)	Attached herewith
6	Semesters	Sem. III & IV
7	Program Academic Level	5.00
8	Pattern	Semester
9	Status	New
10	To be implemented from Academic Year	2025-26

Sd/-

Sign of
Dr. Sunil Patil
Coordinator,
Board of Studies in
Chemistry

Sd/-

Sign of
Prin. (Dr.) Madhav Rajwade
Offg. Associate Dean,
Faculty of Science and
Technology

Sd/-

Sign of
Prof. (Dr.) Shivram Garje
Offg. Dean,
Faculty of Science and
Technology

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	6 Paper I: S3MJ3: Progressive Physical and Analytical Chemistry I Paper II: Theory S3MJ4: Progressive Inorganic and Organic Chemistry I Practical I: S3MJCHP3: Chemistry Practical 3		4	4	SEC: 2, Skills in Chemistry Synthesis of Nanoparti cles	AEC:2	CC: 2 CEP/ FP: 2	22	UG Diploma 88	
	R:_____D										
	IV	Paper I: S3MJ5: Progressive Physical and Analytical Chemistry II Paper II: Theory S3MJ6: Progressive Inorganic and Organic Chemistry II Practical I: S3MJCHP4: Chemistry Practical 4		4	4	VSC:2 Water and Soil Analysis	VEC: 2	CC: 2 CEP/ FP: 2	22		
Cum Cr.		12		08	08	06	04	04	44		

Exit option; Award of UG Diploma in Major and Minor with 80-88 credits and an additional 4 credits core NSQF course/ Internship OR Continuewith 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 – Community Engagement Project, CC – Co-Curricular, RP – Research Project]

Sem. - III

Vertical – 1 Major

Syllabus
B.Sc. Chemistry
(Sem.- III)

Paper I: S3MJ3: Progressive Physical and Analytical Chemistry I
And

Paper II: S3MJ4: Progressive Inorganic and Organic Chemistry I

Sr. No.	Heading	Particulars
1	Description of the course: Including but Not limited to:	This program is meticulously designed to furnish a fundamental understanding of Chemistry. Through a comprehensive academic curriculum encompassing both theoretical and practical courses, we aspire to not only impart knowledge but also to cultivate interest in the discipline. The Bachelor of Science (B.Sc.) in Chemistry course is structured to equip students with a solid theoretical foundation, practical skills, and critical thinking abilities that are essential to navigate the challenges and opportunities within the diverse fields of the subject. Continuous evaluation of students is conducted through quizzes, class tests, and assignments. Emphasis is placed on conceptual understanding of theoretical frameworks, which is subsequently integrated into practical applications. The B.Sc. (Chemistry) program offers two major subjects, one minor subject, and various elective courses including VSCs, SECs, IKS, AECs, OEs, VEC, and CC. Upon successful completion of the first year of the B.Sc. program, learners will be conferred with a Undergraduate Certificate in Chemistry.
2	Vertical :	Major
3	Type :	Theory / Practical
4	Credit:	2 credits / 4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	Hours Allotted :	30 Hours / 60 Hours
6	Marks Allotted:	50 Marks/100 Marks

7

Course Objectives:**Physical and Analytical Chemistry**

CO 1	To understand and apply the basic concept of Free energy, Chemical potential
CO 2	To understand and apply the principles of electrolyte conductance, transference number.
CO 3	To understand and apply the concept of ideal solutions, partially miscible and immiscible liquid pairs
CO 4	To introduce the scope of Analytical Chemistry and the statistical treatment of data in chemical analysis.
CO 5	To Learn and identify the concepts of standard solutions, primary and secondary standards. Type of titrations and indicators used. Facilitate the learner to make solutions of various concentrations.
CO 6	To introduce instrumental analysis, like the spectrometric technique and the law applied to it.

Inorganic and Organic Chemistry

By the end of this course, students will:

1. Understand types of bonding, valence bond theory and MOT and their applications
2. Imbibe the basic concept of chemistry of boron and silicon compound
3. Understand the mechanisms of nucleophilic substitution reactions in haloalkanes and haloarenes.
4. Explore the influence of structural and environmental factors on reactivity and stereochemistry.
5. Examine the structure, nomenclature, and preparation methods of aldehydes and ketones.
6. Analyze nucleophilic addition reactions and their applications in organic synthesis.
7. Learn key name reactions and transformations.

8

Course Outcomes:**Physical and Analytical Chemistry**

On completing the course, the learner will be able to:	
OC 1	Explain and apply concept of Free energy, Chemical potential
OC 2	understand the principle of electrolyte conductance, terms associated and experimental technique to determine transport no. of ions
OC 3	Explain the difference of ideal and non-ideal solution, partially and immiscible liquid pairs
OC 4	Understand the importance of Analytical Chemistry and apply statistical tests to the given data or the data generated in the laboratory to comment on error and minimize it.
OC 5	Explain the various terms involved in titrimetric analysis, choose a suitable indicator, standardization and Preparation of standard solutions
OC 6	Describe the function of the different components of a colorimeter and spectrophotometer.

