



The Kelkar Education Trust's  
**Vinayak Ganesh Vaze College of Arts, Science & Commerce**

**(AUTONOMOUS)**

**College with Potential for Excellence**

Mithaghar Road, Mulund East, Mumbai-400081, India  
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## **Syllabus for T.Y.B.Sc. Programme: Chemistry (Six Units)**

Syllabus as per **Choice Based Credit System**

(June 2025 Onwards)

**Submitted by**

**Department of Chemistry**

Vinayak Ganesh Vaze College of Arts, Science and Commerce  
Mithaghar Road, Mulund (East) Mumbai-400081, Maharashtra, India.

Tel: 022-21631004, Fax: 022-21634262

The Kelkar Education Trust's  
Vinayak Ganesh Vaze College of Arts, Science & Commerce  
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❖ Syllabus as per Choice Based Credit System (NEP 2020)

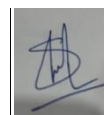
## Syllabus for Approval

**Subject: Chemistry**

Sr. No.	Heading	Particulars
1	Title of Programme	<b>Third Year B.Sc. Chemistry: Semester V and VI</b>
2	Eligibility for Admission	The Second Year B.Sc. examination of this university with chemistry as a Major or Minor subject or any other university recognized as equivalent thereto.
3	Passing marks	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	Ordinances/Regulations (if any)	---
5	No. of Years/Semesters	One year/Two semester
6	Level	U.G. Part-III : Level- 5.5
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic year	2025-2026

Date: April 9, 2025

Signature:



BOS Chairperson: Prof. (Dr) Suresh S. Shendage

## Preamble




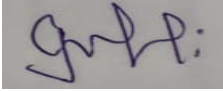
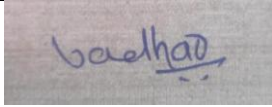

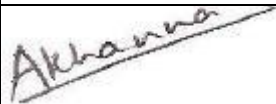

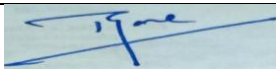


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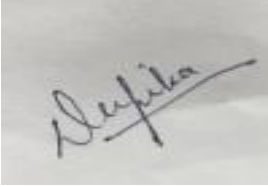
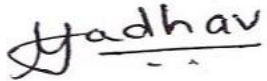
The Board of studies in Third Year Chemistry headed by Prof (Dr.) Suresh Shendage, the Chairman, Department of Chemistry, Vinayak Ganesh Vaze College of Arts, Science and Commerce (Autonomous), Mithagar Road, Mulund (East) Mumbai, University of Mumbai had the thorough discussions on the syllabus of V and VI semester Chemistry for B. Sc. Chemistry courses using the syllabus provided by the NEP Chemistry syllabus drafting Committee. This syllabus has to be accepted for the academic year 2025-26. The Core committee consisting of the faculty members of the Chemistry department with specializations in Analytical, Physical, Inorganic and Organic Chemistry which comprising the BOS and also additional faculty members from other Colleges of University of Mumbai have made effective joint brainstorming discussions and arrived at a Syllabus in Chemistry for V and VI semesters on 5<sup>th</sup> April 2025. The final syllabus incorporating all the suggestions was finally approved by the members of the Board of Studies in Chemistry (UG) on 9<sup>th</sup> April 2025. The following Faculty Members of the Core Committee were involved in the preparation of the Chemistry Syllabus.

1. Prof. (Dr.) Suresh Shendage(Head, Dean, Science, and Nodal Office NEP and ABC)
2. Dr. Ashok Awale
3. Dr. Paresh More
4. Dr. Jagdish Bhangoji
5. Dr. Himanshu Gupta
6. Ms. Pallavi Shirsat
7. Dr. Deepika Dangi
8. Mr. Gahininath Jadhav

Sd/-  
Prof. (Dr.) Suresh Shendage  
Chairman  
BOS in Chemistry

**BOS Members Present:**

Name	Designation	Representation	
Prof.(Dr.) Suresh Shendage	Professor&Head, Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Chairman	
Prof. (Dr.) B. D. Aghav	Professor of Chemistry Changu Kana Thakur A.C.S. College, New Panvel (Autonomous)	Vice-Chancellor's nominee	
Prof. (Dr.) Atul Chaskar	Professor of Chemistry, Institute of Chemical Technology Matunga Mumbai.	Subject Expert (From Other University)	
Dr. Tanaji Jadhav	Senior Research Scientist, Piramal pharma, Limited, Rabale Ghansoli- 400701	Industry Expert	
Mr. Shivaji Jadhav	Technical Manager-IAS, Indoco Remedies Limited Rabale, Navi Mumbai.	Industry Expert	
Dr. Nitin Mirgane	Associate Professor, Department of Chemistry, SIES College Sion Mumbai	Subject Expert From Outside college	
Mr. Aditya Khanna	Assistant Professor, Department of Chemistry, Satish Pradhan Dnyanasadhana College, Thane	Meritorious Alumni	
Dr. Ashok Awale	Associate Professor Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Member of BOS	
Dr. Paresh More	Associate Professor, Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Member of BOS	
Dr. Jagdish Bhangoji	Assistant Professor, Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Member of BOS	
Dr. Himanshu Gupta	Assistant Professor, Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Member of BOS	

Mrs. Pallavi Shirsat	Assistant Professor, Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Member of BOS	
Dr. Deepika Dangi:	Assistant Professor, Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Member of BOS	
Mr. Gahininath Jadhav	Assistant Professor, Department of Chemistry KET'SV.G.Vazecollege(Autonomous),Mulund (E),Mumbai-400081	Member of BOS	

### Third Year B. Sc. Program in Chemistry (Level 5.5)

Semester	Core Course & Credits		NSQF Course & Credits	
<b>Sem - V</b>	<b>MAJOR</b>	<b>No. of Lectures</b>	<b>VSC/SEC</b>	<b>No. of Lectures/Hrs</b>
	<b>Mandatory*Credits 10 (5 x 2)</b>	<b>/Hrs</b>	<b>VSC(Advanced Experimental Chemistry)Credits 2</b>	
	Course 1 Cr. 2: Physical Chemistry-I	2	Course 1 Cr. 2:Practical	4
	Course 2 Cr. 2: Inorganic Chemistry-I	2		
	Course 3 Cr. 2: Organic Chemistry-I	2		
	Course 4 Cr. 2: Analytical Chemistry-I	2		
	Course 5 Cr. 2: Practical (Practical Based on all Papers)	4		
	<b>Electives (select anyone) Credits 4 (2+2)</b>		<b>OJT/FP/CEP/CC/RP</b>	
	Course 1 Cr. 2:Industrial Chemistry- I	2	<b>FP Credits 2</b>	
	Course 2 Cr. 2: Practical (Micro scale Preparation andEstimations)	4	Course 1 Cr. 2:Practical	4
	Course 3 Cr. 2:Medicinal and Green Chemistry	2		
	Course 4 Cr. 2: Practical (Micro scale Preparation andEstimations)	4		
	<b>MINOR Credits 4 (2+2)</b>			
	Course 1 Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - I	2		
	Course 2 Cr. 2: Practical	4		
<b>MAJOR</b>				

<b>Sem - VI</b>	<b>Mandatory*Credits 10 (5 x 2)</b>		<b>SEC (Hands-on Advanced Laboratory Techniques: Synthesis, Analysis, and Sustainable methods)</b> <b>Credits 2</b>	
	Course 1 Cr. 2: Physical Chemistry-II	2	Course 1 Cr. 2:Practical	4
	Course 2 Cr. 2: Inorganic Chemistry-II	2		
	Course 3 Cr. 2: Organic Chemistry-II	2		
	Course 4 Cr. 2: Analytical Chemistry-II	2		
	Course 5 Cr. 2: Practical (Practical Based on allPapers)	4		
	<b>Electives (selected anyone)</b> <b>Credits 4 (2+2)</b>		<b>OJT/FP/CEP/CC/RP</b>	
Course 1 Cr. 2:Industrial Chemistry-II	2	<b>OJTCredits 4</b>		
Course 2 Cr. 2: Practical (Micro scale Preparation andEstimations	4	Course 1 Cr. 2:Practical	8	
Course 3 Cr. 2: Chemistry of Dyestuffs and Green Chemistry	2			
Course 4 Cr. 2: Practical (Micro scale Preparation andEstimations	4			
<b>MINOR Credits 2</b>				
Course 1 Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - II	2			
<b>Total Cumulative credits = 20 + 08 + 06 + 04 + 06 = 44 Credits</b>				
Exit option: <i>Award of UG Degree in Major and Minor with 132 credits OR continue with Major &amp; Minor</i>				

### B. Sc. Program in Chemistry: Cumulative Credit Structure

Level	Sem.	MAJOR		MINOR	VSC	OJT / FP	Cum. Credits	Degree
		Mandatory*	Electives Anyone					
5.5	Sem-V	For Chemistry						
		<b>Credits 10 (4+4+4+2)</b> Course 1 Cr. 2: Physical Chemistry-I Course 2 Cr. 2: Inorganic Chemistry-I Course 3 Cr. 2: Organic Chemistry-I Course 4 Cr. 2: Analytical Chemistry-I Course 5 Cr. 2: Practical (Practical Based on all Papers)	<b>Credits 4 (2+2)</b> Course 1 Cr. 2: Industrial Chemistry- I & Course 2 Cr. 2: Practical (Micro scale Preparation and Estimations OR Course 1 Cr. 2: Medicinal and Green Chemistry & Course 2 Cr. 2: Practical (Micro scale Preparation and Estimations	<b>Credits 4 (2+2)</b> Course 1: Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - I & Course 2: Cr. 2: Practical	<b>Credits 2</b> Practical	<b>Credits 2</b>	<b>22</b>	<b>UG Degree After 3-Yr UG</b>

	<b>Sem-VI</b>	<b>For Chemistry</b>					
		<b>Credits 10 (4+4+4)</b>	<b>Credits 4 (2+2)</b>	<b>Credits 2</b>	<b>Credits 2</b>	<b>Credits 4</b>	<b>22</b>
		Course1 Cr.2: Physical Chemistry-II	Course1 Cr. 2:Industrial Chemistry-II	Course 1: Cr. 2:	Practical		
		Course 2 Cr.2: Inorganic Chemistry-II	&	Modern Chemistry:			
		Course 3 Cr.2: Organic Chemistry-II	Course 2 Cr. 2: Practical (Micro scale	Theory, Reactions, and Techniques - II			
		Course 4 Cr.2: Analytical Chemistry-II	Preparation and Estimations OR				
		Course 5Cr.2: Practical (Practical Based on all Papers)	Course 1 Cr. 2: Chemistry of Dyestuffs and Green Chemistry &				
			Course 2 Cr. 2: Practical (Micro scale				
			Preparation and Estimations				
<b>Total Credits</b>		<b>20</b>	<b>08</b>	<b>06</b>	<b>04</b>	<b>06</b>	<b>44</b>

## Programme Educational Objectives

<b>PEO1</b>	<b>Academic and Professional Excellence</b> Graduates will pursue higher education or professional careers in science and related fields, demonstrating a strong foundation in scientific principles and practices.
<b>PEO2</b>	<b>Research and Innovation</b> Graduates will engage in scientific research, innovation, or industry-based projects, contributing effectively to advancements in science and technology.
<b>PEO3</b>	<b>Ethical and Social Responsibility</b> Graduates will uphold ethical standards and social responsibilities, applying scientific knowledge to address societal and environmental challenges.
<b>PEO4</b>	<b>Experimental and Data Analysis Proficiency</b> Understanding of experimentation, observation and data analysis suitable for any industry
<b>PEO5</b>	<b>Career Readiness and Opportunities</b> Graduates with a B Sc degree in various disciplines of science are equipped to pursue careers in research, industry, academia, and other fields, with opportunities to work in renowned institute

## Programme Outcomes

<b>PO1</b>	<b>Foundational Knowledge</b> Develop a solid scientific foundation to enable graduates to pursue advanced academic programs or careers in research, education, and industry.
<b>PO2</b>	<b>Critical Thinking and Problem-Solving</b> Students develop methodical thinking skills, enabling them to analyze problems, draw logical conclusions, and develop innovative solution
<b>PO3</b>	<b>Practical and Professional Skills</b> Through hands-on experiments, industry collaborations, and expert guidance, students acquire practical skills, preparing them for careers in scientific research, industry, and other fields.
<b>PO4</b>	<b>Scientific Temper and Research Orientation</b> This program fosters a scientific temperament, encouraging students to think critically, evaluate evidence, and contribute to scientific advancements, ultimately benefiting society and the nation.
<b>PO5</b>	<b>Use of Modern Tools</b> Use appropriate laboratory instruments, software, and modern IT tools for scientific investigations with an understanding of limitations
<b>PO6</b>	<b>Scientific Communication Skills Development</b> Students develop the ability to effectively communicate scientific information in written and oral formats.

## Programme Specific Outcomes

Upon successful completion of the B.Sc. (Chemistry) course from Vaze College (Autonomous), graduates can expect the following outcomes:

<b>PSO1</b>	Gain the knowledge of Chemistry through theory and practical.
<b>PSO2</b>	To understand various laws, concepts, formulae and develop problem solving skills in Chemistry.
<b>PSO3</b>	Get to know and understand the topics of three different branches of chemistry, viz. organic, inorganic and physical chemistry in a more detailed and broader way.
<b>PSO4</b>	To explain nomenclature, stereochemistry, structures, reactivity, and mechanism of the chemical reactions.

<b>PSO5</b>	Create an intellectual curiosity and ability to think in a scientific manner and get sensitized to social and environmental realities.
<b>PSO6</b>	Apply laboratory skills, carry out experiments, record observations and inferences and analyze the results.
<b>PSO7</b>	Understand good laboratory practices and safety.

**The Detailed Semester and Course Wise Syllabus as follows:**

The total minimum credits required for completing the B.Sc. in Chemistry is **132**

<b>SEMESTER - V</b>					
<b>Code</b>	<b>Course of Study - Major</b>	<b>L/ hrs</b>	<b>T</b>	<b>P</b>	<b>Cr.</b>
	Course 1 Cr. 2: Physical Chemistry-I	2	-	-	2
	Course 2 Cr. 2: Inorganic Chemistry-I	2	-	-	2
	Course 3 Cr. 2: Organic Chemistry-I	2	-	-	2
	Course 4 Cr. 2: Analytical Chemistry-I	2	-	-	2
	Course 5 Cr. 2: Practical (Practical Based on all Papers)	4	-	2	2
	<b>Electives</b>				
	Course 1 Cr. 2: Industrial Chemistry- I	2	-	-	2
	Course 2 Cr. 2: Practical (Micro scale Preparation and Estimations	4	-	2	2
	Course 3 Cr. 2: Medicinal and Green Chemistry	2	-	-	2
	Course 4 Cr. 2: Practical (Micro scale Preparation and Estimations	4	-	2	2
	<b>MINOR Credits 4 (2+2)</b>				
	Course 1 Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - I	2	-	-	2
	Course 2 Cr. 2: Practical	4	-	2	2
	<b>VSC (Advanced Experimental Chemistry) Credits 2</b>				
	Course 1 Cr. 2: Practical	4	-	2	2
	<b>FP Credits 2</b>				
	Course 1 Cr. 2: Practical	-	-	4	2
	<b>Total</b>	<b>34</b>	<b>-</b>	<b>14</b>	<b>22</b>

**\*\*\*\*\* Note:** Students are allowed to select one elective out of two electives given in curriculum

<b>SEMESTER - VI</b>					
<b>Code</b>	<b>Course of Study - Major</b>	<b>L/ hrs</b>	<b>T</b>	<b>P</b>	<b>C</b>
	Course 1 Cr. 2: Physical Chemistry-II	2	-	-	2
	Course 2 Cr. 2: Inorganic Chemistry-II	2	-	-	2
	Course 3 Cr. 2: Organic Chemistry-II	2	-	-	2
	Course 4 Cr. 2: Analytical Chemistry-II	2	-	-	2
	Course 5 Cr. 2: Practical (Practical Based on all Papers)	4	-	2	2
	<b>Electives</b>				
	Course 1 Cr. 2: Industrial Chemistry- II	2	-	-	2
	Course 2 Cr. 2: Practical (Micro scale Prepn. & Estimation)	4	-	2	2
	Course 3 Cr. 2: Chemistry of Dye stuffs and Green Chemistry	2	-	-	2
	Course 4 Cr. 2: Practical (Micro scale Prepn. & Estimation)	4	-	2	2
	<b>MINOR Credits 2</b>				

Course 1 Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - II	2	-	-	2
<b>VSC</b> (Hands-on Advanced Laboratory Techniques: Synthesis, Analysis, and Sustainable methods) <b>Credits 2</b>				
Course 1 Cr. 2:Practical	4	-	2	2
<b>OJTCredits 4</b>				
Course 1 Cr. 2:Practical	-	-	8	4
	<b>30</b>	-	<b>16</b>	<b>22</b>

\*\*\*\*\* **Note:** Students are allowed to select one elective out of two electives given in curriculum

**Semester – V**  
**Paper I**  
**Course Code: VSCH300**  
**Credits: 2**  
**Physical Chemistry-I**

**Learning Objectives:**

On studying the syllabus, the learner will be able to

1. Differentiate between various branches of spectroscopy.
2. To study the concept of dipole moment and polarization.
3. Understand the basic terminologies used in vibration spectroscopy such as degree of freedom, vibrational modes, spectrum of diatomic molecules.
4. To study the simple harmonic oscillator, energy level, zero-point energy and selection rule of vibrational spectroscopy.
5. To study the application of vib-rot spectroscopy and also to analyze the IR spectra of some molecules.
6. Interpret various thermodynamic properties and their determination.
7. To understand the concept of entropy and third law of thermodynamics.
8. Elaborate the knowledge of Elevation in boiling point, Depression in freezing point along with their derivation.
9. To understand the kinetics of different reactions such as opposing, parallel, and consecutive reactions.
10. To recognize the importance of catalysis Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation).
11. To study the concept of physical and chemical adsorption.
12. Elaborate the knowledge of colloidal state, colloidal electrolytes and surfactants.