Inorganic and Organic Chemistry

After successful completion, students will be able to:

1. Elucidate the types of bonding and enable them to write the VBT and MOT with respect to examples
2. Explain compounds of boron and silicon
3. Differentiate between SN^1 , SN^2 , SN^i , and aromatic substitution mechanisms with stereochemical implications.
4. Predict the reactivity of haloalkanes and haloarenes in various nucleophilic substitution contexts.
5. Identify and describe methods of preparing aldehydes and ketones different precursors.
6. Explain mechanisms and outcomes of reactions involving carbonyl compounds.
7. Describe and illustrate the mechanisms of selected name reactions

9. Modules

Semester	Paper	Unit	Description	Credits
III	Paper I: S3MJ3: Progressive Physical and Analytical Chemistry I	I	Physical Chemistry 1.1. Chemical Thermodynamics II 1.2. Electrochemistry 1.3. Solution	02
		II	Analytical Chemistry 2.1 Scope of Analytical Chemistry and Errors in Analysis with their types 2.2 Classical Methods: Titrimetric Methods of Analysis 2.3 Instrumental Methods-I (Spectrometry)	
	Paper II: S3MJ4: Progressive Inorganic and Organic Chemistry I	I	Inorganic Chemistry 1.1 Chemical Bonding 1.2 Basic Chemistry of Boron and Silicon	02
		II	Organic Chemistry 2.1 Reactions and Reactivity of Halo Alkanes and Halo Arenes 2.2 Chemistry of Carbonyl Compounds 2.3 Name Reactions (Mechanism and Applications) – I	
	S3MJCHP3: Chemistry Practical 3	--	Practical Component	02

Paper I: S3MJ3: Progressive Physical and Analytical Chemistry I

Unit I	Physical Chemistry
1.1	Chemical Thermodynamics-II (5L) 1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibbs Free Energy, Variation of Gibbs Free Energy with Pressure and Temperature. 1.1.2 Gibbs-Helmholtz equation, Concept of fugacity and activity (Numericals expected). 1.1.3 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature. Gibbs Duhem equation.
1.2	Electrochemistry (5L) 1.2.1 Electrolytes: Definition, Strong and Weak electrolytes and their conductance measurement, ions and electrical conductivity by ions. 1.2.2 Kohlrausch law of independent migration of ions. 1.2.3 Applications of conductance measurements: determination of degree of ionization and ionization constant of weak electrolyte, solubility and solubility product of sparingly soluble salts. (Numerical expected). 1.2.4 Transference number and its experimental determination using Moving boundary method. (Numerical expected). Factors affecting transference number.
1.3	Solutions (5L) 1.3.1 Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law–non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. 1.3.2 Partial miscibility of liquids: Definition, Effect of Temperature, effect of impurity and intermolecular interactions on partial miscibility, Critical solution temperature; Phenol-Water, Triethanolamine – Water and Nicotine – Water systems 1.3.3 Immiscibility of liquids- Nernst distribution law and its applications, solvent extraction.

Unit II	Analytical Chemistry
2.1	<p>Scope of Analytical Chemistry and Errors in Analysis with their types (5L)</p> <p>2.1.1 Important terms and their significance in Analytical Chemistry. Classical and Non-Classical Methods of Analysis; their types and Importance. Applications in various fields- Organic, Pharmaceuticals, Electronics & Environmental analysis.</p> <p>2.1.2 Errors in Chemical Analysis and their types: i) Determinate Errors ii) Indeterminate Errors.</p> <p>2.1.3 Classification of determinate errors: i) instrumental errors ii) methodic errors iii) operational errors iv) personal</p> <p>2.1.4 Methods of minimisation of determinate errors in chemical analysis: Calibration, running of blanks, control determination, independent method of analysis, parallel determination.</p> <p>2.1.5 Constant and proportionate errors with examples</p>
2.2	<p>Classical methods: Titrimetric Methods of Analysis (5L)</p> <p>2.2.1 Terms involved in Titrimetric analysis. i) Titrant ii) Titrand iii) Equivalence Point iv) Indicator v) End point vi) Titration Error</p> <p>2.2.2 Types of volumetric analysis with example and indicators i) Neutralisation (Acidimetry, alkalimetry) ii) Redox (Iodometry, Iodimetry) iii) Precipitation iv) Complexometric titrations</p> <p>2.2.3 Standard solutions and standardisation in Titrimetry (primary and secondary standards) Calculations based on preparation of standard solutions and their dilutions.</p>
2.3	<p>Instrumental Methods-I (Spectrometry) (5L)</p> <p>2.3.1 Basic Terms: Radiant Power, Absorbance, Transmittance, Monochromatic Light, Polychromatic Light, Wavelength of Maximum Absorbance, Absorptivity and Molar Absorptivity.</p> <p>2.3.2 Statement and derivation of Beer's Law and Lambert's Law, Combined Mathematical Expression of Beer-Lambert's Law (Numerical based on Beer-Lambert's Law)</p> <p>2.3.3 Block Diagram for Single Beam Colorimeter (Principle, Construction and Working (Details of Components Expected, i.e. source, Sample Holder, Filter, Detector). Comparison between single Beam Colorimeter and double beam colorimeter. Single beam spectrophotometer (Principle, Construction and Working)</p>

Paper II: S3MJ4: Progressive Inorganic and Organic Chemistry I

Unit I	Inorganic Chemistry
1.1	Chemical Bonding (12L) 1.1.1 Non directional Bonding (3L) <ul style="list-style-type: none"> • Ionic Bond: Conditions for the Formation of Ionic Bond and properties • Types of Ionic Crystals • Radius Ratio Rules • Born-Haber Cycle and its Applications 1.1.2 Directional bonding (4L) <ul style="list-style-type: none"> • VBT, introduction and basic tenets • Concept of homo nuclear diatomic molecule from He₂ to Ne₂ • Bonding in Polyatomic Species: The Role of Hybridization. And types of hybrid orbitals-sp, sp^2, sp^3, sp^3d, sp^3d^2, d^2sp^3, Sp^3d^3 with examples. 1.1.3 Molecular Orbital Theory (5L) <ul style="list-style-type: none"> • Comparing Atomic Orbitals and Molecular Orbitals. • Linear combination of atomic orbitals to give molecular orbitals LCAO-MO approach for diatomic homonuclear molecules). • Molecular orbital Theory and Bond Order and magnetic property: with reference to O₂, O⁺, O₂⁻, O₂²⁻
1.2	Basic chemistry of Boron and Silicon (3L) 1.2.1 Basic chemistry of boron and silicon – electronic configuration, oxidation state and inert pair effect. 1.2.2 Preparation, bonding and applications of diborane, silicon dioxide and silicon tetra chloride.
Unit II	Organic Chemistry
2.1	Reactions And Reactivity of Halo Alkanes and Halo Arenes: (4L) 2.1.1 Alkyl halides: (2 L) Nucleophilic substitution reactions: SN ¹ , SN ² and SN ⁱ mechanisms with stereo chemical aspects (examples of chiral carbon are expected) Factors affecting nucleophilic substitution reactions: Nature of substrate, nature of solvent, nature of nucleophilic reagent, nature of leaving group. 2.1.2 Aryl halides: (2 L) Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution: addition-elimination mechanism (S _N Ar), elimination- addition mechanism (benzyne mechanism) and Cine substitution
2.2	Chemistry of Carbonyl Compounds: (8 L) 2.2.1 Recapitulation: (1 L) Introduction to classes of compounds containing carbonyl group Bonding, structure and reactivity of carbonyl group in aldehyde and ketone. IUPAC nomenclature of aldehydes and ketones. 2.2.2 Methods of Preparation (Mechanisms not expected): (1 L) Oxidation of primary and secondary alcohol using PCC, K ₂ Cr ₂ O ₇ , Wacker process (Using PdCl ₂), Swern oxidation (oxyl chloride / DMSO and Et ₃ N), Jones reagent (CrO ₃ in sulfuric acid), Sarett oxidation (CrO ₃ in pyridine, selective oxidation of OH group in presence of double bond. (Preparation of cinnamaldehyde is expected) 2.2.3 Nucleophilic Addition Reactions: (2 L) Mechanism of nucleophilic addition reactions Reactivity of aldehyde and ketone. Example: addition of HCN, NaHSO ₃ , Grignard reagent, alcohol, amines, phenyl hydrazine, 2,4 – DNPH

	<p>2.2.4 Oxidation and Reduction (Mechanisms not expected): (1 L) Reduction to alcohol: Reduction using LiAlH_4, NaBH_4, MPV reduction, Reduction to hydrocarbon: Clemmensen reduction, Wolff – Kishner reduction Oxidation: Oppenauer oxidation, Baeyer – Villiger oxidation</p> <p>2.2.5 Active methylene compounds: (3 L) Introduction and reactivity of active methylene compound and enolate formation, Examples: ethyl acetoacetate, acetyl acetone, malonic ester. Some characteristic reactions of these compounds like salt formation, alkylation. Application of active methylene compounds in name reactions viz: 1) Michael addition 2) Knoevenagel condensation</p>
2.3	<p>Name Reactions (Mechanism and Applications) – I: (3 L)</p> <p>2.3.1 Simmons-Smith reaction 2.3.2 Reformatsky reaction 2.3.3 Reimer-Tiemann reaction 2.3.4 Beckmann rearrangement</p>