**Course Outcome**

Upon completing the course, the student will be able to understand

<b>CO1</b>	<b>Understand the concept of spectroscopic techniques including molecular, rotational vibrational, Raman and Electronic spectroscopy.</b>
<b>CO2</b>	<b>To comprehend the concepts of chemical thermodynamics and chemical kinetics.</b>
<b>CO3</b>	<b>To illustrate the importance of surface chemistry and colloidal state.</b>
<b>CO4</b>	<b>To gain the knowledge of colloidal electrolytes and surfactants.</b>

## COURSE CONTENT

Unit	Contents	No. of lectures
<b>Unit I</b>	<b>Molecular Spectroscopy</b>	
<b>1.1</b>	<p><b>1.1.1</b> Introduction to dipole moment, polarization of a bond, bond moment, molecular structure</p> <p><b>1.1.2 Vibrational spectrum:</b> Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero-point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum.</p> <p><b>1.1.3 Vibrational-Rotational spectrum of diatomic molecule:</b> Energy levels, selection rule, nature of spectrum, P and R branch lines. Anharmonic oscillator-energy levels, selection rule, fundamental band, overtones. Application of vibrational-rotational spectrum in determination of force constant and its significance. Infrared spectra of simple molecules like H<sub>2</sub>O and CO<sub>2</sub>.</p> <p><b>1.1.4 Raman Spectroscopy</b> Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum, Stoke's lines, anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion- CO<sub>2</sub> molecule.</p> <p><b>1.1.5 Electronic spectroscopy:</b> Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and pre-dissociation, calculation of electronic transitions of polyenes using free electron model.</p>	<b>10</b>
<b>Unit II</b>	<b>Chemical Thermodynamics and Chemical kinetics</b>	
<b>2.1</b>	<p><b>2.1.1</b> Recapitulation of entropy. Exact and in-exact differentials, partial derivatives, Euler's reciprocity, cyclic rule; Third law of thermodynamics and its applications</p> <p><b>2.1.2 Colligative properties Of Dilute Solution:</b> Vapor pressure and relative lowering of vapour pressure. Measurement of lowering of vapour pressure – Static and Dynamic method.</p>	<b>03</b>
<b>2.2</b>	<p><b>Solutions of Solid in Liquid:</b></p> <p><b>2.2.1</b> Elevation in boiling point of a solution, thermodynamic derivation relating elevation in boiling point of the solution and molar mass of non-volatile solute. Depression in freezing point of a solution, thermodynamic. Derivation relating the depression in the freezing point of a solution and the molar mass of the non-volatile solute. Beckmann Method.</p> <p><b>2.2.2 Osmotic Pressure:</b> Introduction, thermodynamic derivation of Van't Hoff equation, Van't Hoff Factor, Reverse Osmosis. Measurement of osmotic pressure by Barkeley and Hartley method. Determination of molecular mass from osmotic pressure.</p>	<b>04</b>

2.3	<p><b>Chemical Kinetics</b></p> <p><b>2.3.1 Collision theory of reaction rates:</b></p> <p>Kinetics of opposing, parallel, and consecutive reactions; Steady state approximation in reaction mechanisms;</p> <p>Application of collision theory to</p> <ol style="list-style-type: none"> <li>1. Uni-molecular reaction Lindemann theory and</li> <li>2. Bimolecular reaction. (derivation expected for both)</li> </ol> <p><b>2.3.2 Catalysis:</b></p> <p>Recapitulation of catalysis Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)</p>	03
Unit III	<b>Surface Chemistry</b>	07
3.1	<p><b>3.1.1 Adsorption:</b> Physical and Chemical Adsorption, types of adsorption isotherms. Langmuir's adsorption isotherm (Postulates and derivation expected). B.E.T. equation for multilayer adsorption, (derivation not expected). Determination of surface area of an adsorbent using B.E.T. equation.</p> <p><b>3.1.2 Surface Chemistry and catalysis:</b> Bimolecular surface reactions: reaction between a gas molecule and an adsorbed molecule, reaction between two adsorbed molecules, inhibition and activation energy of such reactions, catalytic activity at surfaces (volcano curve), transition state theory of surface reactions, rates of chemisorption and desorption, unimolecular and bimolecular surface reactions,</p> <p><b>3.1.3 Colloidal State</b></p> <p><b>Introduction to colloids-</b> Emulsions, Gels and Sols</p> <p><b>Electrical Properties:</b></p> <p>Origin of charges on colloidal particles, Concept of electrical double layer, zeta potential, Helmholtz and Stern model. Electro-kinetic phenomena- Electrophoresis, Electro-osmosis, Streaming potential, Sedimentation potential; Donnan Membrane equilibrium</p> <p><b>3.1.4 Colloidal electrolytes:</b> Introduction, micelle formation,</p> <p><b>3.1.5 Surfactants:</b> Classification and applications of surfactants in detergents and food industry.</p>	

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**Reference Books:**

1. Physical Chemistry, Ira Levine, 5<sup>th</sup> Edition, 2002 Tata McGraw Hill Publishing Co. Ltd.
2. Physical Chemistry, P.C. Rakshit, 6<sup>th</sup> Edition, 2001, Sarat Book Distributors, Kolkata.
3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3<sup>rd</sup> edition, John Wiley & Sons, Inc [part 1]
4. Physical Chemistry, G. Castellan, 3<sup>rd</sup> edition, 5<sup>th</sup> Reprint, 1995 Narosa Publishing House.
5. Modern Electrochemistry, J.O. M Bockris & A.K.N. Reedy, Maria Gamboa – Aldeco 2<sup>nd</sup> Edition, 1<sup>st</sup> Indian reprint, 2006 Springer
6. Fundamental of Molecular Spectroscopy, 4<sup>th</sup> Edn., Colin N Banwell and Elaine M Mc Cash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 2008.

7. Physical Chemistry, G.M. Barrow, 6<sup>th</sup> Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
8. The Elements of Physical Chemistry, P.W. Atkins, 2<sup>nd</sup> Edition, Oxford University Press Oxford.
9. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt. Ltd. New Delhi.
10. Principles of Physical Chemistry B. R. Puri, L. R. Sharma, M. S. Pathania, VISHAL PUBLISHING Company, 2008.
11. Chemical Kinetics, K. Laidler, Pearson Education India, 1987

**Semester – V**  
**Paper II**  
**Course Code: VSCH301**  
**Credits: 2**  
**Inorganic Chemistry-I**

### Learning Objectives

Upon completion of the course the student will be able to,

- Discuss the symmetry elements present in a molecule and assign the point group for the molecule. Draw Molecular orbital Diagram of triatomic (AB<sub>2</sub>) molecules and explain their shapes with the help of Walsh Correlation diagrams.
- Discuss electrical properties of conductors, semiconductors based on Band Theory.
- Understand the different types of packing in solids, stoichiometric defects in solids
- Discuss superconductivity. types of superconductors and their applications.
- Discuss the properties of aqueous, non-aqueous solvent, protic and aprotic solvent and memorize application of non-aqueous solvents
- Write the electronic configuration of group 16 elements, recollect the preparation of H<sub>2</sub>SO<sub>4</sub> by contact process, recite application of H<sub>2</sub>SO<sub>4</sub>, and understand catalysis in V<sub>2</sub>O<sub>5</sub> and platinised asbestos.
- Understand the unusual position of inner transition elements, describe the solvent extraction, ion exchange methods used for separation of lanthanides.

### Course Outcome

Upon completing the course, the student will be able to

<b>CO1</b>	Understand the concept of symmetry elements, symmetry operations and point groups, MOT, band theory and can explain applications of MOT as well as can explain electrical properties of semiconductors and conductors.
<b>CO2</b>	The learner can explain physical properties and trends in Lanthanides. Can explain magnetic and spectral properties.
<b>CO3</b>	The Concept of defects to understand various properties. Understand super capacitors with the working and application.
<b>CO4</b>	Learner understands concept of non-aqueous solvents and their importance to carry out several chemical reactions, concept of allotropy, physicochemical principles involved in manufacture of H <sub>2</sub> SO <sub>4</sub> .

## COURSE CONTENT

Unit	Contents	No. of lectures
<b>Unit I</b>	<b>Molecular Symmetry and Chemical Bonding</b>	
<b>1.1</b>	<b>Molecular Symmetry</b> <b>1.1.1</b> Introduction and Importance of symmetry in Chemistry <b>1.1.2</b> Symmetry elements and symmetry operations <b>1.1.3</b> Concept of a point group with illustrations using the following point groups: i) $C_{\infty v}$ ii) $D_{\infty h}$ iii) $C_{2v}$ iv) $C_{3v}$ v) $C_{2h}$ vi) $D_{3h}$	<b>04</b>
<b>1.2</b>	<b>Molecular Orbital Theory</b> <b>1.2.1</b> Polyatomic species LCAO –MO for triatomic species: $H_3^+$ and $H_3$ (correlation between Bond angle and Molecular orbitals) <b>1.2.2</b> Molecular orbital approach for bonding in $AB_2$ molecules. Application of symmetry concepts for linear and angular species considering $\sigma$ bonding only. Examples $BeH_2$ and $H_2O$ (Terms such as Walsh correlation diagram, Symmetry Adapted Linear Combinations (SALC's) Ligand Group Orbitals (LGOs), transformation of atomic orbitals into appropriate symmetry types expected to be discussed.	<b>04</b>
<b>1.3</b>	<b>Metallic bonding</b> Band theory, Explanation of electrical properties of conductors, insulators, semiconductors, extrinsic and intrinsic semiconductor.	<b>02</b>
<b>Unit II</b>	<b>Solid State Chemistry and Superconductivity</b>	
<b>2.1</b>	<b>Structure of Solids.</b> <b>2.1.1</b> Explanation of terms, viz., crystal lattice, lattice points, unit cells and lattice constants <b>2.1.2</b> Closest packing of rigid spheres (hcp, ccp) , packing density in simple cubic, bcc, fcc and hcp lattices. (Numerical problems expected). Relationship between density of unit cell, lattice parameters (Numerical problems expected). <b>2.1.3</b> Stoichiometric Point defects in Solids: Discussion on Frenkel and Schottky defects expected.	<b>06</b>
<b>2.2</b>	<b>Superconductivity.</b> <b>2.2.1</b> Discovery of Superconductivity <b>2.2.2</b> Explanations of terms like superconductivity, transition temperature, Meissner effect <b>2.2.3</b> Different types of Superconductors viz, conventional Superconductors, alkali metal fullerenes, High temperature Superconductors <b>2.2.4</b> Brief applications of superconductors	<b>04</b>
<b>Unit III</b>	<b>Some Selected Topics</b>	
<b>3.1</b>	<b>Chemistry of Non- Aqueous Solvents.</b> <b>3.1.1</b> Classification of solvents and importance of non-aqueous solvents. Characterization and study of $Liq. NH_3$ as a non- aqueous solvent with respect to i) Acid base reactions and ii) redox reactions.	<b>05</b>
<b>3.2</b>	<b>Comparative Chemistry of Group 16.</b> <b>3.2.1</b> Electronic configurations, trends in physical properties, allotropy. Manufacture of sulphuric acid by contact process. Impact of $H_2SO_4$ on environment.	<b>03</b>

<b>3.3</b>	<p>Chemistry of Inner Transition Elements</p> <p><b>3.3.1</b> Introduction: Position in the periodic table and electronic configuration of Lanthanides and actinides.</p> <p><b>3.3.2</b> Occurrence Extraction and Separation of Lanthanides by i) Solvent Extraction ii) Ion exchange method.(Principles and Techniques).</p>	<b>02</b>
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**References:**

1. Cotton, Wilkinson, Murillo and Bochmann, Advanced Inorganic Chemistry, 6th Edition.
2. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993
3. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press
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9. Basolo, F, & Pearson, R.C., Mechanisms of Inorganic Chemistry, John Wiley & Sons, NY
10. R. Gopalan , V. Ramalingam Concise Coordination Chemistry ,Vikas Publishing House
11. Satya Prakash, G.D.Tuli, R.D. Madan , Advanced Inorganic Chemistry. S. Chand & Co Ltd
12. Lesley E. Smart, Elaine A. Moore Solid State Chemistry: An Introduction, 2nd Edition CRC Press,
13. C. N. R. Rao Advances in Solid State Chemistry
14. Ram Charan Mehrotra, Organometallic Chemistry: A Unified Approach, New Age International
15. Inorganic Chemistry. Shriver & Atkins, 5<sup>th</sup> Edition, Oxford University Press.
16. Principles of Inorganic Chemistry. Puri, Sharma & Kalia, Milestone Publisher.
17. Inorganic Chemistry. Catherine Housecroft & Alan G. Sharp, 3<sup>rd</sup> Edition, Pearson Publisher.
18. Principles of Inorganic Chemistry. Puri, Sharma & Kalia, Milestone Publisher.
19. The Organometallic Chemistry: a unified approach. R. C. Mehrotra, New Age International.
20. The Organometallic Chemistry of Transition Metals. Robert H. Carbtree, John Wiley Publisher.
21. Advanced Inorganic Chemistry. Cotton, Wilkinson, Murillo & Bochmann, 6<sup>th</sup> Edition, John Wiley Publisher.
22. Vogel's Textbook of Quantitative Chemical Analysis. G. H. Jeffery, J. Basset, Longman Scientific & Technical John Wiley & Sons Publisher.
23. Vogel's Qualitative Inorganic Analysis. 7<sup>th</sup> Edition. Revised by G. Svehla, Pearson Publisher.
24. Practical Inorganic Chemistry, V. I. Spitsyn, MIR Publisher, Moscow

**Semester – V**  
**Paper III**  
**Course Code: VSCH302**  
**Credits: 2**  
**OrganicChemistry-I**

**Learning Objectives**

Upon completion of the course the student will be able to understand

- To identify the different organic reactions mechanisms and write the expected reaction products based on the type of reaction.
- To introduce students to basic photochemistry and photochemical reactions involving carbonyl compounds and olefins.
- To identify the symmetry elements in organic compounds and the optical activity of substituted cummulenes and biphenyls.
- To predict the stereochemical outcome of nucleophilic substitution and electrophilic addition reactions.
- To write the IUPAC nomenclature of given compound and draw the structure of compounds corresponding to a given IUPAC name.
- To expose the students to the principles of Green Chemistry, Principle and applications of Microwave and Ultrasound assisted Organic synthesis and their comparison with conventional methods.
- To familiarize students with the concept of retrosynthesis and designing of organic synthesis from simple starting compounds
- To learn about basic concept of UV, IR, NMR and Mass spectroscopy and their application in structure determination of organic compounds.

**Course Outcome**

Upon completing the course, the student will be able to understand

<b>CO1</b>	The basics of reaction mechanism, the mechanistic concepts and photo induced electron transfer and excitation energy transfer,
<b>CO2</b>	Understand the various types of rearrangement reactions and Determine the structure of organic compounds by analysing their spectral data.
<b>CO3</b>	The Concept of Pericyclic reactions and their applications
<b>CO4</b>	Predict the mechanism and stereochemical outcome of nucleophilic substitution reactions and electrophilic addition reactions.

## COURSE CONTENT

Unit	Contents	No. of lectures
Unit I	<p><b>Mechanism of organic reactions</b></p> <p><b>1.1.1</b> The basic terms &amp; concepts: bond fission, reaction intermediates, electrophiles &amp; nucleophiles, ligand, base, electrophilicity vs. acidity &amp; nucleophilicity vs basicity.</p> <p><b>1.1.2</b> Neighboring group participation in nucleophilic substitution reactions: participation of lone pair of electrons, kinetics and stereochemical outcome.</p> <p><b>1.1.3</b> Acyl nucleophilic substitution (Tetrahedral mechanism): Acid catalyzed esterification of carboxylic acids (AAC2) and base promoted hydrolysis of esters (BAC2).</p> <p><b>1.1.4</b> Pericyclic reactions, classification and nomenclature</p> <p><b>1.1.4.1</b> Electrocyclic reactions (ring opening and ring closing), cycloaddition, sigmatropic Rearrangement, group transfer reactions, cheletropic reaction (definition and one example of each type)</p> <p><b>1.1.4.2</b> Pyrolytic elimination: Cope, Chugaev, pyrolysis of acetates</p>	<b>07</b>
	<p><b>1.2 Photochemistry</b></p> <p><b>1.2.1</b> Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triplet states, allowed and forbidden transitions, fate of excited molecules, photosensitization.</p> <p><b>1.2.2</b> Photochemical reactions of olefins: photoisomerization, photochemical rearrangement of 1,4-dienes (di-<math>\pi</math> methane)</p> <p><b>1.2.3</b> Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages. Photo reduction (e.g. benzophenone to benzpinacol)</p>	<b>03</b>
Unit II	<p><b>2.1 Stereochemistry I</b></p> <p><b>2.1.1</b> Molecular chirality and elements of symmetry: Mirror plane symmetry, inversion center, rotation-reflection (alternating) axis.</p> <p><b>2.1.2</b> Chirality of compounds without a stereogenic center: cummulenes and biphenyls.</p> <p><b>2.2 Stereochemistry II</b></p> <p><b>2.2.1</b> Stereoselectivity and stereospecificity: Idea of enantioselectivity (ee) and diastereoselectivity (de), Topicity: enantiotopic and diastereotopic atoms, groups and faces.</p> <p><b>2.2.2</b> Stereochemistry of :</p> <ol style="list-style-type: none"><li>Substitution reactions: <math>S_Ni</math> (reaction of alcohol with thionyl chloride)</li><li>Elimination reactions: <math>E_2</math>-Base induced dehydrohalogenation of 1-bromo-1,2-diphenylpropane.</li><li>Addition reactions to olefins:<ol style="list-style-type: none"><li>bromination (electrophilic anti addition)</li><li>syn hydroxylation with <math>OsO_4</math> and <math>KMnO_4</math></li></ol></li></ol> <p>c) epoxidation followed by hydrolysis.</p>	<b>05</b> <b>05</b>

<b>Unit III</b>	<p><b>Spectroscopy</b></p> <p><b>3.1</b> Introduction: Electromagnetic spectrum, units of wavelength and frequency</p> <p><b>3.2</b> UV visible spectroscopy: Basic theory, allowed and forbidden transitions, selection Rule, concept of chromophore, auxochrome, bathochromic and hypsochromic shifts, hyperchromic and hypochromic effects, chromophore-chromophore interactions and chromophore–auxochrome interactions; Woodward Fieser Rules for calculation of <math>\lambda_{\text{max}}</math> of simple polyenes.</p> <p><b>3.3</b> IR spectroscopy: Basic theory, selection rule, fingerprint region and functional group region, characteristic IR peaks for different functional groups.</p> <p><b>3.4</b> PMR spectroscopy: Basic theory of PMR, Internal standard, solvents chemical shift, factors affecting chemical shift, spin-spin coupling and coupling constant, Exchangeable protons, application of PMR in structure determination.</p> <p><b>3.5</b> Mass spectrometry: Basic theory, molecular ion peak and base peak and their importance, isotopic peaks, Nitrogen rule, rule of 13 for determination of empirical formula and molecular formula, fragmentation of alkanes, alkenes and aliphatic carbonyl compounds including McLafferty rearrangement.</p> <p><b>3.6</b> Problems of structure elucidation of simple organic compounds using individual or combined use of UV-VIS, IR, PMR and Mass spectral data.</p>	<b>10</b>
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#### References:

1. A guidebook to mechanism in Organic Chemistry, 6th edition, Peter Sykes, Pearson education, New Delhi
2. Organic Reaction Mechanism, 4th edition, V. K. Ahluwalia, R. K. Parashar, Narosa Publication.
3. Organic reactions & their mechanisms, 3<sup>rd</sup> revised edition, P.S. Kalsi, New Age International Publishers.
4. M. B. Smith and J. March, Advanced organic chemistry- reactions mechanism and structure, 5th edition.
5. Organic Chemistry, 7th Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.
6. Organic chemistry, 8th edition, John Mc Murry
7. L. Eliel, stereochemistry of carbon compounds, Tata McGraw Hill
8. Stereochemistry P.S.Kalsi, New Age International Ltd., 4th Edition
9. Stereochemistry by Nassipuri.
10. Nomenclature of Organic Chemistry: IUPAC recommendations and preferred Names 2013, RSC publication.
11. IUPAC nomenclature by S. C. Pal.
12. Green chemistry an introductory text : Mike Lancaster
13. Green chemistry: V. K. Ahluwalia (Narosa publishing house pvt. ltd.)
14. Green chemistry: V. K. Ahluwalia (Narosa publishing house pvt. ltd.)
15. Green chemistry an introductory text: RSC publishing.
16. New trends in green chemistry V. K. Ahluwalia, M. Kidwai, Klumer Academic publisher
17. Green chemistry by V. Kumar.
18. Organic chemistry: Francis Carey
19. Organic chemistry: Carey and Sundberg.
20. Organic Synthesis: The Disconnection Approach 2nd Edition, Wiley, by Stuart Warren, Paul Wyatt

21. Organic spectroscopy (Second edition), Jag Mohan, Narosa publication
22. Spectroscopy, Pavia, Lampman, Kriz, Vyvyan.
23. Elementary organic spectroscopy (Third edition), Y.R.Sharma, S.Chand publication.
24. Introduction to spectroscopy (third edition), Pavia, Lampman, Kriz, John von Delinger, Emily Barrosse.
25. Organic Chemistry Paula Y. Bruice, Pearson education.
26. Spectral identification of organic molecules by Silverstein.
27. Absorption spectroscopy of organic molecules by V.M.Parikh.