S3MJCHP3: Chemistry Practical 3

Physical Chemistry

- 1 To verify Ostwald's dilution law for weak acid conductometrically.
- 2 To investigate the reaction between $K_2S_2O_8$ and KI with equal initial concentrations of the reactants
- 3 To determine the critical solution temperature (CST) of phenol-Water system
- 4 To determine the Solubility product and solubility of AgCl potentiometrically using a chemical cell

Analytical Chemistry

1) Tools of analytical chemistry-I (theory within practical)

- a) Analytical glassware like burettes, pipettes, Standard flasks, and separating funnels.
- b) Weighing tools such as two pan balance and a monopan balance and digital balances
- c) Incineration devices: Burners, Electrical Incinerators, Muffle Furnace
- d) Drying Devices: Hot Air Oven, Microwave Oven, Desiccators, Vacuum desiccators
- e) Monochromators, Filters, Sample holders, Prisms, Diffraction Gratings, Photo-emissive cells, Photomultiplier tubes

- 2) **Colourimetry:** Determination of copper ions as an ammine complex in the given solution is obtained by the calibration curve method.
- 3) **Conductometry:** Estimation of a given weak acid with a strong base by conductometric titration.
- 4) Estimation of drugs - Estimation of aspirin.
- 5) Estimation of Mg content in talcum powder by using standard EDTA solution.

Inorganic Chemistry

Inorganic preparation (2):

- 1) bis(dimethylglyoximate)Ni(II)
- 2) tris ethylene diamine Ni(II) thiosulphate

Complexometric titration (1)

- 1) Estimation of total hardness of water

Gravimetric estimation (1)

- 1) Barium as $BaCrO_4$

Organic Chemistry

Organic Qualitative Analysis (Minimum 4 compounds to be analysed)

Qualitative analysis of bi-functional organic compounds on the basis of

1. Preliminary examination
2. Solubility / miscibility profile
3. Detection of elements C, H, (O), N, S, X.
4. Detection of functional groups
5. Determination of physical constants (M.P/B.P)

Solid or liquid compounds containing not more than two functional groups from among the following classes may be given for analysis

• Suggested Compounds

Carboxylic Acids: Salicylic acid, Acetyl alicyclic acid, o-chloro benzoic acid, o or m or p -nitro benzoic acid, anthranilic Acid

Phenols: o or m or p -nitro Phenol

Amines: o or m or p -nitro aniline or p-toluidine

Mono-functional Compound List:

Aldehydes: Benzaldehyde

Ketones: Benzophenone, acetophenone

Esters: Methyl acetate, Ethyl acetate, Ethyl benzoate

Alcohols: Propanol, butanol, benzyl alcohol

Ethers: Anisole

Amides & anilides: Urea, thiourea, benzamide, acetanilide, benzanilide

Sem. - IV

Vertical – 1 Major

Syllabus

B.Sc. Chemistry

(Sem.- IV)

Paper I: S3MJ5: Progressive Physical and Analytical Chemistry II

And

Paper II: S3MJ6: Progressive Inorganic and Organic Chemistry II

Sr. No.	Heading	Particulars												
1	Description of the course:	This course provides an integrated study of the principles and applications of physical and analytical chemistry. It is designed to build a concrete foundation in the theoretical concepts of chemical systems as well as practical techniques used to analyse them.												
2	Vertical :	Major												
3	Type :	Theory / Practical												
4	Credit:	2 credits / 4 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)												
5	Hours Allotted :	30 Hours / 60 Hours												
6	Marks Allotted:	50 Marks/100 Marks												
7	Course Objectives: Physical and Analytical Chemistry <table><tr><td>CO:1</td><td>To understand the basic concepts, reaction mechanism and type of complex chemical reactions.</td></tr><tr><td>CO:2</td><td>To understand the chemical cell and types of electrodes and apply emf data to calculate equilibrium constant and pH of the solution.</td></tr><tr><td>CO:3</td><td>To understand the Phase Rule and apply it to one and two-component systems.</td></tr><tr><td>CO: 4</td><td>To learn chromatography and Solvent Extraction as a tool for Separation.</td></tr><tr><td>CO: 5</td><td>To understand the basic concepts of some instrumental method of analysis.</td></tr><tr><td>CO: 6</td><td>To learn about the Statistical treatment of analytical data.</td></tr></table> Inorganic and Organic Chemistry <p>By the end of this course, students will:</p> <ol style="list-style-type: none">1.Understand the placement of transition elements in Periodic table and their magnetic properties and qualitative test2.Imbided the basic concepts of coordination theory, rules and applications3.Explore the types of oxides of nitrogen, sulphur and their impact on environment4.Understand the basic structure, classification, and nomenclature of common heterocyclic compounds.		CO:1	To understand the basic concepts, reaction mechanism and type of complex chemical reactions.	CO:2	To understand the chemical cell and types of electrodes and apply emf data to calculate equilibrium constant and pH of the solution.	CO:3	To understand the Phase Rule and apply it to one and two-component systems.	CO: 4	To learn chromatography and Solvent Extraction as a tool for Separation.	CO: 5	To understand the basic concepts of some instrumental method of analysis.	CO: 6	To learn about the Statistical treatment of analytical data.
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CO:3	To understand the Phase Rule and apply it to one and two-component systems.													
CO: 4	To learn chromatography and Solvent Extraction as a tool for Separation.													
CO: 5	To understand the basic concepts of some instrumental method of analysis.													
CO: 6	To learn about the Statistical treatment of analytical data.													