**Semester – V**  
**Paper IV**  
**Course Code: VSCH303**  
**Credits: 2**  
**Analytical Chemistry-I**

**Learning Objectives:**

The primary objective of this course is to acquire basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical mind set and the ability to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results. On successful completion of this course, students will be able

- ❖ To introduce basic analytical techniques and practical aspects of classical chemical analysis.
- ❖ To establish an appreciation of the role of chemistry in quantitative analysis
- ❖ To provide an understanding of chemical methods employed for elemental and compound analysis.
- ❖ To provide experience in some scientific methods employed in analytical chemistry.

**Course Outcomes (COs):**

**CO-1: Explain the principles and instrumentation of classical analytical techniques** (precipitation titrations, complexometric titrations, fluorescence, phosphorescence, turbidimetry, and nephelometry).

**CO-2: Evaluate the factors influencing fluorescence and phosphorescence spectroscopy**, such as quenching, solvent effects, and molecular structure, to optimize analytical results.

**CO-3: Interpret experimental data, identify interferences, and implement corrective measures** to enhance accuracy and precision in classical analytical techniques.

**CO-4: Compare and justify the selection of appropriate analytical techniques** based on sensitivity, selectivity, and applicability for real-world chemical analysis.

**COURSE CONTENT**

UNIT	TOPICS	No. of lectures
<b>UNIT I : Fundamentals of Quality Management in Chemical Sciences</b>		
1.1	<b>Introduction to Quality Management</b> <b>1.1.1 Fundamentals of Quality Management</b> Definition and importance of quality in chemical industries Key quality concepts: QA, QC, Total Quality Management (TQM), Good Manufacturing Practices (GMP) Quality vs. productivity: Striking the right balance <b>1.1.2 Evolution of Quality Standards</b> Historical development of quality management Contributions of Deming, Juran, and Crosby Importance of international standards: ISO 9001, ISO 17025	<b>02</b>

1.2	<p><b>Quality Assurance &amp; Quality Control in Chemical Sciences</b></p> <p><b>1.2.1 Quality Assurance (QA) Principles</b>  Definition and scope of QA  Role of documentation and standard operating procedures (SOPs)  Key elements: validation, calibration, and qualification</p> <p><b>1.2.2 Quality Control (QC) in Chemical Processes</b>  Difference between QA and QC  QC techniques in laboratories and manufacturing  Sampling methods, test validation, and data integrity</p> <p><b>1.2.3 Statistical Quality Control</b>  Concept of variability in chemical processes  Statistical Process Control (SPC) tools: Control charts, process capability analysis  Application of Six Sigma in chemical industries</p>	03
1.3	<p><b>Regulatory &amp; Compliance Aspects</b></p> <p><b>1.3.1 Good Manufacturing Practices (GMP) and GLP</b>  Overview of GMP and Good Laboratory Practices (GLP)  Role of regulatory agencies: FDA, WHO, ICH, and EPA  Compliance challenges in the chemical and pharmaceutical industries</p> <p><b>1.3.2 Audits &amp; Quality Risk Management</b>  Types of quality audits: Internal vs. external audits  Risk management principles (ICH Q9)  Corrective and Preventive Actions (CAPA)</p>	02
1.4	<p><b>Case Studies &amp; Industry Applications</b></p> <p><b>1.4.1 Case Studies in Chemical and Pharmaceutical Industries</b>  Notable quality failures and lessons learned (e.g., thalidomide tragedy, Heparin contamination)  Continuous improvement strategies</p> <p><b>1.4.2 Quality in Analytical Laboratories</b>  Importance of accuracy, precision, and reproducibility  Role of laboratory accreditation and ISO 17025</p> <p><b>1.4.3 Future Trends in Quality Management</b>  Digital transformation in quality management (AI, big data)  Industry 4.0 and smart quality control  Sustainability and green chemistry in quality assurance</p>	03
<b>UNIT II: OPTICAL METHODS</b>		
2.1	<p><b>Introduction to Atomic Spectroscopy</b>  Basic principles of atomic spectroscopy  Types of atomic spectroscopic methods  Comparison of emission, absorption, and fluorescence spectroscopy</p>	01

2.2	<p><b>Flame Emission Spectroscopy (FES)</b></p> <p><b>2.2.1 Principle of Flame Emission Spectroscopy</b>  Excitation of atoms in the flame  Emission of characteristic radiation  Relationship between emission intensity and concentration</p> <p><b>2.2.2 Instrumentation of FES</b>  Radiation source (flame as an excitation source)  Monochromator and wavelength selection  Detector and signal processing</p> <p><b>2.2.3 Applications of Flame Emission Spectroscopy</b>  Determination of alkali and alkaline earth metals (Na, K, Ca, Li)  Clinical and environmental analysis  Agricultural and food analysis</p> <p><b>2.2.4 Limitations of FES</b>  Interference (spectral, ionization, chemical)  Sensitivity and detection limits</p>	03
2.3	<p><b>Atomic Absorption Spectroscopy (AAS)</b></p> <p><b>2.3.1 Principle of Atomic Absorption Spectroscopy</b>  Absorption of specific wavelengths by ground-state atoms  Beer-Lambert's law and its application  Relationship between absorbance and concentration</p> <p><b>2.3.2 Instrumentation of AAS</b>  Radiation source (Hollow Cathode Lamp, Electrodeless Discharge Lamp)  Atomization methods (Flame Atomization, Graphite Furnace Atomization)  Monochromator and wavelength selection  Detector (Photomultiplier tube, photodiode)</p> <p><b>2.3.3 Applications of AAS</b>  Environmental monitoring (heavy metal analysis in water, soil)  Clinical and pharmaceutical analysis (trace metal detection in biological samples)  Food and agricultural analysis</p> <p><b>2.3.4 Advantages and Limitations of AAS</b>  High sensitivity and specificity  Limited to metals and metalloids  Sample preparation requirements</p>	03

2.4	<p><b>Molecular Fluorescence and Phosphorescence Spectroscopy Syllabus</b></p> <p><b>2.4.1 Introduction and Theory of Molecular Fluorescence and Phosphorescence</b>  Comparison of fluorescence, phosphorescence, and other spectroscopic techniques  Jablonski diagram and electronic transitions  Singlet and triplet states</p> <p><b>2.4.2 Instrumentation for Fluorescence and Phosphorescence Spectroscopy</b>  <b>Light sources:</b> Xenon lamps, LED sources, lasers  <b>Monochromators and filters:</b> Grating monochromators, interference filters  <b>Detectors:</b> Photomultiplier tubes (PMTs), charge-coupled devices (CCDs)</p> <p><b>Fluorometers and spectrofluorometers</b></p> <p><b>2.4.3 Factors Affecting Fluorescence and Phosphorescence</b>  Molecular structure and conjugation  Solvent effects and environmental influences  pH and temperature dependence  Quenching mechanisms (dynamic and static quenching)  Concentration effects and self-absorption</p> <p><b>2.4.4 Applications of Fluorescence and Phosphorescence Spectroscopy</b>  <b>Biochemical and clinical applications:</b> DNA/RNA analysis, enzyme assays, medical diagnostics  <b>Environmental analysis:</b> Detection of pollutants and toxins  <b>Pharmaceutical applications:</b> Drug analysis and quality control  <b>Material science applications:</b> Fluorescent dyes and nanomaterials</p>	03
<b>UNIT-III Optical and Separation Techniques in Chemical Analysis</b>		
3.1	<p><b>Optical Techniques – Turbidimetry &amp; Nephelometry</b></p> <p><b>3.1.1 Principles of Light Scattering Techniques</b>  Interaction of light with suspended particles  Basic principles of <b>Turbidimetry and Nephelometry</b>  Factors affecting light scattering (particle size, concentration, wavelength)</p> <p><b>3.1.2 Instrumentation &amp; Working Principles</b>  Light sources, detectors, sample cells  Sensitivity and limitations of both techniques</p> <p><b>3.1.3 Applications in Chemical and Biological Analysis</b>  Environmental monitoring (water quality, air pollution)  Pharmaceutical and biochemical applications</p> <p><b>3.1.4 Comparison with Other Spectroscopic Techniques</b>  Differences between Turbidimetry, Nephelometry, and UV-Vis Spectroscopy</p>	04
3.2	<p><b>Separation Techniques – High-Performance Liquid Chromatography (HPLC)</b></p> <p><b>3.2.1 Introduction to Separation Methods</b>  Importance of separation in chemical analysis  Physical and chemical properties affecting separation</p> <p><b>3.2.2 Principles of High-Performance Liquid Chromatography (HPLC)</b>  <b>Fundamental Concepts</b>  Mobile phase, stationary phase, column packing  Retention time, resolution, and efficiency  <b>Instrumentation</b>  Pump, injector, column, detector, and data system</p> <p><b>3.2.3 Applications of HPLC in Chemical Analysis</b>  <b>Pharmaceutical Analysis</b>  Drug purity, stability testing, bioavailability studies  <b>Environmental Analysis</b>  Detection of pollutants, pesticide residues, and toxins</p>	06

	<b>Food and Beverage Industry</b> Quality control of additives, preservatives, and contaminants <b>3.3.4 Case Studies and Recent Advances</b> Comparative study of HPLC with other chromatographic techniques Advances in <b>Ultra-High-Performance Liquid Chromatography (UHPLC)</b> Automation and software applications in modern HPLC	
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References:

1. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2017). *Fundamentals of Analytical Chemistry*. Cengage Learning.
2. Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A. (1988). *Instrumental Methods of Analysis*. CBS Publishers.
3. Harris, D. C. (2020). *Quantitative Chemical Analysis*. Macmillan Learning.
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6. Meyer, V. R. (2013). *Practical High-Performance Liquid Chromatography*. Wiley.
7. 3000solvedproblemsinChemistry,DavidE. Goldberg,PhD.,Schaums Outline
8. InstrumentalmethodsofAnalysis,byDr SupriyaSMahajan,PopularPrakashanLtd.
9. Qualityin theAnalyticalChemistryLaboratory,  
ElizabethPrichard,NeilT.Crosby,FlorenceElizabethPrichard, John Wiley and Sons, 1995
10. Chemicalmethodsofseparation,JADean,VanNostrand Reinhold, 1969.

## PRACTICALS

### SEMESTER V

#### PHYSICAL CHEMISTRY

COURSE CODE: VSCH304

CREDITS:2

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#### Course Outcome

Upon completing the course, the student will be able to understand

CO1	To study the phase diagram of 3 component systems and to understand the concept of ionic strength and adsorption using various laboratory techniques.
CO2	To understand the determination of surface tension and transition temperature using laboratory techniques.
CO3	To determine solubility product, pka values, velocity constant and dissociation constant using different instruments including potentiometer, conductivity meter and pH meter.

#### Non-Instrumental

1) **Phase rule:**

To study phase diagram of three component system water -chloroform/  
toluene - acetic acid

2) **Chemical Kinetics:**

Investigate the influence of ionic strength of rate constant between potassium per sulphate and potassium iodide.

3) **Surface phenomena:**

To investigate the adsorption of acetic acid on activated charcoal and test the validity of Freundlich adsorption isotherm.

4) **Stalagmometer:**

Determine the surface tension of liquid by stalagmometer method.

5) **Thermochemistry:**

Determine the transition temperature of given substance (sodium sulphate) by thermometric method.

#### Instrumental

6) **Potentiometry**

(1) To determine the solubility product and solubility of AgCl potentiometrically using chemical cell.

(2) Titrate potentiometrically a phosphoric acid solution against NaOH and calculate  $pK_1$ ,  $pK_2$  and  $pK_3$  of the acid.

### 7) Conductometry

To determine the velocity constant of alkaline hydrolysis of ethyl acetate by conductometric method.

### 8) pH-metry

To determine acidic and basic dissociation constant of amino acid and hence to calculate isoelectric point.

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### References:

1. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001
2. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
3. Experiments in Physical Chemistry R.C. Das and B. Behra, Tata McGraw Hill
4. Advanced Practical Physical Chemistry J.B. Yadav, Goel Publishing House
5. Advanced Experimental Chemistry. Vol-II. N. Gurtu and R. Kapoor, S. Chand and Co.
6. Senior Practical Physical Chemistry By: B.D. Khosla, V.C. Garg and A. Gulati, R. Chand and Co.. 2011
7. Systematic experimental physical chemistry Dr. T.K Chondhekar and S.W. Rajbhoj Anjali publications.

## PRACTICALS

### SEMESTER V

#### INORGANIC CHEMISTRY-I

COURSE CODE: VSCH304

CREDITS: 02

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<b>CO: 1</b>	Demonstrate the ability to synthesize transition metal complexes such as tris(ethylenediamine) nickel (II) thiosulphate and tetraamine copper (II) sulphate, followed by their quantitative estimation using appropriate titrimetric methods.
<b>CO: 2</b>	Develop analytical skills to determine the percentage purity of water-soluble salts and qualitatively detect cations and anions using wet chemical tests.
<b>CO: 3</b>	Apply analytical techniques to estimate boric acid content, understanding its properties and role in inorganic chemistry.

#### SEMESTER V:

Inorganic preparations and characterization

- Preparation of tris(ethylenediamine) nickel (II) thiosulphate. (Estimation of nickel complexometric ally)
  - Preparation of tetraamine copper (II) sulphate (Estimation of copper iodometric ally) II. Determination of percentage purity of the given water-soluble salt and qualitative detection w.r.t added cation and/or anion (qualitative analysis only by wet tests). (Any three salts of transition metal ions)
  - Estimation of boric acid
  - Gravimetric Estimation of Barium as Barium Sulphate – Understanding precipitation gravimetry.
- 

#### References:

1. Vogel Textbook of Quantitative Chemical Analysis G.H. Jeffery, J. Basset.
2. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd.
3. Vogel's. Textbook of. Macro and Semimicro qualitative inorganic analysis. Fifth edition.

## PRACTICALS

### SEMESTER V

#### ORGANIC CHEMISTRY-I

COURSE CODE: VSCH304

CREDITS: 02

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#### Learning Objectives:

1. Identify the chemical nature of components in a given binary solid-solid mixture. Select an appropriate separating reagent based on the chemical properties of the mixture components.
2. Perform the separation of binary solid-solid mixtures using recrystallization techniques.
3. Follow the systematic separation scheme with a bulk sample of the binary mixture.
4. Analyse and identify one separated component through melting point determination.
5. Complete the separation and identification process for at least six different binary mixtures.

#### Course Outcomes:

CO 1	Apply systematic analytical techniques to separate and identify components of binary solid-solid mixtures based on their chemical properties.
CO 2	Develop problem-solving skills by selecting appropriate separating reagents and executing separation schemes effectively.
CO 3	Demonstrate proficiency in qualitative analysis through melting point determination and characterization of separated compounds.

#### SEMESTER V: Separation of Binary solid-solid mixture (2.0 g mixture to be given).

- Minimum Six mixtures to be completed by the students.
  - Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols(2-naphthol, 1-naphthol), water insoluble bases (nitroanilines), water soluble neutral (thiourea) and water insoluble neutral compounds (anilides , amides, m-DNB, hydrocarbons)
  - After correct determination of chemical type, the separating reagent should be decided by the student for separation.
  - Follow separation scheme with the bulk sample of binary mixture.
  - After separation into component A and component B, one component (decided by the examiner) is to be analyzed and identified with m.p.
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#### References:

1. Practical organic chemistry – A. I. Vogel
2. Practical organic chemistry – H.Middleton.
3. Practical organic chemistry – O.P.Aggarwal.

## PRACTICALS SEMESTER V

### ANALYTICAL CHEMISTRY

COURSE CODE: VSCH304

CREDITS: 2

#### Learning Objectives:

1. **Spectrophotometric Estimation of Fluoride in Water Samples:** Learn to determine fluoride concentration in water using a colorimetric method with SPADNS or Alizarin Red S reagents.
2. **Complexometric Estimation of Magnesium in Talcum Powder:** Understand how to determine magnesium content in talcum powder via EDTA titration using Eriochrome Black T as an indicator.
3. **Determination of Chemical Oxygen Demand (COD) in Water Samples:** Analyze the level of organic pollutants in water by measuring Chemical Oxygen Demand using the dichromate reflux method.
4. **Quantitative Estimation of Potassium in Fertilizer by Flame Photometry:** Quantify potassium in fertilizers by constructing and applying a calibration curve using flame photometry.
5. **Back Titration Method for Persulfate Determination:** Use the back titration method to quantify persulfate content with Fe(II) ammonium sulfate as a reducing agent and potassium permanganate for titration.
6. **Turbidimetric Determination of Sulfate in Water Samples:** Measure sulfate concentration in water samples by precipitation with barium chloride and nephelometric analysis.
7. **Cyclic Voltammetric Study of Potassium Ferricyanide:** Investigate the electrochemical behavior and redox reactions of  $[\text{Fe}(\text{CN})_6]^{3-}/[\text{Fe}(\text{CN})_6]^{4-}$  using cyclic voltammetry.
8. **Electrochemical Behavior of Ascorbic Acid (Vitamin C):** Study the oxidation of ascorbic acid (Vitamin C) in a phosphate buffer using electrochemical techniques.

#### Course Outcomes:

CO 1: Demonstrate proficiency in classical and instrumental analytical techniques for the quantitative estimation of ions and compounds in real-world samples.

CO 2: Analyze environmental and industrial samples using standard methods to assess water quality and elemental composition.

CO 3: Interpret electrochemical data obtained through cyclic voltammetry to study redox behavior and evaluate electroactive species.

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#### Practical Content

1. **Spectrophotometric Estimation of Fluoride in Water Samples** – Quantitative determination of fluoride using a colorimetric method based on SPADNS reagent or Alizarin Red S.
2. **Complexometric Estimation of Magnesium in Talcum Powder** – Determination of magnesium content using EDTA titration with Eriochrome Black T indicator.
3. **Determination of Chemical Oxygen Demand (COD) in Water Samples** – Analysis of organic pollutant levels using the dichromate reflux method.

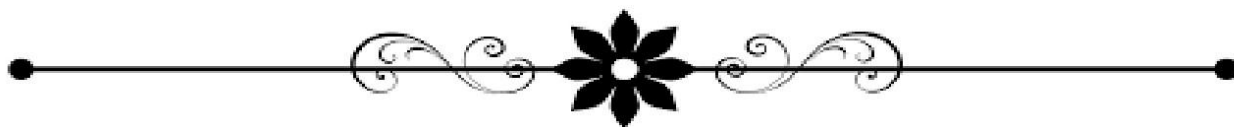
4. **Quantitative Estimation of Potassium in Fertilizer by Flame Photometry** – Calibration curve method using **standard potassium solutions**.
5. **Back Titration Method for Persulfate Determination** – Quantification of persulfate content using **Fe(II) ammonium sulfate as a reducing agent, followed by titration with potassium permanganate**.
6. **Turbidimetric Determination of Sulfate in Water Samples** – Measurement of sulfate concentration using **barium chloride precipitation**.
7. Cyclic Voltammetric Study of Potassium Ferricyanide – Investigation of the  $[\text{Fe}(\text{CN})_6]^{3-}/[\text{Fe}(\text{CN})_6]^{4-}$  reversible redox reaction
8. Electrochemical Behavior of Ascorbic Acid (Vitamin C) – Oxidation of ascorbic acid in phosphate buffer.

Note: Calculation of percent error is expected for all the experiments.

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## References

1. **Vogel, A. I.** (2008). *Vogel's Textbook of Quantitative Chemical Analysis*. Pearson.
  2. **Skoog, D. A., West, D. M., & Holler, F. J.** (2017). *Fundamentals of Analytical Chemistry*. Cengage Learning.
  3. **Christian, G. D.** (2004). *Analytical Chemistry*. John Wiley & Sons.
  4. **Harris, D. C.** (2020). *Quantitative Chemical Analysis*. Macmillan Learning.
- Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A.** (1988). *Instrumental Methods of Analysis*. Wadsworth.



**SEM- VI**  
**Paper I**  
**Course Code: VSCH350**  
**Credits: 2**  
**Physical Chemistry-II**

Learning Objectives:

On studying the syllabus, the learner will be able to:

1. To study the advanced electrochemistry equations like Debye Hückel-Onsager equation.
  2. To discuss the importance of conductance measurement.
  3. To study the basic terminologies of electrochemistry.
  4. To analyze the difference between different cells such as Chemical cells and Concentration cells.
  5. Interpret decomposition potential and overvoltage.
  6. Explain various aspects of advance electrochemistry.
  7. Elaborate the knowledge of polymers.
  8. Classification of different types of polymers.
  9. To introduce the basic concept of quantum chemistry.
  10. To study the instrumentation and principle of electron spin resonance spectroscopy.
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**Course Outcome**

Upon completing the course, the student will be able to understand

<b>CO1</b>	To introduce classification of polymers ,types of molar masses and light emitting polymers
<b>CO2</b>	To know basics of quantum chemistry, concepts of progressive and standing waves, operators and eigenvalues
<b>CO3</b>	Togetbasicsof Nuclear Magneticresonanceandelectronspinresonancespectroscopy
<b>CO4</b>	To introduce various concepts of electrochemistry and applied electrochemistry.

## COURSE CONTENT

Unit	Contents	No. of lectures
<b>Unit I</b>	<b>Electrochemistry</b>	<b>10</b>
<b>1.1</b>	<p>1.1.1 DebyeHückel-Onsager equation; Ionic velocities, mobilities, transference numbers; Applications of conductance measurement; Electromotive force of a cell,</p> <p><b>1.1.2 Activity and Activity Coefficient</b> Lewis concept, ionic strength, Mean ionic activity and mean ionic activity coefficient of an electrolyte, expression for activities of electrolytes. Debye- Huckel limiting law (No derivation).</p> <p><b>1.1.3 Classification of cells</b> Chemical cells and Concentration cells. Chemical cells with and without transference, Electrode Concentration cells, Electrolyte concentration cells with and without transference (derivations are expected),</p> <p><b>1.1.4 Applied Electrochemistry</b> <b>Polarization:</b> Concentration polarization and it's elimination <b>Decomposition Potential and Overvoltage:</b> Introduction, experimental determination of decomposition potential, factors affecting decomposition potential. Tafel's equation for hydrogen overvoltage, experimental determination of over -voltage.</p>	
<b>Unit II</b>	<b>Polymers</b>	<b>10</b>
<b>2.1</b>	<p><b>2.1.1 Basic terms :</b> macromolecule, monomer, repeat unit, degree of polymerization.</p> <p><b>2.1.2 Classification of polymers:</b> Classification based on source, structure, thermal response and physical properties.</p> <p><b>2.1.3 Molar masses of polymers:</b> Number average, Weight average, Viscosity Average molar mass, Mono-dispersity and Poly-dispersity</p> <p><b>2.1.4 Method of determining molar masses of polymers:</b> Viscosity method using Ostwald Viscometer.(derivation expected)</p> <p><b>2.1.5 Light Emitting Polymers:</b> Introduction, Characteristics, Method of preparation and applications.</p> <p><b>2.1.6 Antioxidants and Stabilizers:</b> Antioxidants, Ultraviolet stabilizers, Colourants, Antistatic agents and Curing agents.</p>	
<b>Unit III</b>	<b>Basics of Quantum Chemistry</b>	
<b>3.1</b>	<p><b>3.1.1 Classical mechanics:</b> Introduction, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect.</p> <p><b>3.1.2 Quantum mechanics:</b> Introduction, Planck's theory of quantization, Wave particle duality, de-Broglie's equation, Heisenberg's uncertainty principle.</p> <p><b>3.1.3 Progressive and standing waves-</b>Introduction, boundary conditions, Schrodinger's time independent wave equation (no derivation expected), interpretation and properties of wave function.</p> <p><b>3.1.4 Quantum mechanics</b> State function and its significance, Concept of operators - definition,</p>	<b>07</b>

	addition, subtraction and multiplication of operators, commutative and non - commutative operators, linear operator, Hamiltonian operator, Eigen function and Eigen value.	
<b>3.2</b>	<p><b>Electron Spin Resonance Spectroscopy:</b></p> <p><b>Principle:</b> Fundamental equation, g-value dimensionless constant or electron g-factor, hyperfine splitting.</p> <p><b>Instrumentation:</b> ESR spectrometer, ESR spectrum of hydrogen and deuterium.</p>	<b>03</b>

#### References:

1. Physical Chemistry, Ira Levine, 5<sup>th</sup> Edition, 2002 Tata McGraw Hill Publishing Co. Ltd.
  2. Physical Chemistry, P.C. Rakshit, 6<sup>th</sup> Edition, 2001, Sarat Book Distributors, Kolkata.
  3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3<sup>rd</sup> edition, John Wiley & Sons, Inc [part 1]
  4. Physical Chemistry, G. Castellan, 3<sup>rd</sup> edition, 5<sup>th</sup> Reprint, 1995 Narosa Publishing House.
  5. Modern Electrochemistry, J. O. M Bockris & A.K.N. Reedy, Maria Gamboa – Aldeco 2<sup>nd</sup> Edition, 1<sup>st</sup> Indian reprint, 2006 Springer
  6. Fundamental of Molecular Spectroscopy, 4<sup>th</sup> Edn., Colin N Banwell and Elaine M Mc Cash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 2008.
  7. Physical Chemistry, G.M. Barrow, 6<sup>th</sup> Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
  8. The Elements of Physical Chemistry, P. W. Atkins, 2<sup>nd</sup> Edition, Oxford University Press Oxford.
  9. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt. Ltd. New Delhi.
  10. Principles of Physical Chemistry B. R. Puri, L. R. Sharma, M. S. Pathania, VISHAL PUBLISHING Company, 2008.
  11. Text book of Polymer Science, Fred W Bilmeyer, John Wiley & Sons (Asia) Pvt. Ltd., Singapore, 2007.
  12. Polymer Science, V. R. Gowariker, N. V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd., Publishers, 2005.
  13. Chemical Kinetics, K. Laidler, Pearson Education India, 1987
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# SEMESTER : VI

## Course content

### Paper II

Course Code: VSCH351 Credits: 2

### Inorganic Chemistry-II

#### Course Learning Objectives

Upon completion of the course the student will be able to understand

- ❖ Crystal Field theory and its application to explain variation in properties of coordination compounds.
- ❖ Experimental evidence suggesting covalence in metal -ligand bond
- ❖ Application of Molecular Orbital Theory to explain properties of octahedral complexes.
- ❖ Stability, reactivity and electronic spectra of metal complexes to understand the properties of the metal complexes.
- ❖ The concept of synthesis and application of organometallic compounds and Sandwich type of compounds.
- ❖ The structure and bonding of ferrocenes on the basis of VBT and homogeneous catalysis with the example of Wilkinson's catalyst in hydrogenation of alkenes.
- ❖ The concept of compounds of Xenon with respect to preparation and structure (VSEPR), applications.
- ❖ The concept of nano materials with synthesis and application.
- ❖ Introduced to the role of inorganic elements in biological system along with the sodium and potassium pump.

#### Course Outcome

Upon completing the course, the student will be able to

CO1	Understand variation in properties like color, magnetic moment etc, distortion in geometry of octahedral complexes based on Crystal Field Theory.
CO2	Draw Molecular Orbital diagram of octahedral complexes and explain variation in properties, labile and inert complexes and discuss different mechanisms of substitution reactions metal complexes
CO3	Distinguish between homogeneous and heterogeneous catalysis, understand the mechanism of catalysis, write mechanism of Wilkinson's catalyst in hydrogenation of alkenes.
CO4	Define nanomaterial, write different methods of synthesis of nanomaterial, recite application of nanomaterials

## COURSE CONTENT

<b>Unit I</b>	<b>Theories of Metal Ligand Bond.</b>	
<b>1.1</b>	<b>Crystal field Theory (CFT) for coordination compounds</b>  1.1.1 Basic terms of CFT  1.1.2 Effect of crystal field on d orbitals in octahedral, square planar and tetrahedral complexes.  1.1.3 Distortions from octahedral geometry: Jahn teller Distortions  1.1.4 Crystal field splitting parameter $10 Dq / \Delta$ , its calculation and factors affecting it in octahedral complex, Spectrochemical series.  1.1.5 Crystal Field Stabilization Energy (CFSE) , calculation of CFSE for octahedral and tetrahedral complexes d <sup>0</sup> - d <sup>10</sup> metal ion configurations.  1.1.6 Consequences of crystal field splitting on various properties such as ionic radii, hydration energy, lattice energy, colour and magnetic properties  1.1.7 Limitations of CFT: Evidences for covalence in metal complexes: i) intensities of d-d transitions, ii) ESR spectrum [Ir Cl <sub>6</sub> ] <sup>2-</sup> iii) Nephelauxetic effect.	<b>06</b>
<b>1.2</b>	<b>Molecular Orbital theory for Coordination Compounds</b>  1.2.1 Identification of central metal orbitals and their symmetry suitable for formation of $\sigma$ and $\pi$ bonds with ligand orbitals.  1.2.2 Construction of Ligand Group orbitals 1.2.3 Construction of $\sigma$ Molecular orbitals for ML <sub>6</sub> complexes. 1.2.4 Effect of $\pi$ bonding on $\Delta$ values 1.2.5 Molecular Orbital diagram for complexes: [Ti(H <sub>2</sub> O) <sub>6</sub> ] <sup>+3</sup> [Fe (CN) <sub>6</sub> ] <sup>-3</sup> , [Fe (F) <sub>6</sub> ] <sup>-3</sup> , [Fe (CN) <sub>6</sub> ] <sup>4-</sup> , [Fe (F) <sub>6</sub> ] <sup>-4</sup> , [Co(NH <sub>3</sub> ) <sub>6</sub> ] <sup>+3</sup> , [Co(F) <sub>6</sub> ] <sup>-3</sup>	<b>04</b>
<b>Unit II</b>	<b>Properties of complexes</b>	
<b>2.1</b>	Stability of Metal Complexes  2.1.1 Thermodynamic and Kinetic Stability of metal complexes  2.1.2 Stability constants: Stepwise and overall stability constants and their Interrelationship  2.1.3 Factors affecting thermodynamic stability: nature of metal, nature of ligand, Chelate effect	<b>04</b>
<b>2.2</b>	<b>Reactivity of Metal Complexes.</b>  2.2.1 Types of reactions in metal complexes  2.2.2 Inert and Labile complexes: Correlation between electronic configurations and lability of complexes.	<b>03</b>

	<p>2.2.3 Ligand substitution reactions: Associative and Dissociative mechanisms.</p> <p>2.2.4 Acid hydrolysis, base hydrolysis and anation reaction.</p>	
<b>2.3</b>	<p><b>Electronic Spectra.</b></p> <p>2.3.1 Origin of electronic spectrum</p> <p>2.3.2 Types of electronic transitions in coordination compounds; Intrametal, intraligand, charge transfer.</p> <p>2.3.3 Selection rules for electronic transitions.</p> <p>2.3.4 Electronic configuration and electronic microstates, Terms and Term symbols for transition metal ions, rules for determination of ground state Terms.</p> <p>2.3.5 Determination of Terms for p<sup>2</sup> and d<sup>2</sup> electronic configurations. Orgel Diagram for D and F Terms (in octahedral crystal field)</p>	<b>03</b>
<b>Unit III</b>	<b>Organometallic Chemistry.</b>	
<b>3.1</b>	<p><b>Organometallic Compounds of Main Group Metals.</b></p> <p><b>3.1.1</b> General Characteristics of various types of organometallic compounds i.e. ionic, <math>\sigma</math>-bonded and electron deficient compounds.</p> <p><b>3.1.2</b> General Synthetic methods of organometallic compounds: i) Oxidative addition ii) Metal- metal exchange reaction (transmetallation), iii) Carbanion- halide exchange, iv) Metal hydrogen exchange (metallation) and v) Methylene insertion reactions.</p> <p><b>3.1.3</b> Some chemical reactions of organometallic compounds: i) Reactions with oxygen and halogens, ii) Alkylations and arylations iii) Reactions with protic reagents, iv) Redistributions reactions and v) Complex formation reactions.</p>	<b>04</b>
<b>3.2</b>	<p><b>Catalysis.</b></p> <p><b>3.2.1</b> Comparison between homogeneous and heterogeneous catalysis.</p> <p><b>3.2.2</b> Basic steps involved in catalysis reactions i) Oxidative addition ii) Reductive elimination iii) Insertion reaction iv) Application of EAN rule/ 18 electron rule.</p> <p><b>3.2.3</b> Catalytic Reactions i) Wilkinson catalyst ii) Suzuki Coupling iii) Heck Reactions.</p>	<b>03</b>

<b>3.3</b>	<p><b>Nanomaterials</b></p> <p><b>3.3.1</b> Introduction and importance of nanomaterials.</p> <p><b>3.3.2</b> Properties (Comparison between bulk and nanomaterials): i) Optical properties ii) Electrical conductivity iii) Melting points, and iv) Mechanical properties.</p> <p><b>3.3.3</b> Forms of nanomaterials: nanofilms, nanolayers, nanotubes, nanowires and nano particles.</p> <p><b>3.3.4</b> Synthesis of nanoparticles using colloidal route</p>	<b>03</b>
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References:

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2. R. K. Sharma Text Book of Coordination Chemistry Discovery Publishing House
3. R. Gopalan , V. Ramalingam Concise Coordination Chemistry , Vikas Publishing House;
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5. Glen E. Rodgers, Descriptive Inorganic, Coordination, and Solid-State Chemistry Publisher: Thomson Brooks/Cole
6. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers,
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	<p>Anomers, stability of anomers epimers</p> <p>1.2.3 Mutarotation and its mechanism</p> <p>1.2.4 Chain lengthening and chain shortening reactions</p> <p>1.2.5 Reactions of D-Glucose and D-fructose</p> <p>1.2.6 Introduction to glycosides</p>	
<b>Unit II</b>	<p><b>2.1 Molecular rearrangements:</b></p> <p>Mechanism of the following rearrangements with examples and stereochemistry wherever applicable</p> <p>2.1.1 Wagner Meerwein rearrangement</p> <p>2.1.2 Pinacol-pinacolone rearrangement</p> <p>2.1.3 Beckman rearrangement</p> <p>2.1.4 Favorskii rearrangement</p> <p>2.1.5 Baeyer Villiger Oxidation</p> <p><b>2.2 Organometallic chemistry</b></p> <p>2.2.1 Introduction: Carbon-metal bond Nature, types and reactivity.</p> <p>2.2.2 Organo magnesium Compounds: Grignard reagent: Reaction with compounds containing acidic hydrogen, carbonyl compounds, cyanides and CO<sub>2</sub>.</p> <p>2.2.3 Organolithium Compounds: Preparation using alkyl/aryl halides. Reactions with compounds containing acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO<sub>2</sub>. Lithium dialkyl cuprates: Preparation and reactions with aliphatic /aromatic/vinylic halides.</p> <p>2.2.4 Organozinc compounds: Preparation of dialkyl zinc. Reaction with water, acid chlorides and alkyl halides. Reformatsky reaction (with mechanism).</p> <p>2.2.5 Organocopper reagents: Ullman reaction</p>	<p><b>04</b></p> <p><b>06</b></p>
<b>Unit III</b>	<p><b>3.1 Chemistry of enolates</b></p> <p>3.1.1 Introduction: generation of enolates, kinetically controlled and thermodynamically controlled enolates</p> <p>3.1.2 Mechanism and applications of the following reactions</p> <p>i) Aldol reaction ii) Knoevenagel reaction iii) Michael reaction</p> <p>iv) Robinson annulations v) Wittig reaction vi) Cannizzaro reaction</p> <p>vii) Claisen ester condensation and Dieckmann condensation</p> <p>viii) Claisen -Schmidt reaction</p>	<p><b>06</b></p> <p><b>04</b></p>

	<p><b>3.2 Catalysts and reagents</b></p> <p>Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism)</p> <p><b>3.2.1 Catalysts for hydrogenation</b></p> <p>i. Raney Nickel  ii. Pt &amp; PtO<sub>2</sub> ( C=C, CN, NO<sub>2</sub>, aromatic ring)  iii. Pd/C(C=C, COCl to CHO (Rosenmund reduction)  iv. Lindlar catalyst (alkynes)</p> <p><b>3.2.2 Reagents</b></p> <p>i) LiAlH<sub>4</sub> (reduction of CO, COOR, CN, NO<sub>2</sub>)  ii) NaBH<sub>4</sub> (reduction of CO)  iii) SeO<sub>2</sub> (Oxidation of CH<sub>2</sub> alpha to CO)  iv) mCPBA (epoxidation of C=C)  v) NBS (allylic and benzylic bromination)</p>	
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### References:

1. Name Reactions in Heterocyclic Chemistry, Jie-Jack Li, Wiley-Interscience publications, 2005.
  2. Handbook of Heterocyclic Chemistry, 2nd Edition, Alan R. Katritzky and Alexander F. Pozharskii, Elsevier Science Ltd, 2000.
  3. Heterocyclic Chemistry, 5th Edition, John A. Joule and Keith Mills, Wiley publication, 2010.
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  5. Biochemistry, 8 th Ed., Jeremy Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto Pub. W. H. Freeman Publishers
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  10. Introduction to Organic Chemistry (Third edition), Andrew Streetwise, Jr. Clayton H. Heathcock, Macmillan publishing.
  11. Organic chemistry fourth edition, Morrison and Boyd.
  12. Introduction to Organic chemistry, John McMurry.
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  14. Chemistry of natural products by Chatwal Anand – Vol I and Vol II
  15. Chemistry of natural products by O.P. Agarwal
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  19. Principles of Organometallic Chemistry, by Coates G.E., K. Wade, P. Powell
  20. Basic Organometallic Chemistry: Concepts, Syntheses and Applications by BD Gupta, Anil J. Elias
  21. Organometallic Chemistry, by Gary O. Spessard, Gary L. Miessler
  22. Organic chemistry by Francis Carey – McGrawHill .
  23. Organic chemistry by Carey and Sundberg, Part A & B
  24. Modern Enolate Chemistry: From Preparation to Applications in Asymmetric Synthesis by Manfred Braun
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## Paper IV

Course Code: VSCH353 Credits: 2

### Analytical Chemistry-II

#### Learning Objectives:

The primary objective of this course is to acquire basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results. On successful completion of this course, students will be able

1. To introduce basic analytical techniques and practical aspects of classical chemical analysis.
2. To establish an appreciation of the role of chemistry in quantitative analysis
3. To provide an understanding of chemical methods employed for elemental and compound analysis.
4. To provide experience in some scientific methods employed in analytical chemistry.