	<p>5. Study the synthesis, reactivity, and substitution patterns of five- and six-membered heterocycles.</p> <p>6. Analyze conformational behavior and stereochemistry of mono- and disubstituted cyclohexanes.</p> <p>7. Explore symmetry elements and their role in determining stereochemical outcomes.</p> <p>8. Understand and apply mechanisms of selected name reactions relevant to synthesis and rearrangements.</p>												
8	<p>Course Outcomes:</p> <p>Physical and Analytical Chemistry</p> <table border="1"> <tr> <td colspan="2">Course Outcomes (OC): On completing the course, the learner will be able to:</td></tr> <tr> <td>OC 1</td><td>Demonstrate an understanding about chemical kinetics, reaction mechanism and complex chemical reaction.</td></tr> <tr> <td>OC 2</td><td>Learn chemical cell, distinguish between reversible/ irreversible cells, types of electrode, use of emf data to calculate equilibrium constant and pH of solution.</td></tr> <tr> <td>OC3</td><td>Develop a clear understanding of the criteria for phase equilibrium and apply Gibbs Phase Rule to different systems</td></tr> <tr> <td>OC 4</td><td>Develop a clear understanding of the principle, technique and application of PC and TLC , Solvent extraction.</td></tr> <tr> <td>OC: 5</td><td>Understand the details of working and application of potentiometer, Conductometer and pH-meter</td></tr> </table> <p>Inorganic and Organic Chemistry</p> <p>After successful completion, students will be able to:</p> <ol style="list-style-type: none"> 1. Discern the position of transition elements, properties and qualitative analysis 2. Determine the rules , theories of coordination compounds and their application 3. Expound the types of oxides of nitrogen, Sulphur and their impact on environment 4. Classify and name five- and six-membered heterocyclic compounds containing one heteroatom. 5. Describe and compare synthesis methods and electrophilic substitution reactivity of furan, pyrrole, thiophene, and pyridine. 6. Predict conformational preferences and stereochemical behavior of mono- and disubstituted cyclohexanes. 7. Identify symmetry elements in organic molecules and relate them to optical activity. 8. Explain mechanisms and applications of selected named reactions. 	Course Outcomes (OC): On completing the course, the learner will be able to:		OC 1	Demonstrate an understanding about chemical kinetics, reaction mechanism and complex chemical reaction.	OC 2	Learn chemical cell, distinguish between reversible/ irreversible cells, types of electrode, use of emf data to calculate equilibrium constant and pH of solution.	OC3	Develop a clear understanding of the criteria for phase equilibrium and apply Gibbs Phase Rule to different systems	OC 4	Develop a clear understanding of the principle, technique and application of PC and TLC , Solvent extraction.	OC: 5	Understand the details of working and application of potentiometer, Conductometer and pH-meter
Course Outcomes (OC): On completing the course, the learner will be able to:													
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OC 4	Develop a clear understanding of the principle, technique and application of PC and TLC , Solvent extraction.												
OC: 5	Understand the details of working and application of potentiometer, Conductometer and pH-meter												

9 Modules

Semester	Paper	Unit	Description	Credits
IV	Paper I: S3MJ5: Progressive Physical and Analytical Chemistry II	I	Physical Chemistry 1.1. Chemical Kinetics II 1.2. Electrochemistry II 1.3. Phase Equilibria	02
		II	Analytical Chemistry 2.1 Methods of Separation 2.2 Instrumental Methods-II 2.3 Statistical Treatment of Analytical Data	

	Paper II: S3MJ6: Progressive Physical and Analytical Chemistry II	I	Inorganic Chemistry 1.1 Comparative chemistry of transition metals 1.2 Coordination chemistry 1.3 Study of oxides, volatile oxides and oxo acids	02
		II	Organic Chemistry 2.1 Heterocyclic Compounds 2.2 Stereochemistry of mono and disubstituted cyclohexanes 2.3 Name Reactions (Mechanism and Applications) – II	
	S3MJCHP4: Chemistry Practical 4		Practical Component	02

Paper I: S3MJ5: Progressive Physical and Analytical Chemistry II

Unit I	Physical Chemistry
1.1	Chemical Kinetics-II (5L) 1.1.1 Introduction to reaction mechanism (concept of elementary steps, intermediates, and the overall reaction mechanism with an example of Thermal chain reactions: H ₂ and Br ₂ reaction. 1.1.2 Types of Complex Chemical reactions: Reversible or opposing, consecutive and parallel reactions (No derivations, only examples expected)
1.2	Electrochemistry-II (5L) 1.2.1 Electrochemical cells, Nernst equation and its importance in generating electricity through chemical reactions. Types of electrochemical cells - Reversible and irreversible cells (Definition, example, characteristics) 1.2.2 Types of electrodes, Standard electrode potential, Electrochemical series. 1.2.3 Calculation of equilibrium constant and pH measurement using quinhydrone electrode, from EMF data. (Numericals to be solved wherever necessary)
1.3	Phase Equilibria (5L) 1.3.1 Introduction to Phase equilibria, Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule. 1.3.2 Phase diagrams of one-component systems (water and sulphur). 1.3.3 Two-component systems involving eutectics – Condensed Phase rule, Definition of eutectic Phase diagram of Lead-Silver system.
Unit II	Analytical Chemistry
2.1	Methods of Separation (5L) 2.1.1. Types of separation methods Based on volatility – Distillation (definition, types and example) Based on electrical effects – Electrophoresis (definition, principle and applications) 2.1.2. Chromatography – General idea of paper chromatography and thin layer chromatography (principle, technique and applications) 2.1.3. Solvent Extraction – Introduction, Nernst Distribution Law, Distribution Ratio. Single-step and multistep extraction, Percentage extraction for single-step and multistep extraction. Batch Extraction (Simple separating technique -diagram and process) (Numerical problems expected on 2.1.3)
2.2	Instrumental Methods-II (6L) 2.2.1 Potentiometry – Principle, role of reference and indicator electrodes, Graphical Methods of detection of end points. (first derivative and second derivative methods) 2.2.2 pH metry – Principle, construction and working of the glass electrode. 2.2.3 Conductometry – Conductivity cell: Construction. Principle, application in neutralization titration with respect to strong acid–strong base, strong acid – weak base, strong base – weak acid.
2.3	Statistical Treatment of Analytical Data (4L) 2.3.1 Normal error curve or Gaussian distribution curve: Equation and important features

	of Gaussian distribution curve. Gaussian error curve and precision and accuracy.
2.3.2	Linear Regression analysis between two variables: Obtaining equation of the best fitting line for line passing through origin and for line not passing through origin using: i) method of averages ii) method of least squares [Numerical problems expected on 2.3.2]

Paper II: S3MJ6: Progressive Inorganic and Organic Chemistry II

Unit I	Inorganic Chemistry
1.1	Comparative chemistry of transition metals (4L) 1.1.1 Position of transition elements in periodic table, occurrence (ores and minerals), oxidation state and transition elements 1.1.2 Magnetic properties of transition metal compounds. Origin of magnetism (Spin & Spin-Orbital) 1.1.3 Qualitative tests for transition metal ions (Cr, Mn, Fe, Co, Ni, and Cu)
1.2	Coordination chemistry (7L) 1.2.1 Introduction to coordination compounds, basic terms and nomenclature, types of ligands 1.2.2 Isomerism (stereoisomerism of coordination compounds no. 6) 1.2.3 Theories of coordination compounds (Werner's Theory), Effective atomic number rule, Eighteen electron rule. 1.2.4 VBT for sp^3d^2 and d^2sp^3 hybridization , inner and outer orbital , Complexes, limitation of VBT 1.2.5 Applications of coordination compounds
1.3	Study of oxides, volatile oxides and oxo acids (4L) 1.3.1 Oxides of nitrogen with respect to preparation and structure of NO, NO ₂ , N ₂ O and N ₂ O ₄ 1.3.2 Volatile oxides and oxo acids of sulphuric acid and nitric acid 1.3.3 Uses and environment aspects of sulphuric acid and nitric acid with respect to acid rain and photochemical smog respectively.
Unit II	Organic Chemistry
2.1	Heterocyclic Compounds: (6 L) 2.1.1 Introduction: (1 L) Introduction, classification, nomenclature of 5 and 6-membered heterocycles containing one heteroatom 2.1.2 Five membered heterocycles (Furan, Pyrrole and Thiophene): (3 L) Synthesis of furan, pyrrole and thiophene (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), thiophene (Hantzsch synthesis), Reactivity of furan, pyrrole and thiophene towards electrophilic substitution on the basis of stability of intermediate. Reactions of furan, pyrrole and thiophene: halogenation, nitration, sulphonation, Vilsmeier-Haack reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction, ring opening reaction. Pyrrole: Acidity and basicity of pyrrole, comparison of basicity of pyrrole, pyrrolidine and pyridine. 2.1.3 Six membered heterocycles (Pyridine): (2 L) Hantzsch synthesis pyridine. Reactivity of pyridine towards electrophilic and nucleophilic substitution on the basis of electron distribution. Pyridine: Basicity, sulphonation of pyridine (with and without catalyst),