#### Course Outcome

**CO 1:** Understand the fundamental principles and applications of electroanalytical techniques such as potentiometry, conductometry, and voltammetry.

**CO 2:** Apply chromatographic and ion exchange techniques for the qualitative and quantitative separation of chemical species.

**CO 3:** Demonstrate the ability to interpret thermal analysis data for the characterization of materials using TGA, DTA, and DSC.

**CO 4:** Compare and evaluate the advantages, limitations, and applications of electroanalytical, separation, and thermal methods in modern analytical chemistry.

#### CONTENT

UNIT	TOPICS	No. of lectures
<b>Unit 1: Introduction to Electroanalytical Techniques</b>		
1.1	<b>Introduction to Electroanalytical Techniques</b> Overview of <b>electrochemical techniques</b> <b>Basic electrode processes and redox reactions</b> Classification of <b>electroanalytical methods</b> Advantages and limitations of <b>polarography and amperometry</b>	<b>01</b>

1.2	<b>Polarography</b> <b>1.2.1 Fundamentals of Polarography</b> Principle of <b>polarographic analysis</b> <b>Ilkovic equation</b> and its significance <b>Dropping Mercury Electrode (DME)</b> : Properties and role in polarography <b>1.2.2 Instrumentation and Types of Polarography</b> Components of a <b>polarographic system</b> <b>Classical DC Polarography</b> and its limitations Advanced polarographic techniques: <b>Differential Pulse Polarography (DPP)</b> <b>Square Wave Polarography (SWP)</b> <b>1.2.3 Applications of Polarography</b> <b>Quantitative analysis</b> of metal ions (e.g., Pb, Cd, Zn) <b>Pharmaceutical applications</b> (drug stability and degradation studies) <b>Environmental monitoring</b> (pollutant analysis in water and soil) <b>Polarographic titrations</b> (redox and complexometric titrations)	06
1.3	<b>Amperometry</b> <b>1.3.1 Fundamentals of Amperometry</b> Principle of <b>amperometric detection</b> Comparison with <b>voltammetry and potentiometry</b> <b>Faraday's Law</b> and its role in current measurement <b>1.3.2 Amperometric Techniques &amp; Instrumentation</b> <b>Single and dual electrode systems</b> <b>Amperometric titrations</b> : Concept and methodology Industrial applications in <b>corrosion monitoring and food analysis</b> <b>1.3.3 Applications of Amperometry</b> <b>Biomedical applications</b> (enzyme-based glucose biosensors) <b>Environmental applications</b> (detection of pesticides and pollutants) <b>Industrial applications</b> (oxygen sensors and gas analysis)	03
<b>UNIT II:                   METHODSOFSEPARATION-II</b>		
2.1	<b>Gas Chromatography (GC)</b> <b>2.1.1 Fundamentals of Gas Chromatography</b> <b>Principle of GC</b> : Separation based on volatility and boiling point Types of GC: <b>Gas-Liquid Chromatography (GLC) &amp; Gas-Solid Chromatography (GSC)</b> Comparison with <b>HPLC and other chromatographic techniques</b> <b>2.1.2 Instrumentation &amp; Methodology</b> <b>Components of GC system</b> : Carrier gas, injectors, columns, detectors <b>Stationary phases</b> and column selection (Capillary vs. Packed columns) Sample injection techniques: <b>Split, splitless, and on-column injection</b> <b>2.1.3 Detectors &amp; Data Interpretation</b> <b>Types of detectors</b> : Flame Ionization Detector (FID), Thermal Conductivity Detector (TCD), Electron Capture Detector (ECD), Mass Spectrometry (GC-MS) Interpretation of <b>chromatograms</b> and qualitative/quantitative analysis <b>2.1.4 Applications of GC</b> <b>Pharmaceutical industry</b> : Analysis of volatile drugs and residual solvents <b>Food and beverage industry</b> : Detection of <b>flavors, additives, and contaminants</b> <b>Environmental monitoring</b> : Analysis of <b>pesticides and air pollutants</b>	05
2.2	<b>Ion Exchange Chromatography (IEC)</b> <b>2.2.1 Fundamentals of Ion Exchange Chromatography</b> <b>Basic principles</b> : Separation based on ion exchange equilibria	05

	<p>Types of ion exchangers: <b>Cation exchangers &amp; Anion exchangers</b>  Factors affecting separation: <b>pH, ionic strength, and temperature</b></p> <p><b>2.2.2 Instrumentation &amp; Resin Properties</b>  <b>Types of ion exchange resins</b> (Strong/weak acid and base exchangers)  <b>Column packing and selection of eluents</b>  Techniques: <b>Gradient elution &amp; isocratic elution</b></p> <p><b>2.2.3 Applications of Ion Exchange Chromatography</b>  <b>Water purification and desalination</b>  <b>Separation of amino acids, proteins, and nucleotides</b>  <b>Pharmaceutical applications:</b> Drug formulation and purification  <b>Industrial applications:</b> Recovery of metal ions and biochemical separations</p>	
<b>UNIT III: Thermal Methods</b>		
<b>3.1</b>	<p><b>3.1.1 Introduction to Thermal Analysis</b>  <b>Overview of thermal analysis techniques</b>  <b>Basic principles:</b> Heat flow, weight loss, and phase transitions  Importance of <b>thermal methods in chemical analysis</b></p> <p><b>Thermogravimetric Analysis (TGA)</b></p> <p><b>3.1.2 Fundamentals of TGA</b>  Principle of <b>weight loss measurement as a function of temperature</b>  Types of <b>TGA curves and decomposition patterns</b>  Factors affecting TGA results: <b>Heating rate, sample mass, and atmosphere</b></p> <p><b>3.1.3 Instrumentation &amp; Methodology</b>  <b>TGA system components:</b> Furnace, balance, sample holders  <b>Isothermal and non-isothermal analysis</b>  <b>Selection of carrier gas (inert vs. oxidative atmospheres)</b></p> <p><b>3.1.4 Applications of TGA</b>  <b>Thermal stability studies</b> of polymers and pharmaceuticals  <b>Decomposition kinetics</b> of materials  <b>Environmental applications:</b> Analysis of <b>waste materials and carbon content</b></p>	<b>04</b>
<b>3.2</b>	<p><b>Differential Thermal Analysis (DTA)</b></p> <p><b>3.3.1 Fundamentals of DTA</b>  Principle of <b>heat flow and temperature difference measurement</b>  <b>Comparison of DTA and DSC</b>  Endothermic vs. Exothermic transitions</p> <p><b>3.3.2 Instrumentation &amp; Experimental Techniques</b>  Components of DTA  Sample preparation and selection of <b>reference materials</b></p> <p><b>3.3.3 Applications of DTA</b>  <b>Pharmaceutical analysis:</b> Drug purity and polymorphism studies  <b>Polymers and materials science:</b> Crystallinity, glass transition temperature (T<sub>g</sub>), and melting point determination  <b>Food industry:</b> Fat crystallization and thermal stability  Environmental studies: Thermal degradation of waste and hazardous materials</p>	<b>04</b>
<b>3.3</b>	<p><b>Thermometric titration</b></p> <p><b>3.3.1 Fundamentals TT</b>  Principle of thermometric titration</p>	<b>02</b>

	<b>3.3.2 Instrumentation &amp; Experimental Techniques</b> Experimental set-up of thermometric titration <b>3.3.3 Applications of TT to various types of titration</b>	
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**References:**

**Kolthoff, I. M., & Lingane, J. J. (1952).***Polarography: Principles and Applications.* Interscience Publishers.

**Bard, A. J., & Faulkner, L. R. (2001).***Electrochemical Methods: Fundamentals and Applications.* Wiley.

**Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017).***Principles of Instrumental Analysis.* Cengage Learning.

**Wang, J. (2000).***Analytical Electrochemistry.* Wiley-VCH.

**Kissinger, P. T., & Heineman, W. R. (1996).***Laboratory Techniques in Electroanalytical Chemistry.* CRC Press.

Covers experimental techniques, including polarography and amperometry, with real-world applications.

Christian, G. D. (2004). *Analytical Chemistry.* John Wiley & Sons.

Meyer, V. R. (2010). *Practical Gas Chromatography.* Wiley.

Fritz, J. S., & Gjerde, D. T. (2009). *Ion Chromatography.* Wiley-VCH.

Harris, D. C. (2020). *Quantitative Chemical Analysis.* Macmillan Learning.

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## PRACTICALS

### SEMESTER VI

#### PHYSICAL CHEMISTRY

COURSE CODE: VSCH354

CREDITS: 2

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#### Course Outcome

Upon completing the course, the student will be able to understand

CO1	To learn the laboratory technique for determining molecular weights of different polymers.
CO2	To determine the amount of halides using potentiometer.
CO3	To understand the complex formation using colorimeter.

#### Non-Instrumental

##### Viscosity:

1. To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement.

#### Instrumental

##### Potentiometry:

2. To determine the amount of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.
3. To determine the number of electrons in the redox reaction between ferrous ammonium sulphate and ceric sulphate potentiometrically.

##### Conductometry:

4. To titrate a mixture of weak acid and strong acid against strong base and estimate the amount of each acid in the mixture conductometrically.
5. To determine the velocity constant of alkaline hydrolysis of ethylacetate by conductometric method.
6. Determine the equivalent conductance of strong electrolyte at several concentrations and hence verify Onsager's equation.

##### Colorimetry

7. To estimate the amount of Fe(III) in the complex formation with salicylic acid by Static Method.

##### pH-metry

8. To determine acidic and basic dissociation constants of amino acid and hence to calculate isoelectric point.
-

## References:

1. Experimental Physical Chemistry, V. D. Athawale and P. Mathur, New Age International Publishers, 2001
2. Practical Physical Chemistry, B. Viswanathan and P. S. Raghavan, Viva Books Private Limited, 2005.
3. Experiments in Physical Chemistry R. C. Das and B. Behra, Tata McGraw Hill
4. Advanced Practical Physical Chemistry J.B. Yadav, Goel Publishing House
5. Advanced Experimental Chemistry. Vol-I J. N. Gurtu and R Kapoor, S. Chand and Co.
6. Senior Practical Physical Chemistry By: B. D. Khosla, V. C. Garg and A. Gulati, R Chand and Co.. 2011.

## PRACTICALS

### SEMESTER VI

#### INORGANIC CHEMISTRY

COURSE CODE: VSCH354

CREDITS: 02

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#### Course Outcome

Upon completing the course, the student will be able to

CO1	Demonstrate the ability to synthesize metal complexes such as <b>tris(acetylacetonate) iron(III)</b> , <b>bis(dimethylglyoxime) nickel(II)</b> , and <b>potassium trioxalatoaluminate(III)</b> using various inorganic synthesis techniques and analyze their properties.
CO2	Apply eco-friendly approaches to prepare metal complexes and <b>nanomaterials using the co-precipitation method</b> , understanding their structural and functional properties through characterization techniques.
CO3	Develop analytical skills to determine the <b>percentage purity of water-soluble salts</b> and qualitatively detect main-group metal ions using <b>systematic wet chemical tests</b> .

#### Inorganic preparations

- Preparation of Tris(acetylacetonate) iron(III)
- Green synthesis of bis(dimethylglyoxime) nickel (II) complex using nickel carbonate and sodium salt of dmg.
- Preparation of potassium trioxalato aluminate (III)
- Synthesis of Nanomaterials using co-precipitation method

II. Determination of percentage purity of the given water-soluble salt and qualitative detection w.r.t added cation and/or anion (qualitative analysis only by wet tests). (Any three salts of main group metal ions)

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#### References:

1. Vogel Textbook of Quantitative Chemical Analysis G.H. Jeffery, J. Basset.
  2. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd
  3. Vogel's. Textbook of. Macro and Semimicro qualitative inorganic analysis. Fifth edition
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**PRACTICALS**  
**SEMESTER VI**  
**ORGANIC CHEMISTRY**

**COURSE CODE:** VSCH354

**CREDITS: 02**

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**Learning Objectives:**

1. Identify the physical type of a given binary mixture (solid-liquid or liquid-liquid) through preliminary tests.
2. Classify components based on their volatility, solubility, and functional groups.
3. Select and apply an appropriate microscale distillation technique for separation of binary mixtures.
4. Perform systematic separation of volatile and non-volatile components in liquid-liquid and solid-liquid mixtures.
5. Analyse and confirm the identity of one separated component using physical and chemical characterization techniques.
6. Develop proficiency in handling microscale separation techniques and understanding their practical applications.

**Course Outcomes:**

<b>CO 1</b>	Demonstrate the ability to distinguish between solid-liquid and liquid-liquid binary mixtures based on their physical properties.
<b>CO 2</b>	Apply microscale distillation techniques to effectively separate and purify components of binary mixtures.
<b>CO 3</b>	Identify separated compounds using analytical methods, reinforcing theoretical concepts through practical experience.

**Separation of Binary solid-liquid and liquid-liquid mixture (2.0 g mixture to be given)**

- Minimum Six mixtures to be completed by the students.
- Components of the liq-liq mixture should include volatile liquids like acetone, methyl acetate, ethyl acetate, isopropyl alcohol, ethyl alcohol, EMK and non-volatile liquids like chlorobenzene, bromobenzene, aniline, N,N dimethylaniline, acetophenone, nitrobenzene, ethyl benzoate.
- Components of the liq- solid mixture should include volatile liquids like acetone, methyl acetate, ethyl acetate, ethyl alcohol, IPA, EMK and solids such as water insoluble acids, phenols, bases, neutral.
- One ml of sample mixture to be given to the student for physical type detection of the mixture.
- After correct determination of physical type, separation of the binary mixture to be carried out by distillation method using microscale technique.

After separation into component A and component B, the compound to be identified can be decided by examiner.

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**References:**

1. Practical organic chemistry – A. I. Vogel
2. Practical organic chemistry – H.Middleton.
3. Practical organic chemistry – O.P.Aggarwal

## PRACTICALS SEMESTER-VI

### ANALYTICAL CHEMISTRY

COURSE CODE: VSCH354

CREDITS: 2

#### Learning Objectives:

1. **Spectrophotometric Estimation of Chromium in Water Samples:** Understand how to determine chromium concentration in water using the Diphenylcarbazide reagent and UV-Vis spectrophotometry.
2. **Estimation of Reducing Sugar in Honey by Willstätter Method:** Learn how to quantify reducing sugars in honey by oxidizing sugars with Fehling's solution and performing a titration.
3. **Estimation of  $Mg^{2+}$  and  $Zn^{2+}$  using Anion Exchange Resin:** Gain knowledge on the separation and estimation of  $Mg^{2+}$  and  $Zn^{2+}$  ions through anion exchange chromatography.
4. **Potentiometric Estimation of Acetic Acid in Vinegar using Quinhydrone Electrode:** Understand the procedure for determining acetic acid concentration through potentiometric titration with a quinhydrone electrode.
5. **Determination of Phosphoric Acid in Cola Samples using pH-Metry:** Learn how to measure phosphoric acid content in cola samples using a pH-metric titration.
6. **Cyclic Voltammetric Determination of Paracetamol (Acetaminophen):** Study the electrochemical oxidation of paracetamol and determine its concentration using cyclic voltammetry.

#### Course Outcomes:

- CO-1: Apply spectrophotometric and chromatographic techniques for the qualitative and quantitative analysis of metal ions and organic compounds in various sample matrices.
- CO-2: Utilize electrochemical and pH-metric methods for the estimation of acidic analytes in food and beverage samples.
- CO-3: Investigate the electrochemical behavior of biologically active molecules using cyclic voltammetry for their qualitative and quantitative evaluation.

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### Practical Content

#### *Spectrophotometry & Chromatography Experiments:*

1. **Spectrophotometric Estimation of Chromium in Water Samples**
  - Determination of chromium concentration using **Diphenylcarbazide reagent** and UV-Vis spectrophotometry.
2. **Estimation of Reducing Sugar in Honey by Willstätter Method**
  - Quantification of reducing sugars based on **oxidation of sugars by Fehling's solution followed by titration.**
3. **Estimation of  $Mg^{2+}$  and  $Zn^{2+}$  using Anion Exchange Resin**
  - Separation and estimation of  **$Mg^{2+}$  and  $Zn^{2+}$  ions** using **anion exchange chromatography.**

*Electrochemical & pH-Metric Experiments:*

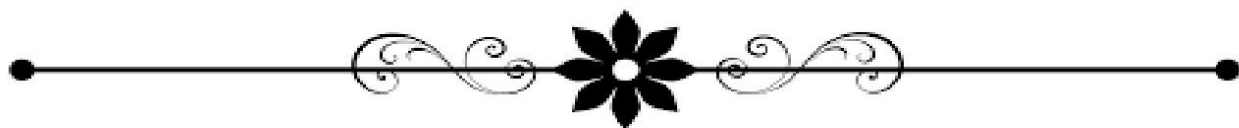
4. **Potentiometric Estimation of Acetic Acid in Vinegar using Quinhydrone Electrode**
  - Determination of acetic acid concentration based on **potentiometric titration using the quinhydrone electrode**.
5. **Determination of Phosphoric Acid in Cola Samples using pH-Metry**
  - Measurement of **phosphoric acid content** in soft drink samples using **pH-metric titration**.

*Cyclic Voltammetry Experiments:*

6. **Cyclic Voltammetric Determination of Paracetamol (Acetaminophen)**
    - Investigation of the electrochemical oxidation of **paracetamol** and determination of its concentration.
  7. **Electrochemical Analysis of Uric Acid using Cyclic Voltammetry**
    - Study of **uric acid oxidation** and determination of its concentration in biological samples.
- 

References:

1. **Vogel, A. I.** (2008). *Vogel's Textbook of Quantitative Chemical Analysis*. Pearson.
2. **Skoog, D. A., West, D. M., & Holler, F. J.** (2017). *Fundamentals of Analytical Chemistry*. Cengage Learning.
3. **Harris, D. C.** (2020). *Quantitative Chemical Analysis*. Macmillan Learning.
4. **Christian, G. D.** (2004). *Analytical Chemistry*. John Wiley & Sons.
5. **Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A.** (1988). *Instrumental Methods of Analysis*. Wadsworth.
6. **Bard, A. J., & Faulkner, L. R.** (2001). *Electrochemical Methods: Fundamentals and Applications*. Wiley.
7. **Kissinger, P. T., & Heineman, W. R.** (1996). *Laboratory Techniques in Electroanalytical Chemistry*. CRC Press.



## Semester – V

### Paper V: Electives-1

Course Code: VSCH305 Credits: 2

### (Industrial Chemistry-I)

#### Learning Objectives

Upon completion of the course the student will be able to understand

- Importance of chemical industry,
- Meaning of the terms involved,
- Comparison between batch and continuous process,
- Knowledge of various industrial aspects
- Concept of basic chemicals,
- Their uses and manufacturing process.
- They should also know the physico-chemical principals involved in manufacturing process

#### Course Outcome

Upon completing the course, the student will be able to

<b>CO1</b>	Explain the basics of small-scale industry right from its setting to the various operations and processes used in different chemical manufacturing processes.
<b>CO2</b>	Explore the process of manufacture of fertilizers, agrochemicals and brief account of perfumes, flavours and sweeteners
<b>CO3</b>	Demonstrate the process of preparation and uses of <b>Industrial solvents</b>
<b>CO4</b>	Outline the safe handling of chemicals and environmental issues for the betterment of mankind.

#### COURSE CONTENT

<b>Unit I</b>	<b>1.1 Introduction to Chemical Industry.</b> Explanation of the terms Heavy (Bulk) and Fine (Speciality) Chemicals.	<b>02</b>
	<b>1.2 Silicates:</b> a) Introduction to silicates: Properties, structure and types of silicates. Preparation of sodium silicate.	<b>03</b>
	<b>1.3 Manufacture and applications of the following:</b> a) Talcum powder      b) Nitric acid c) Sodium dichromate      d) Chromium trioxide	<b>05</b>
<b>Unit II</b>	<b>2.1 Fertilizers:</b> Preparation, properties and uses of a) Normal superphosphate      b) Triple Superphosphate c) Ammonium nitrate      d) Ammonium Sulphate	<b>04</b>
	<b>2.2 Industrial solvents</b> Manufacture and uses of ethyl acetate, isopropyl alcohol, Acetone, Acetic acid, Dimethyl formamide, Brief idea of green solvents.	<b>06</b>

<b>Unit III</b>	<b>3.1</b> Brief idea about the economic aspects of chemical manufacturing processes with respect to Location, Raw materials, Energy, Capital, Manpower, Ecological aspects, Tax benefits.	<b>04</b>
	<b>3.2</b> Brief account of perfumes, flavours and sweeteners: <b>3.2.1 Perfumes:</b> Introduction, classification (ethers, esters and essential oils) Composition, formation, blending and applications. Synthesis of $\alpha$ and $\beta$ -ionone's from citral . <b>3.2.2 Flavours:</b> Introduction, Classification (natural and synthetic), applications of Vanillin, Coumarin (structures), Synthesis of Vanillin. <b>3.2.3 Sweeteners:</b> Introduction, classification with examples and structures of <b>3.2.4 Naturalsweetners:</b> Carbohydrates (Glucose, Fructose) <b>3.2.5 Synthetic sweeteners:</b> i) Sucralose, ii) Sulphonamide: eg Saccharin, iii) Peptides: Aspartame, Synthesis of Saccharin	<b>06</b>

### Reference Books:

1. Industrial Chemistry, B. K. Sharma, Goel publishing House, 18th Ed. (2014)
2. Faith Keyes and Clerk's Industrial Chemicals, 4<sup>th</sup>Edn., Wiley Inter-science 1975.
3. P. H. Groggins: Unit Processes in Organic Synthesis, McGraw Hill.
4. Kirk & Othmer: Encyclopaedia of Chemical Technology, John Wiley and sons.
5. Industrial Inorganic Chemistry-Buchner, Schliebs, Winter, translated by D. H. Tenell, VCH Publishers, New York.
6. Industrial Organic Chemistry- K. Welssermel, H. J. Arpe, VCH Publishers, New York.
7. Pearson- Speciality Chemical Innovations in Industrial Synthesis.
8. Shreeves 'Chemical Process Industries' 5<sup>th</sup> Edition, G. T. Oustin, McGraw Hill.
9. Riegel's Hand Book of Industrial Chemistry, 9<sup>th</sup> Edition, Jems A. Kent.
10. Industrial Chemistry- E Stoch, Vol- I, Ellis Horwood Ltd. UK.
11. An Introduction to Industrial Organic Chemistry- Wiseman and Peter, ""
12. Riegel's Handbook of Industrial Chemistry, J. A. Kent, CBS Publishers, New Delhi
13. Industrial Chemistry, Part-II, R. K. Das, Kalyani Publisher, Second Ed. Shreeves 'Chemical Process Industries' 5<sup>th</sup> Edition, G. T. Austin, McGraw Hill, 1984.



## Semester – V

### Practicals–Elective-1

Course Code: VSCH306 Credits: 2

#### (Industrial Chemistry - I)

#### (Micro scale Preparation and Estimations)

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#### Learning Objectives:

- Understand the principles and procedures involved in the synthesis of Ferrous sulphate heptahydrate and Aspirin.
  - Carry out solvent-free green synthesis of benzillic acid using benzil.
  - Analyze the efficiency, yield, and purity of synthesized compounds on a micro scale.
  - Accurately estimate iodine content in tincture iodine using titration.
  - Perform back titration to estimate methyl salicylate in a given sample.
  - Determine the concentration of acetic acid in vinegar using standard acid-base titration.
  - Calculate percentage yield and error analysis for synthesized compounds.
  - Explain reaction mechanisms and stoichiometry of the synthesis and estimation experiments.
  - Correlate lab outcomes with theoretical principles and assess environmental impact of methods used.
- 

#### Course Outcomes

Upon completing the course, the student will be able to

CO 1	Perform micro-scale synthesis of selected organic and inorganic compounds using eco-friendly methods.
CO 2	Demonstrate proficiency in quantitative estimations using classical titrimetric methods.
CO 3	Demonstrate proficiency in quantitative estimations using classical titrimetric methods.

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#### Single step organic/Inorganic preparation (1.0 g scale) involving purification by recrystallization method for organic preparations

##### Preparations: (Micro scale)

1. Preparation of Ferrous sulphate heptahydrate
2. Preparation of Aspirin
3. Green synthesis: Solvent free synthesis of benzillic acid from benzil

##### Estimations

- 1) Estimation of tincture iodine.
  - 2) Estimation of methyl salicylate. (Back titration method)
  - 3) Estimation of acetic acid in a sample of vinegar (Titrimetric)
-

**Reference:**

1. Comprehensive Practical Organic Chemistry: Preparation and
2. Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
5. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
6. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
7. Vogel's Textbook of Practical Organic Chemistry, Fifth edition, 2008, B.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
8. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.

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**Semester – V**  
**Paper V: Electives-2**  
**Course Code: VSCH307Credits: 2**  
**(Medicinal and Green Chemistry)**

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### Learning Objectives

Upon completion of the course the student will be able to understand

- Importance of pharmaceutical industry,
- Meaning of the different terms involved in medicinal chemistry, their uses and manufacturing process.
- Raising an awareness on the potential toxic effects of different chemicals and problems related to waste generation.
- Inculcating the need to practice green chemistry as it is the only way to meet the global challenges the world is facing today.
- Familiarizing students with the new emerging green technologies (new catalysts, solvents and energy sources) that would help them gain new insights on how pollution can be prevented through thoughtful design of chemical products and processes.
- Enabling students to learn about the green trends being practiced by industries as well as academicians through demonstration of some real-world case studies.

### Course Outcome

Upon completing the course, the student will be able to

<b>CO1</b>	Understand the basic understanding of drugs, Sources of Drugs, classification and terminology involved in pharmacopeia
<b>CO2</b>	Designing and uses of different drugs used in the common diseases
<b>CO3</b>	Recognize and acknowledge the role of green chemistry in reducing waste, learn about new strategies (emerging green technologies-green catalysts, solvents, energy, plastics etc.) that possess tremendous potential in reducing waste
<b>CO4</b>	Creatively redesign traditional experiments with a green focus (using the various principles of green chemistry)

### COURSE CONTENT

<b>Unit I</b>	<b>Medicinal Chemistry</b>	<b>10</b>
	<b>1.1 :General Introduction to Drugs:</b> Sources of Drugs, Requirement of an Ideal Drug, Classification of Drugs, Nomenclature of Drugs, Definition of Some Medicinal Terms, Pharmacopoeia	<b>04</b>
	<b>1.1.2 Synthesis and uses of the following drugs:</b> 1) Ethambutol    2) Mebendazole    3) Benadryl 4) Ibuprofen    5) Miconidazole    6) Diazepam	<b>04</b>
	<b>1.1.3 Fluoroaromatics:</b>	



<b>Unit III</b>	<b>Green chemistry - I</b>	<b>10</b>
	<p><b>3.1 Introduction, basic principles of green chemistry and synthesis:</b>  Twelve principles of green chemistry, concept of atom economy and E-factor, calculations and their significance, numerical examples.  General idea of the following;  i) Green reagents: dimethyl carbonate. ii) Green starting materials: D-glucose  iii) Green solvents : supercritical CO<sub>2</sub> iv) Green catalysts: Bio catalysts.</p> <p><b>3.2 Accelerating Innovations through Emerging Green Technologies</b>  <b>3.2.1</b> Green Energy, Global Warming (Climate Change), Renewable energy  <b>3.2.2</b> Microwave Assisted Synthesis; Ultrasound Assisted Synthesis  <b>3.2.3 Green Solvents</b>  Problems associated with traditional solvents, Water as a green solvent, Ionic Liquids, Supercritical CO<sub>2</sub>  <b>3.2.4 Green Catalysts</b>  General Introduction to Catalysis, Types of Catalysts, Green Catalyst,  Nano catalyst: Advantages and Disadvantages of Nano catalysts</p>	<p><b>04</b></p> <p><b>06</b></p>

### Reference:

1. B.Pearson- Speciality Chemical Innovations in Industrial Synthesis.
2. Text Book of Organic Medicinal and Pharmaceutical Chemistry Wilson & Giswold
3. Text Book of Pharmacology – Satoskar & Bhandarkar.
4. Shreeves 'Chemical Process Industries' 5<sup>th</sup> Edition, G. T. Oustin, McGraw Hill.
5. Industrial Chemistry- B. K. Sharma, Goyal publishing house, Mirut.
6. Riegel's Handbook of Industrial Chemistry, J. A. Kent, CBS Publishers, New Delhi
7. Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner
8. Green Chemistry: An Introductory Text by Mike Lancaster
9. Green Chemistry and Engineering: A Practical Design Approach by Concepción Jiménez-González and David J.C. Constable
10. Introduction to Green Chemistry by Albert Matlack
11. Green Chemistry: Environmentally Benign Reactions by V. K. Ahluwalia
12. Green Chemistry: Introduction, Application and Scope" by Vinod K. Tiwari, Abhijeet Kumar, Sanchayita Rajkhowa, Garima Tripathi, and Anil Kumar Singh
13. Green Chemistry: Principles and Case Studies by V. K. Ahluwalia

## Semester – V

### Practicals–Elective-2

Course Code: VSCH308 Credits: 2

(Medicinal and Green Chemistry)

(Micro scale Preparation and Estimations)

#### Learning Objectives:

- Understand the procedure and crystallization method for the preparation of **Ferrous sulphate heptahydrate**.
- Synthesize **Aspirin** and explain its mechanism of formation and pharmaceutical relevance.
- Perform **green synthesis of benzilic acid** using solvent-free conditions and evaluate its environmental benefits
- Estimate the iodine content in **tincture iodine** using redox titration principles.
- Conduct **back titration** for the estimation of **methyl salicylate** in a sample and understand the concept of excess reagent.
- Estimate the concentration of **acetic acid in vinegar** using standard base titration.
- Calculate **percentage yield, purity, and experimental errors** for the prepared compounds.
- Interpret **stoichiometric relationships** and **titration curves** to understand the quantitative aspects of chemical reactions.
- Evaluate the **sustainability and safety** aspects of green chemistry practices used in synthesis.

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#### Course Outcomes

CO 1: Apply principles of green and conventional chemistry to perform micro-scale preparations of organic and inorganic compounds

CO 2: Develop analytical skills for the estimation of organic and inorganic substances using classical titrimetric and back titration techniques.

CO 3: Analyze experimental data to assess the efficiency, accuracy, and environmental impact of chemical processes.

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#### Single step organic/Inorganic preparation (1.0 g scale) involving purification by recrystallization method for organic preparations

##### Preparations: (Micro scale)

4. Preparation of Ferrous sulphate heptahydrate
5. Preparation of Aspirin
6. Green synthesis of benzilic acid from benzil

##### Estimations

- 4) Estimation of tincture iodine.
  - 5) Estimation of methyl salicylate. (Back titration method)
  - 6) Estimation of acetic acid in a sample of vinegar (Titrimetric)
-

## Reference:

1. Comprehensive Practical Organic Chemistry: Preparation and
  2. Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
  3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
  4. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
  5. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
  6. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
  7. Vogel's Textbook of Practical Organic Chemistry, Fifth edition, 2008, B.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
  8. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
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## Semester – VI

### Paper IV: Electives-1

Course Code: VSCH355 Credits: 2

#### (Industrial Chemistry- II)

#### Course Learning Objectives

Upon completion of the course the student will be able to understand

- Importance of chemical industry,
- Meaning of the terms involved,
- Comparison between batch and continuous process,
- Knowledge of various industrial aspects
- Concept of basic chemicals,
- Their uses and manufacturing process.
- They should also know the physico-chemical principals involved in manufacturing process

#### Course Outcome

Upon completing the course, the student will be able to understand

CO1	Various methods of refrigeration and cold storage systems.
CO2	Manufacturing process, properties and applications of bulk chemicals and composite materials.
CO3	Concept of Small-Scale Industries, rules and regulations and R and D technology in industry.
CO4	General idea of the common unit operations used in chemical Industries

#### COURSE CONTENT

Unit-I	Bulk Chemicals	10
	<b>1.1 Refrigeration:</b> System, media used for cold transfer (i.e. brine and other)	02
	<b>1.2 Manufacturing process properties and applications of :</b> a) Sulphuric acid (Contact Process) b) Ammonia (Haber's process) c) Sodium hydroxide	02
	<b>1.3 Zeolites, Clays and Ion-exchange resins</b>	02
	<b>1.4 Design of vessel :</b> Classification of chemical reactors, pressure vessels for internal or external pressure, Maintenance, storage vessels for liquids and gases	02
	<b>1.5 Industrial preparation of Inorganic Fine chemicals:</b> KMnO <sub>4</sub> , FeSO <sub>4</sub> .10H <sub>2</sub> O	02
Unit-II	<b>2.1 Composite materials:</b> Introduction, Constitution of composites, Classification of composites, Particle Reinforced composites, Fiber reinforced composites, Structural composites or Layered composites, Applications of composite materials.	03
	<b>2.2 Unit Operations:</b> General idea of the following operations used in Industries; <b>a. Filtration:</b> Introduction, factors affecting the rate of Filtration, Filtration Processes. a) Plate and frame filter Press b) Rotary Drum filter <b>b. Distillation:</b> Introduction, Distillation methods a) Bubble cap column distillation b) Fractional distillation	07

	<p><b>c. Crystallization :</b>Introduction, Solubility, Super saturation, Nucleation, Crystal growth, Crystallization process ,</p> <p>a) Agitated Tank Crystallizer, b) Swenson Walker Crystallizer</p> <p><b>d. Centrifugation:</b> Introduction, Centrifugation process used in Industry.</p>	
<b>Unit III</b>	<b>Small Scale Industries</b>	<b>10</b>
	<p><b>3.1 Small Scale Industries and R and D technology:</b> Need and scope of small-scale industry, SSI rules and regulations R and D, technology transfer, Role of R and D, Functional structure of R and D unit, Research strategies and manufacturing interface, University-Industry interface,</p> <p><b>3.2 Manufacture of soaps:</b> Raw materials, Preparation, properties and types of soaps, Continuous process for the manufacture of soap.</p> <p><b>3.3 Oils and Fats:</b> Introduction, Classification, Properties of oils and fats, extraction of oils from oil seeds, hydraulic pressing and solvent extraction, extraction of animal fats, hardening of oils</p> <p><b>3.4 Detergents:</b> Introduction, classification, manufacture of DDBS, industrial applications.</p>	<p>04</p> <p>02</p> <p>02</p> <p>02</p>

#### Reference:

1. Industrial Chemistry, B. K. Sharma, Goel publishing House, 18th Ed. (2014)
  2. Faith Keyes and Clerk's Industrial Chemicals, 4<sup>th</sup>Edn., Wiley Inter-science 1975.
  3. P. H. Groggins: Unit Processes in Organic Synthesis, McGraw Hill.
  4. Kirk & Othmer: Encyclopaedia of Chemical Technology, John Wiley and sons.
  5. Industrial Inorganic Chemistry-Buchner, Schliebs, Winter, translated by D. H. Tenell, VCH Publishers, New York.
  6. Industrial Organic Chemistry- K. Welssermel, H. J. Arpe, VCH Publishers, New York.
  7. Pearson- Speciality Chemical Innovations in Industrial Synthesis.
  8. Shreeves 'Chemical Process Industries' 5<sup>th</sup> Edition, G. T. Oustin, McGraw Hill.
  9. Riegel's Hand Book of Industrial Chemistry, 9<sup>th</sup> Edition, Jems A. Kent.
  10. Industrial Chemistry- E Stoch, Vol- I, Ellis Horwood Ltd. UK.
  11. An Introduction to Industrial Organic Chemistry- Wiseman and Peter, ""
  12. Riegel's Handbook of Industrial Chemistry, J. A. Kent, CBS Publishers, New Delhi
  13. Industrial Chemistry, Part-II, R. K. Das, Kalyani Publisher, Second Ed.Shreeves 'Chemical Process Industries' 5<sup>th</sup> Edition, G. T. Austin, McGraw Hill, 1984.
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## Semester – VI

### Practicals–Elective-1

Course Code: VSCH356 Credits: 2

#### (Industrial Chemistry- II)

#### (Micro scale Preparation and Estimations)

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#### Learning Objectives:

1. Understand the fundamental principles behind micro-scale synthesis of organic and inorganic compounds.
2. Perform single-step syntheses of compounds like copper sulfate pentahydrate, Ni-DMG complex, and paracetamol on a 1.0 g scale.
3. Develop skills in purification techniques, specifically recrystallization, for organic preparations.
4. Accurately prepare standard solutions and perform acid-base and back titration methods.
5. Estimate active pharmaceutical ingredients (e.g., aspirin, ibuprofen) in commercial samples using titrimetric analysis.
6. Apply appropriate indicators (1-naphtholphthalein, phenolphthalein) in the titration of complex samples like phosphoric acid.
7. Analyze and interpret experimental data to determine the composition and purity of chemical samples.
8. Relate laboratory procedures to real-world applications through an industrial visit and report writing.