	(Chichibabin reaction)
2.2	<p>Stereochemistry of mono and disubstituted cyclohexanes (6L)</p> <p>2.2.1 Conformational analysis (2 L) Monosubstituted cyclohexanes: methyl cyclohexane, tert-butylcyclohexane. Disubstituted cyclohexanes: 1,2-dimethylcyclohexane, 1-tert-butyl-4-methylcyclohexane,</p> <p>2.2.2 Cis-trans isomerism in disubstituted cyclohexanes: (1 L) 1-chloro-2-methylcyclohexane, 1,3-dimethylcyclohexane</p> <p>2.2.3 Elements of Symmetry: (1L) Mirror plane symmetry, inversion center, rotation -reflection (alternating) axis</p> <p>2.2.4 Stereochemical Consequences: (2L) Cis-1,2-dimethylcyclohexane, cis-1,3-dimethylcyclohexane-optically inactive (presence of plane of symmetry), trans-1,2-dimethylcyclohexane-optically active. Note: Gauche-butane interaction to be discussed.</p>
2.3	<p>Name Reactions (Mechanism and Applications) – II: (3 L)</p> <p>2.3.1 Darzens reaction</p> <p>2.3.2 Wittig reaction</p> <p>2.3.3 McMurry reaction</p> <p>2.3.4 Wagner-Meerwein rearrangement</p>

Semester IV Practical

S3MJCHP4: Chemistry Practical 4

Physical Chemistry

- 1) Determination of energy of activation of acid-catalyzed hydrolysis of methyl acetate.
- 2) To determine the standard reduction potential of $\text{Ag}|\text{Ag}^+$ using *Nernst Equation*
- 3) To determine ΔG^0 and equilibrium constant for cell reaction in the cell set up with copper and silver electrodes.
- 4) To determine the amount of strong acid present in a given solution by titration with a strong base using a **pH meter**

Analytical Chemistry

- 1) Tools in analytical chemistry-II
 - a. Filtration Flasks, Funnels, Separating Funnels, Distillation apparatus, Vacuum Distillation assembly, Centrifuge machine, Electrophoresis apparatus.
 - b. Development chamber for chromatography
 - c. Electrodes like Reference Electrodes and Indicator Electrodes (with respect to care and maintenance).
 - d. Conductivity cell (with respect to care and maintenance).
 - e. Combined Glass electrode (with respect to care and maintenance).
 - f. Types of Salt Bridges and preparation of any one or use of salt bridge, its effect on the potential of a given electrode/cell.
- 2) **Paper Chromatography**: - Separation of Cation Fe (III), Ni (II) and Cu (II) in a sample
- 3) **Colorimeter**: - Estimation of the concentration of Iron by using 1,10-Phenanthroline.
- 4) **Potentiometry**: - Estimation of Fe (II) in the given solution by titration against $\text{K}_2\text{Cr}_2\text{O}_7$.
- 5) Estimation of copper by EDTA method using fast sulphone black F indicator.

Inorganic Chemistry

- 1) **Identification of cations – (minimum 2)**
Identification of cations in a given mixture and analytical separation of mixture [from a mixture containing not more than two of the following; Pb(II), Ba(II), Ca(II), Sr(II), Cu(II), Cd(II), Mg(II), Zn(II), Fe(II), Fe(III), Ni(II), Co(II), Al(III), Cr(III)]
- 2) **Volumetric Analysis / Redox titration**
Estimation of amount of Iron present in the given ferric alum solution
- 3) **Iodometric titration**
Estimation of Cu(II) by using sodium thiosulfate

Organic Chemistry

Short organic preparation and their purification: (Minimum 4 compounds to be prepared)

Use 0.5-1.0g of the organic compound. Purify the product by recrystallization. Report 1) Theoretical yield, 2) Percentage yield and 3) Melting point of the purified product

(Minimum 4 compounds to be prepared)

Preparation of:

1. Cyclohexanone oxime from cyclohexanone.
2. Glucosazone from dextrose or fructose
3. Tribromoaniline from aniline.
4. β -Naphthylbenzoate from β -naphthol
5. m-Dinitrobenzene from nitrobenzene
6. Acetanilide from aniline
7. p-Bromoacetanilide from acetanilide
8. Iodoform from acetone
9. Phthalic anhydride from phthalic acid by sublimation

10. 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)

Analytical Chemistry

1. Analytical Chemistry, Gary D. Christan, Purnendu Dasgupta, 7th Edition, Wiley.
2. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch, 10th edition.
3. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R. Crouch, 7th edition.
4. Basic Concepts of Analytical Chemistry, S.M. Khopkar, 3rd Edition, New academic sciences.
5. Modern Analytical Chemistry, David Harvey, 2nd edition, 2009.