#### Course Outcomes:

**CO1:** Demonstrate competency in performing micro-scale organic and inorganic syntheses with proper purification and yield calculation.

**CO2:** Quantitatively analyze pharmaceutical and industrial samples using titrimetric techniques with accuracy and precision.

**CO3:** Connect theoretical chemistry concepts with practical applications through hands-on lab work and exposure to industrial practices.

#### Single step organic/Inorganic preparation (1.0 g scale) involving purification by recrystallization method for organic preparations.

##### Preparation: (Micro scale)

1. Copper sulphate pentahydrate
2. Preparation of Ni-DMG complex
3. Paracetamol from p-Aminophenol

##### Estimation:

1. Determination of the amount of phosphoric acid from a given sample using 1-naphtholphthalein and phenolphthalein indicator. (Students to prepare succinic acid solution for standardization of NaOH).
2. Determination of the amount of magnesium hydroxide in a commercial sample of milk of magnesia.
3. Estimation of Ibuprofen in the given sample (Back titration method)

**Industrial visit:**

- Visit to any one of the Chemical / Pharmaceutical / Polymer / Research Institutes / Sugar Factories / waste water treatment plants, etc. is essential and a systematic report is to be submitted by the student along with the journal to the Department of Chemistry
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**Learning points:**

1. Students are expected to know
    - Calculation of theoretical yield, percentage yield and reaction parameters employed in the reactions, and **safety Aspects including MSDS**
    - The possible mechanism, preparations of standard solutions, standardization, etc
  2. Students are expected to purify the product by recrystallization method for organic preparations, determine physical constant and calculate percentage yield.
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**Reference:**

1. Comprehensive Practical Organic Chemistry: Preparation and
  2. Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
  3. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
  4. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
  5. Vogel's Textbook of Practical Organic Chemistry, Fifth edition, 2008, B.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
  6. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
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**Semester – VI**  
**Paper V: Electives-2**  
**Course Code: VSCH357      Credits: 2**  
**(Chemistry of Dyestuffs and Green Chemistry)**

**Course Learning Objectives**

Upon completion of the course the student will be able to understand

- Importance of Dyestuffs industry,
- Meaning of the different terms involved in Dyestuffs industry,
- Their uses and manufacturing process.
- Inculcating the need to practice green chemistry as it is the only way to meet the global challenges the world is facing today.
- Providing a basis and framework for pursuing science in the most creative, innovative and responsible manner possible.
- Enabling students to learn about the green trends being practiced by industries as well as academicians through demonstration of some real-world case studies.

**COURSE OUTCOME**

Upon completing the course, the student will be able to

<b>CO1</b>	Understand the basic understanding of dyes, sources of dyes, classification and terminology involved in Dyestuffs industry
<b>CO2</b>	Designing and uses of different dyes used for dyeing different fibers.
<b>CO3</b>	Learn about the green trends being practiced in pharmaceutical industries through depiction of some interesting industrial case studies
<b>CO4</b>	Learn about academic-industrial collaborations and the potential these relationships hold in furthering green chemistry and making our planet Earth greener

**COURSE CONTENT**

<b>Unit-1</b>	<b>Introduction to the Dye-stuff Industry</b>	<b>10 H</b>
	Definition of dyes, Requirements of a good dye, Chromophore and Auxochrome, Solubility, Economic viability. Definition of fastness and its properties and Mordants with examples	03
	<b>Natural Dyes:</b> Definition and limitations of natural dyes. Examples and uses of natural dyes: Heena, Turmeric, Saffron, Indigo, Madder, Chlorophyll – names of the chief dyeing material/ s in each natural dye.	03
	<b>Synthetic dyes:</b> Definition of synthetic dyes, primaries and intermediates. Important milestones in the development of synthetic dyes – Emphasis on Name of the Scientist and dyes.	
	<b>Classification of Dyes based on Applications and Dyeing</b> Classification of dyes based on applicability on substrates (examples with structures). a) Acid Dyes – Orange II	04

	<p>b) Basic Dyes – Methyl Violet</p> <p>c) Direct Cotton Dyes – Benzofast Yellow 5GL</p> <p>d) Azoic Dyes – Diazo components; Fast Yellow G, Fast Orange R</p> <p>e) Mordant Dyes – Eriochrome Black A, Alizarin</p> <p>f) Vat Dyes – Indanthrene Brown RRD</p> <p>g) Sulphur Dyes – Sulphur Black T (no structure)</p> <p>h) Disperse Dyes – Celliton Fast Brown 3R</p> <p>i) Reactive Dyes – Cibacron Brilliant Red B</p>	
<b>Unit II</b>	<p><b>2.1 Substrates for Dyes:</b> Types of Fibres, Natural: cellulosic and proteinaceous fibres, examples – wool, silk and cotton structures and names of dyes applied on each of them. Semi-synthetic: definition and examples [structures not expected]. Synthetic: Nylon, Polyesters and Polyamides structures and names of dyes applied on each of them. Blended fabrics: definition and examples [structures not expected]. Binding forces of dyes on substrate: ionic forces, covalent linkages, hydrogen bonding, vander-waals forces.</p> <p><b>2.2 Dyeing methods</b> <b>Basic operations involved in dyeing process:</b> (i) Preparation of fibres (ii) Preparation of dyebath (iii) Application of dyes (iv) Finishing <b>Dyeing method of Cotton Fibres:</b> (i) Direct dyeing (ii) Vat dyeing (iii) Mordant dyeing (iv) Disperse dyeing</p> <p><b>2.3 Synthesis and applications of the following dyes:</b> 1) Indigo 2) Alizarin 3) Eriochrome Black-T 4) Auramine-O 5) Procion-red 6) Congo red</p>	<p>04</p> <p>03</p> <p>03</p>
<b>Unit III</b>	<b>Green chemistry-II</b>	<b>10</b>
	<p><b>3.1 Green Chemistry solutions for water pollution (Current Green Technologies employed in Water Treatment)</b></p> <ul style="list-style-type: none"> <li>➤ Water Pollution and root causes</li> <li>➤ Catalytic Degradation of organic water pollutants</li> <li>➤ Photo-oxidation technologies</li> <li>➤ Removal of heavy metals (inorganic pollutants) via new adsorption technology</li> </ul> <p><b>3.2 Green Chemistry in Pharmaceutical Industry</b></p> <ul style="list-style-type: none"> <li>➤ Green Trends being followed in Pharmaceutical Industry</li> <li>➤ Industrial Case Studies: Ranitidine, Celecoxib, Ibuprofen, Sertraline</li> <li>➤ Special Recognition: US Presidential Green Challenge Awards</li> </ul> <p><b>3.3 New Technological Developments:</b> New Avenues for the Green Economy and Sustainable Future of Science and Technology Future Prospectives</p>	<p>04</p> <p>04</p> <p>02</p>

## Reference:

1. B. Pearson- Speciality Chemical Innovations in Industrial Synthesis.
  2. Text Book of Organic Medicinal and Pharmaceutical Chemistry Wilson & Giswold
  3. Text Book of Pharmacology – Satoskar & Bhandarkar.
  4. Shreeves 'Chemical Process Industries' 5<sup>th</sup> Edition, G. T. Oustin, McGraw Hill.
  5. Industrial Chemistry- B. K. Sharma, Goyal publishing house, Mirut.
  6. Riegel's Handbook of Industrial Chemistry, J. A. Kent, CBS Publishers, New Delhi
  7. Green Chemistry: Theory and Practice by Paul T. Anastas and John C. Warner
  8. Green Chemistry: An Introductory Text by Mike Lancaster
  9. Green Chemistry and Engineering: A Practical Design Approach by Concepción Jiménez-González
  10. and David J.C. Constable
  11. Introduction to Green Chemistry by Albert Matlack
  12. Green Chemistry: Environmentally Benign Reactions by V. K. Ahluwalia
  13. Green Chemistry: Introduction, Application and Scope" by Vinod K. Tiwari, Abhijeet Kumar,
  14. Sanchayita Rajkhowa, Garima Tripathi, and Anil Kumar Singh
  15. Green Chemistry: Principles and Case Studies by V. K. Ahluwalia
  16. The Chemistry of Synthetic Dyes – Edited by K. Venkatraman. Academic press Inc. London
  17. Elementary Idea of Textile Dyeing, Printing and Finishing" by Kanwar Varinder Pal Singh
  18. Wild Colour: How to Grow, Prepare and Use Natural Plant Dyes" by Jenny Dean
  19. Handbook on Natural Dyes for Industrial Applications" by NIIR Project Consultancy Services
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## Semester – VI

### Practicals–Elective-II

Course Code: VSCH358 Credits: 2

(Chemistry of Dyestuffs and Green Chemistry)

(Micro scale Preparation and Estimations)

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#### Learning Objectives:

1. Understand the theoretical basis and experimental techniques for single-step organic and inorganic synthesis on a 1.0 g scale.
  2. Synthesize copper sulfate pentahydrate and perform bromination and nitration reactions under controlled micro-scale conditions.
  3. Gain hands-on experience in using eco-friendly and aqueous media for substitution reactions (e.g., using  $\text{Ca}(\text{NO}_3)_2$  and ferric ammonium nitrate).
  4. Learn and apply purification techniques such as recrystallization to isolate and purify organic compounds.
  5. Accurately determine the strength and content of acids, bases, and pharmaceutical compounds using titrimetric methods.
  6. Prepare standard solutions (e.g., succinic acid) and use appropriate indicators (1-naphtholphthalein, phenolphthalein) for complex titrations.
  7. Perform back titration techniques for the estimation of compounds like aniline and magnesium hydroxide in commercial samples.
  8. Relate laboratory skills to real-world industrial practices through a guided visit and report to a chemical/pharmaceutical/research facility.
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#### Course Outcomes

After successful completion of the course, students will be able to:

**CO1:** Demonstrate practical skills in synthesizing and purifying compounds using green and micro-scale chemistry techniques.

**CO2:** Apply accurate volumetric analysis methods to estimate active ingredients in industrial and pharmaceutical samples.

**CO3:** Integrate theoretical understanding with industrial exposure through analytical tasks and a structured industrial visit report.

**Single step organic/Inorganic preparation (1.0 g scale) involving purification by recrystallization method for organic preparations.**

#### Preparation: (Micro scale)

1. Copper sulphate pentahydrate
2. Bromination of acetamide using ferric ammonium nitrate and KBr in aqueous medium.
3. Nitration of phenol or substituted phenols using  $\text{CaNO}_3$

### **Estimation:**

1. Determination of the amount of phosphoric acid from a given sample using 1-naphtholphthalein and phenolphthalein indicator. (Students to prepare succinic acid solution for standardization of NaOH).
2. Determination of the amount of magnesium hydroxide in a commercial sample of milk of magnesia.
3. Estimation of Aniline (Back titration method)

### **Industrial visit:**

- Visit to any one of the Chemical / Pharmaceutical / Polymer / Research Institutes / Sugar Factories / waste water treatment plants, etc. is essential and a systematic report is to be submitted by the student along with the journal to the Department of Chemistry
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### **Learning points:**

1. Students are expected to know
    - a. Calculation of theoretical yield, percentage yield and reaction parameters employed in the reactions, and **safety Aspects including MSDS**
    - b. The possible mechanism, preparations of standard solutions, standardization, etc
  2. Students are expected to purify the product by recrystallization method for organic preparations, determine physical constant and calculate percentage yield.
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### **Reference:**

1. Comprehensive Practical Organic Chemistry: Preparation and
2. Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
5. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
6. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
7. Vogel's Textbook of Practical Organic Chemistry, Fifth edition, 2008, B.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
8. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.



T.Y.B.Sc. CHEMISTRY (Six Units): Choice Based Credit System			
Semester - V			
PAPER – IV: VSC (Advanced Experimental Chemistry)			
Course Name: Vocational Skill Course in Chemistry (VSC)(60Hrs Practicals)		Course Code: VSCH309	
Periods per week (1 period 120 minutes)			
Credits		2	
EvaluationSystem		Hours	Marks
	Practical Examination	2.0	100
<p><i>Learning Objectives:</i></p> <ol style="list-style-type: none"> <li>1. To perform the synthesis of aspirin and analyze its purity using melting point and TLC techniques.</li> <li>2. To prepare soap from natural oils and determine its cleansing efficiency through standardized testing methods.</li> <li>3. To extract and characterize essential oils from citrus peels using steam distillation and discuss its industrial relevance.</li> <li>4. To assess environmental water samples for DO, COD, and sulphate content, interpreting results with respect to water quality standards.</li> <li>5. To utilize analytical instruments such as spectrophotometers, flame photometers, potentiometers, and conductometers for chemical estimations in complex matrices.</li> <li>6. To explore redox behavior and surface area estimation through cyclic voltammetry for environmental and pharmaceutical applications.</li> </ol>			
<p>❖ <b>Course Outcomes (COs)</b></p> <p>By the end of this course, students will be able to:</p> <p><b>CO1:</b> Apply chemical synthesis and purification techniques to develop and analyze common industrial and pharmaceutical compounds like aspirin and soap.</p> <p><b>CO2:</b> Evaluate environmental samples using standard green chemistry protocols for water quality analysis, including DO, COD, and sulphate estimation.</p> <p><b>CO3:</b> Employ modern instrumental techniques (e.g., spectrophotometry, potentiometry, flame photometry) for qualitative and quantitative analysis of chemical species.</p> <p><b>CO4:</b> Interpret electrochemical behavior of biologically and environmentally relevant analytes using cyclic voltammetry and other electroanalytical methods.</p>			
UNIT	Practical Contents	No. of lectures	
UNIT - I	Industrial & Applied Chemistry	15	
	<ol style="list-style-type: none"> <li>1. Synthesis of Aspirin and its Purity Analysis by Melting Point &amp; TLC</li> <li>2. Preparation of Soap and Determination of its Cleansing Power</li> <li>3. Extraction of Essential Oil from Citrus Peels using Steam Distillation</li> <li>4. Determination of Saponification and Acid Value of Oils &amp; Fats</li> </ol>		

<b>UNIT - II</b>	Environmental & Green Chemistry	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Analysis of Dissolved Oxygen (DO) in Water by Winkler's Method</li> <li>2. Estimation of pH and TDS in Drinking Water</li> <li>3. Natural Indicator Preparation from Plant Sources</li> <li>4. Simple Paper Chromatography of Dyes in Polluted Water</li> <li>5. Paper Chromatography for Separation of Plant Pigments or Ink Dyes</li> </ol>	
<b>UNIT - III</b>	Instrumental & Analytical Techniques	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Colorimetric Estimation of Copper Using Spectrophotometer/Colorimeter</li> <li>2. Flame Photometric Estimation of Sodium and Potassium in a Sample</li> <li>3. Potentiometric Titration of Fe<sup>2+</sup> with K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub></li> <li>4. Conductometric Determination of Critical Micelle Concentration (CMC) of a Surfactant</li> <li>5. Determination of pH of Various Samples Using a Digital pH Meter (Beverages)</li> </ol>	
<b>UNIT - IV</b>	Cyclic Voltammetry & Electrochemical Analysis	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Electrochemical Analysis of Dopamine: Investigating its Redox Behavior in Biological Systems</li> <li>2. Determination of Electrochemical Active Surface Area using Ferrocene as a Probe</li> <li>3. Cyclic Voltammetric Study of Lead and Cadmium Ions in Water Samples.</li> <li>4. Electrochemical Behavior of Plant Extracts (e.g., Green Tea or Neem) using CV</li> </ol>	

#### References:

1. Vogel, A. I. (2008). Vogel's Textbook of Quantitative Chemical Analysis. Pearson.
2. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of Instrumental Analysis. Cengage Learning.
3. Bard, A. J., & Faulkner, L. R. (2001). Electrochemical Methods: Fundamentals and Applications. Wiley.
4. Christian, G. D. (2004). Analytical Chemistry. Wiley.
5. Bahl, B. S., & Bahl, A. (2012). Advanced Organic Chemistry. S. Chand.
6. Manahan, S. E. (2011). Environmental Chemistry. CRC Press.
7. Laboratory Manual of Organic Chemistry, R. K. Bansal, New Age International Publishers.
8. Environmental Chemistry, A.K. De, New Age International Publishers.
9. Standard Methods for the Examination of Water and Wastewater, APHA, AWWA, WEF.
10. Instrumental Methods of Chemical Analysis, B.K. Sharma, Goel Publishing House.
11. Electrochemical Methods: Fundamentals and Applications, Allen J. Bard, Larry R. Faulkner, Wiley.