Inorganic Chemistry

Transition Metal and Coordination Chemistry

1. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
2. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.
3. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
4. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2nd Edition 2005.
5. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry-Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
6. R. L. Dekock and H.B. Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989.
7. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
8. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.
9. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
10. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.
11. D. Banerjee, Coordination Chemistry Tata McGraw Hill, 1993.

Study of oxides, volatile oxides and oxo acids

1. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers.

2013-2014.

2. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
3. Andrew Barron, Chemistry of the Main Group Elements, Middas Green Innovations, 2020.
4. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.

Inorganic Practical

1. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
2. A. I. Vogel, Quantitative Inorganic Analysis, 5th Edn Longman Scientific and Technical, 1989.
3. J. D. Woolins, Inorganic Experiments. Hohn Wiley and Sons, 2010
4. G. Raj, Advanced Practical Inorganic Chemistry. Goel Publication, 2010
5. J. E. House, Inorganic chemistry, Academic press, 2nd edition, 2013.
6. G. N. Mukherjee, Advanced Experiments in Inorganic Chemistry., U. N. Dhur & Sons Pvt. Ltd. 2010.
7. G. Christian, Analytical Chemistry, John Wiley, New York 4th edition 1986.

Organic Chemistry

1. Acheson, R. H. (1976). *An Introduction to the Chemistry of Heterocyclic Compounds* (3rd ed.). John Wiley & Sons.
2. Gilchrist, T. L. (1997). *Heterocyclic Chemistry* (3rd ed.). Pearson Education.
3. Joule, J. A., & Mills, K. (2010). *Heterocyclic Chemistry* (5th ed.). Wiley-Blackwell.
4. Parashar, R. K. (2010). *Heterocyclic Chemistry*. Ane Books India.
5. Bansal, R. K. (2022). *Heterocyclic Chemistry* (7th ed.). New Age International Private Limited.
6. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, Peter Wothers- Oxford University Press
7. Stereochemistry of Organic Compounds, Ernest Eliel, Samuel Wilen, A Wiley-Inter-science Publication
8. Organic Chemistry, G. Marc Loudon (4th Edition) Oxford University Press
9. Stereochemistry of Organic Compounds, Principles and Applications, D. Nasipuri, 4th Edition, New Academic Science
10. Heterocyclic Cyclic, Shrikrishna Tupare, String Production

Evaluation Pattern for Major Theory Course

MAJOR: 6 Credits

Theory/Practical	Credits	No. of Hours	Marks
Theory: Paper I: S3MJ3: Progressive Physical and Analytical Chemistry I	2	30	50
Theory: Paper II: S3MJ4: Progressive Inorganic and Organic Chemistry	2	30	50
Practical: S3MJCHP3: Chemistry Practical 3	2	60	50

Semester IV

Theory/Practical	Credits	No. of Hours	Marks
Theory: Paper I: S3MJ5: Progressive Physical and Analytical Chemistry I	2	30	50
Theory: Paper II: S3MJ6: Progressive Inorganic and Organic Chemistry	2	30	50
Practical: S3MJCHP4: Chemistry Practical 4	2	60	50

Evaluation Pattern for Semester III and IV:

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:

- Duration - These examinations shall be of **one hour** duration.
- Theory question paper pattern:
 - There shall be **02** questions each of **15 marks** on each unit
 - All questions shall be compulsory with internal choice within the questions.

Question	Particulars	Marks	Questions Based on
Q.1	A) Objective Questions 06 out of 10	06	Unit I
	B) Subjective Questions 03 out of 05	09	
Q.2	A) Objective Questions 06 out of 10	06	Unit II
	B) Subjective Questions 03 out of 05	09	
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.

Examination Pattern for Vocational Skill Courses (VSC) and Skill Enhancement Courses (SEC)

Practical	Credit	No. of Hours	Marks
	02	60	50

Internal Continuous Assessment: 40% (20 Marks)	Practical Examination: 60% (30 Marks)
Continuous Evaluation through: Presentation, project, creative writing, Industrial Visit report submission (at least 1) (10 Marks) and Survey Reports (any two) (10 Marks)	Practical Journal: 05 Marks Practical on Unit I or Unit II: 25 Marks
Individual Passing in Internal and External Examination	

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

Sd/-

Sign of
Dr. Sunil Patil
Coordinator,
Board of Studies in
Chemistry

Sd/-

Sign of
Prin. (Dr.) Madhav Rajwade
Offg. Associate Dean,
Faculty of Science and
Technology

Sd/-

Sign of
Prof. (Dr.) Shivram Garje
Offg. Dean,
Faculty of Science and
Technology