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<b>T.Y.B.Sc. CHEMISTRY (Six Units):Choice Based Credit System</b>			
<b>Semester - VI</b>			
<b>PAPER – IV: VSC</b> (Hands-on Advanced Laboratory Techniques: Synthesis, Analysis, and Sustainable methods)			
<b>Course Name: Vocational Skill Course in Chemistry (VSC)(60Hrs Practicals)</b>		<b>Course Code:</b> VSCH359	
<b>Periods per week (1 period 120 minutes)</b>			
<b>Credits</b>		<b>2</b>	
<b>Evaluation System</b>		<b>Hours</b>	<b>Marks</b>
	<b>Practical Examination</b>	<b>2.0</b>	<b>100</b>
<p><i>Learning Objectives:</i></p> <ol style="list-style-type: none"> <li>1. To estimate phosphate in detergents and other samples using spectrophotometric analysis, correlating with environmental regulations.</li> <li>2. To synthesize and evaluate soaps and bioethanol, determining their physical and chemical properties including saponification value.</li> <li>3. To conduct pharmaceutical assays (e.g., aspirin, vitamin C, paracetamol) using spectroscopic and electrochemical methods.</li> <li>4. To understand and perform dissolution and disintegration tests of tablets as per pharmacopeial standards.</li> <li>5. To apply electrochemical techniques (CV, EIS) and separation methods (ion exchange, HPLC) in analyzing real-world pharmaceutical and environmental samples.</li> <li>6. To explore green chemistry techniques in the synthesis of biodegradable polymers, nanoparticles, and natural dyes with potential industrial applications.</li> </ol>			
<p>❖ <b>Course Outcomes (COs)</b></p> <p>By the end of this course, students will be able to:</p> <ol style="list-style-type: none"> <li>1. <b>CO1:</b> Apply chemical synthesis and characterization techniques to manufacture and evaluate industrial and pharmaceutical products like soap, bioethanol, and polymers.</li> <li>2. <b>CO2:</b> Utilize spectrophotometric, conductometric, and chromatographic techniques for qualitative and quantitative pharmaceutical analysis.</li> <li>3. <b>CO3:</b> Demonstrate electrochemical methods such as cyclic voltammetry and electrochemical impedance spectroscopy in evaluating pharmaceutical compounds and metal complexes.</li> <li>4. <b>CO4:</b> Integrate principles of green chemistry and sustainability by employing eco-friendly approaches in nanoparticle synthesis, natural dye extraction, and environmental pollutant estimation.</li> </ol>			
<b>UNIT</b>	<b>Practical Contents</b>	<b>No. of lectures</b>	
<b>UNIT - I</b>	Industrial and Pharmaceutical Chemistry	<b>15</b>	
	<ol style="list-style-type: none"> <li>1. Estimation of Phosphate in Detergents (Spectrophotometric Method)</li> <li>2. Preparation of Soap and Determination of Saponification Value</li> <li>3. Synthesis of Bioethanol from Sugar or Starch Sources</li> <li>4. Polymerization Reaction for Making a Simple Polymer</li> </ol>		

<b>UNIT - II</b>	Analytical and Instrumental Techniques	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Spectrophotometric Estimation of Iron using 1,10-Phenanthroline</li> <li>2. Assay of Aspirin and Vitamin C Tablets- by Conductometry</li> <li>3. Determination of paracetamol in tablets by using spectrophotometric method.</li> <li>4. Dissolution and Disintegration Tests for Tablets</li> <li>5. pH and Buffer Preparation in Pharmaceutical Solutions</li> </ol>	
<b>UNIT - III</b>	Electrochemical and Separation Techniques	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Cyclic Voltammetric Study of a Metal Complex (Electrochemical Characterization)</li> <li>2. Electrochemical Analysis of Tartaric acid using CV</li> <li>3. Determination of Corrosion Rate using Electrochemical Impedance Spectroscopy (EIS)</li> <li>4. Ion Exchange Chromatography – Separation of Metal Ions (<math>Zn^{2+}</math> &amp; <math>Mg^{2+}</math>)</li> <li>5. HPLC Analysis of Caffeine Content in Beverages (Demonstration/Hands-on Analysis)</li> </ol>	
<b>UNIT - IV</b>	Environmental and Sustainable Chemistry	<b>15</b>
	<ol style="list-style-type: none"> <li>1. Estimation of Nitrate in Drinking Water</li> <li>2. Synthesis of Nanoparticles using Green Chemistry Approach</li> <li>3. Extraction of Natural Dyes and Their Applications.</li> <li>4. Biodegradable Polymer Synthesis and Characterization</li> </ol>	

#### References:

1. Vogel, A. I. (2008). Vogel's Textbook of Quantitative Chemical Analysis. Pearson.
2. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of Instrumental Analysis. Cengage Learning.
3. Bard, A. J., & Faulkner, L. R. (2001). Electrochemical Methods: Fundamentals and Applications. Wiley.
4. Christian, G. D. (2003). Analytical Chemistry. Wiley India Pvt. Ltd.
5. Manahan, S. E. (2011). Environmental Chemistry. CRC Press.
6. Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A. (2012). Instrumental Methods of Analysis. CBS Publishers.
7. Pavia, D. L., Lampman, G. M., & Kriz, G. S. (2014). Introduction to Spectroscopy. Cengage Learning.
8. Anastas, P. T., & Warner, J. C. (1998). Green Chemistry: Theory and Practice. Oxford University Press.
9. Practical Pharmaceutical Chemistry, A.H. Beckett & J.B. Stenlake, Part I & II, CBS Publishers.
10. Instrumental Methods of Analysis, Willard, Merritt, Dean & Settle, CBS Publishers.
11. Indian Pharmacopoeia / USP / BP (for standards on assays and tablet analysis).



<b>T.Y.B.Sc. Chemistry: Choice Based Credit System</b>				
<b>Semester-V</b>				
<b>Course Name: Modern Chemistry: Theory, Reactions, and Techniques – I</b>			<b>Course Code</b>	
(30 Lectures) (Minor)			VSCH310	
<b>Periods per week(1period 60 minutes)</b>			<b>02</b>	
<b>Credits</b>			<b>02</b>	
<b>Evaluation System</b>			<b>Hrs</b>	<b>Marks</b>
	<b>Theory Examination</b>		<b>2.0</b>	<b>60</b>
	<b>Theory Internal</b>			<b>40</b>
<b>Learning Objectives:</b>				
<ol style="list-style-type: none"> <li>1. Apply Thermodynamic Principles – Understand and apply the laws of thermodynamics, calculate changes in enthalpy, entropy, and internal energy, and use Gibbs free energy to predict spontaneity and equilibrium.</li> <li>2. Analyze Chemical Equilibria – Describe dynamic equilibrium in chemical and phase systems, apply Le Chatelier’s Principle, and interpret phase diagrams while calculating equilibrium constants (K<sub>p</sub>, K<sub>c</sub>).</li> <li>3. Understand Chemical Kinetics – Derive and use rate laws, determine reaction order and rate constants, propose reaction mechanisms, and analyze energy profiles and transition states in reaction pathways.</li> <li>4. Apply Electrochemical Principles – Perform calculations involving electrolysis (Faraday’s laws), describe the working of galvanic and electrolytic cells, apply the Nernst equation, and predict redox reaction direction under non-standard conditions.</li> <li>5. Characterize Organic Molecules and Reactions – Identify stereoisomerism, analyze molecular chirality and optical activity, evaluate conformers, predict products of nucleophilic and electrophilic reactions, and explain regioselectivity in aromatic substitution.</li> <li>6. Utilize Spectroscopic Techniques – Understand the principles of UV-Vis, IR, and NMR spectroscopy, interpret spectra to identify functional groups and molecular structures, and correlate spectroscopic data with organic compounds.</li> <li>7. Analyze Coordination Chemistry and Materials Science – Classify ligands, apply Crystal Field Theory, interpret electronic structures, understand the role of metal complexes in catalysis and medicine, and discuss industrial and environmental impacts of metals.</li> <li>8. Apply Analytical and Thermal Methods – Understand GC, HPLC, polarography, and amperometry, interpret chromatograms and voltammograms, and analyze material properties using TGA, DTA, and DSC for thermal stability and phase transitions.</li> </ol>				

**Course Outcomes (COs):**By the end of this course, students will be able to:

<b>CO 1:</b>	<b>Demonstrate</b> an understanding of fundamental concepts in Physical, Organic, Inorganic, and Analytical Chemistry.
<b>CO 2:</b>	<b>Apply</b> chemistry principles to solve theoretical and experimental problems in different domains
<b>CO 3:</b>	<b>Analyze</b> data using spectroscopic, chromatographic, and electroanalytical techniques for qualitative and quantitative estimations.
<b>CO 4:</b>	<b>Understand</b> the fundamentals of organic reaction mechanisms including nucleophilic and electrophilic reactions. Describe mechanisms and factors influencing electrophilic and nucleophilic aromatic substitution reactions.

<b>Unit</b>		<b>No. of Periods</b>
<b>Unit-I</b>	<p><b>1.1 Thermodynamics and Equilibrium</b></p> <p>1.1.1 Laws of thermodynamics and Gibbs free energy</p> <p>1.1.2 Chemical and phase equilibria</p> <p><b>1.2 Chemical Kinetics</b></p> <p>1.2.1 Rate laws and reaction mechanisms</p> <p>1.2.2 Catalysis and reaction dynamics</p> <p><b>1.3 Electrochemistry</b></p> <p>1.3.1 Conductance, electrolysis, and electrochemical cells</p> <p>1.3.2 Nernst equation and applications</p>	<b>07</b>
<b>Unit-II</b>	<p><b>2.1 Reaction Mechanisms and Stereochemistry</b></p> <p>2.1.2 Stereoisomerism and conformational analysis</p> <p><b>2.2 Functional Group Chemistry</b></p> <p>2.2.1 Alcohols, carbonyl compounds, and amines</p> <p>2.2.2 Aromatic substitution reactions</p> <p><b>2.3 Introduction to UV-Vis, IR, and NMR spectroscopy for organic compound identification</b></p>	<b>08</b>

<b>Unit-III</b>	<p><b>3.1 Coordination Chemistry</b>  3.1.1 Ligands, coordination numbers, and crystal field theory  3.1.2 Applications in catalysis and medicine</p> <p><b>3.2 Introduction to Transition Elements</b>  3.2.2 Biological and industrial importance of metals</p> <p><b>3.3 Solid State Chemistry</b>  3.3.1 Crystal structures, defects, and band theory  3.3.2 Superconductors and nanomaterials</p>	<b>08</b>
<b>Unit-IV</b>	<p><b>4.1 Instrumental Techniques</b>  4.1.1 Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC)</p> <p><b>4.2 Electroanalytical Methods</b>  4.2.1 Polarography amperometry,</p> <p><b>4.3 Thermal Analysis Techniques</b>  4.3.1 Thermogravimetric Analysis (TGA)  4.3.2 DTA/TT</p>	<b>07</b>
<p><b>References:</b></p> <ol style="list-style-type: none"> <li>1. <b>Atkins, P., &amp; de Paula, J.</b> (2018). <i>Atkins' Physical Chemistry</i>. Oxford University Press.</li> <li>2. <b>Clayden, J., Greeves, N., Warren, S., &amp; Wothers, P.</b> (2012). <i>Organic Chemistry</i>. Oxford University Press.</li> <li>3. <b>Shriver, D. F., &amp; Atkins, P.</b> (2010). <i>Inorganic Chemistry</i>. Oxford University Press.</li> <li>4. <b>Skoog, D. A., Holler, F. J., &amp; Crouch, S. R.</b> (2017). <i>Principles of Instrumental Analysis</i>. Cengage Learning.</li> <li>5. <b>Vogel, A. I.</b> (2008). <i>Vogel's Textbook of Quantitative Chemical Analysis</i>. Pearson.</li> </ol>		

Practicals

(Minor)

Semester:

V

COURSE CODE: VSCH311

CREDITS: 2

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**Learning Objectives:**

1. Understand and Apply Kinetic and Thermodynamic Principles in Chemistry
2. Analyze Molecular and Ionic Behavior in Solutions
3. Develop Skills in Spectroscopic and Colorimetric Analysis
4. Master Separation and Purification Techniques in Organic Chemistry
5. Quantify and Analyze Chemical Composition of Natural Products
6. Perform Advanced Water Quality and Environmental Analysis
7. Develop Proficiency in Volumetric and Gravimetric Analytical Techniques
8. Enhance Practical Skills in Organic Synthesis and Inorganic Analysis

<b>CO 1</b>	Analyze reaction kinetics by determining activation energy, study temperature dependence of reactions, and apply theory of rate processes to experimental data.
<b>CO 2</b>	Perform conductometric measurements to determine Critical Micelle Concentration (CMC), apply the Nernst equation to evaluate standard electrode potentials, and analyze electrochemical behavior.
<b>CO 3</b>	Determine molecular weight of polymers using viscosity measurements, explore molecular interactions, and relate experimental findings to fundamental physical chemistry concepts.

**List of Experiments**

❖ **Physical Chemistry Experiments**

1. Determination of Activation Energy of the Reaction Between HCl and Sodium Thiosulfate – Study of temperature dependence.
2. Conductometric Determination of the Critical Micelle Concentration (CMC) of Sodium Dodecyl Sulfate (SDS) – Using conductivity measurements.
3. Determination of the Standard Electrode Potential of a  $Zn^{2+}/Zn$  Electrochemical Cell – Application of the Nernst equation.
4. Determination of Molecular Weight of a Polymer by Viscosity Measurements – Using an Ostwald viscometer.

❖ **Organic Chemistry Experiments**

5. Separation of a Mixture of Organic Compounds using Thin Layer Chromatography (TLC) – Identification of components.
6. Isolation of Caffeine from Tea Leaves and its Characterization – Using solvent extraction.

7. Determination of the Saponification Value of Coconut Oil – Analysis of fatty acids.
8. Synthesis of Aspirin (Acetylsalicylic Acid) and its Purity Analysis by Melting Point Measurement – Application of organic synthesis techniques.

#### ❖ Inorganic Chemistry Experiments

9. Synthesis of  $[\text{Cu}(\text{NH}_3)_4]^{2+}$  Complex and its Spectrophotometric Analysis – Understanding coordination chemistry.
10. Complexometric Determination of Calcium and Magnesium in Hard Water using EDTA – Quantification of metal ions.
11. Spectrophotometric Determination of Iron (III) using 1,10-Phenanthroline – Colorimetric analysis.
12. Analysis of Water Hardness using EDTA Titration – Estimation of total hardness.
13. Qualitative Analysis of Inorganic Cations and Anions in a Given Salt Mixture – Systematic identification.

#### ❖ Analytical Chemistry Experiments

14. Spectrophotometric Determination of Fluoride in Water – Quantitative estimation of fluoride.
15. Estimation of Chromium in a Water Sample using Diphenylcarbazide Spectrophotometry – Environmental analysis.
16. Determination of Chemical Oxygen Demand (COD) of water Sample – Water pollution assessment.
17. Potentiometric Determination of Acetic Acid Concentration in a Vinegar Sample using a Quinhydrone Electrode – Application of potentiometry.
18. Flame Photometric Determination of Sodium and Potassium in a Fertilizer Sample – Quantitative estimation of alkali metals

## References:

1. **Vogel, A. I.** (2008). *Vogel's Textbook of Quantitative Chemical Analysis*. Pearson.
2. **Skoog, D. A., Holler, F. J., & Crouch, S. R.** (2017). *Principles of Instrumental Analysis*. Cengage Learning.
3. **Mendham, J., Denney, R. C., Barnes, J. D., & Thomas, M.** (2000). *Vogel's Quantitative Chemical Analysis*. Pearson Education.
4. **Christian, G. D.** (2004). *Analytical Chemistry*. Wiley.
5. **Bassett, J., Denney, R. C., Jeffery, G. H., & Mendham, J.** (1999). *Vogel's Textbook of Inorganic Quantitative Analysis*. Longman.

## T.Y.B.Sc. Chemistry: Choice Based Credit System

### Semester-VI

#### Minor

<b>Course Name: Modern Chemistry: Theory, Reactions, and Techniques - II</b> (30 Lectures)	<b>Course Code VSCH360</b>
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**Periods per week(1period 60 minutes)**

**02**

**Credits**

**02**

**Evaluation System**

**Hrs**

**Marks**

**Theory Examination**

**2.0**

**60**

**Theory Internal**

**40**

**Learning Objectives:**

1. **Understand Partition Functions and Their Role** – Explain the significance of **partition functions** in molecular thermodynamics and their application in predicting **thermodynamic properties**.
2. **Apply the Boltzmann Distribution** – Use the **Boltzmann distribution** to describe the population of energy levels and its implications in **chemical and physical systems**.
3. **Compare Collision and Transition State Theories** – Differentiate between **collision theory** and **transition state theory**, explaining their role in **reaction rate determination**.
4. **Analyze Unimolecular and Bimolecular Reactions** – Interpret the kinetics of **unimolecular and bimolecular reactions**, applying theoretical models to explain **reaction mechanisms**.
5. **Evaluate Pericyclic Reactions** – Describe the principles and applications of **Michael addition, Diels-Alder reaction, electrocyclic, and sigmatropic rearrangements** in **organic synthesis**.
6. **Explore Heterocyclic Chemistry in Pharmaceuticals** – Synthesize and analyze the reactions of **furan, thiophene, and pyrrole**, and explore their role in **drug development**.
7. **Understand Metal-Ligand Interactions** – Explain the **spectrochemical series, ligand field stabilization energy (LFSE)**, and their influence on **coordination complexes**.
8. **Apply Organometallic Chemistry in Catalysis** – Describe the structure and reactivity of **metal-carbonyl complexes**, and compare **homogeneous and heterogeneous catalysis** in **industrial applications**.
9. **Apply Radioanalytical Techniques in Analysis** – Explain the **principles of neutron activation analysis (NAA) and isotope dilution**, and discuss their applications in **environmental and forensic science**.
10. **Analyze Environmental Pollutants and Contaminants** – Identify methods for detecting **pollutants in air, water, and soil**, and assess techniques for analyzing **toxic metals and organic contaminants**.

**Course Outcomes (COs):**

<b>CO 1</b>	Apply molecular and statistical thermodynamics principles to predict chemical behavior.
<b>CO 2</b>	Analyze organic reaction mechanisms and their industrial or pharmaceutical applications
<b>CO 3</b>	Interpret coordination and organometallic chemistry concepts for catalysis and material synthesis
<b>CO 4</b>	Utilize radioanalytical and environmental chemistry techniques for scientific investigation

<b>Unit</b>		<b>No. of Periods</b>
<b>Unit-I</b>	<b>1.1 Molecular Thermodynamics and Statistical Mechanics</b> 1.1.1 Partition functions and their significance 1.1.2 Boltzmann distribution and its applications <b>1.2 Chemical Kinetics and Reaction Dynamics</b> 1.2.1 Collision theory and transition state theory 1.2.2 Unimolecular and bimolecular reactions	<b>07</b>
<b>Unit-II</b>	<b>2.1 Reaction Mechanisms and Pericyclic Reactions</b> 2.1.1 Michael addition and Diels-Alder reaction 2.1.2 Electrocyclic and sigmatropic rearrangements <b>2.2 Heterocyclic Chemistry</b> 2.2.1 Synthesis and reactions of furan, thiophene, and pyrrole 2.2.2 Applications in pharmaceuticals	<b>08</b>
<b>Unit-III</b>	<b>3.1 Coordination Chemistry and Metal-Ligand Bonding</b> 3.1.1 Spectrochemical series and ligand field stabilization energy <b>3.2 Organometallic Chemistry and Catalysis</b> 3.2.1 Metal-carbonyl complexes and their applications 3.2.2 Homogeneous and heterogeneous catalysis	<b>08</b>
<b>Unit-IV</b>	<b>4.1 Radioanalytical Techniques</b> 4.1.1 Principles of neutron activation analysis (NAA) and isotope dilution 4.1.2 Applications in environmental and forensic science <b>4.2 Forensic and Environmental Chemistry</b> 4.2.1 Analysis of pollutants in air, water, and soil 4.2.2 Detection of toxic metals and organic contaminants	<b>07</b>

**References:**

1. **Atkins, P., & de Paula, J.** (2018). *Atkins' Physical Chemistry*. Oxford University Press.
2. **Clayden, J., Greeves, N., Warren, S., & Wothers, P.** (2012). *Organic Chemistry*. Oxford University Press.
3. **Shriver, D. F., & Atkins, P.** (2010). *Inorganic Chemistry*. Oxford University Press.
4. **Skoog, D. A., & West, D. M.** (2004). *Fundamentals of Analytical Chemistry*. Brooks/Cole.
5. **Holler, F. J., & Crouch, S. R.** (2017). *Principles of Instrumental Analysis*. Cengage Learning.

