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 2026 Onwards)

Submitted by

Department of Chemistry

Vinayak Ganesh Vaze College of Arts, Science and Commerce
Mithagar 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

(Autonomous)

❖ **Syllabus as per Choice Based Credit System (NEP 2020)**

Syllabus for Approval

Subject: Chemistry

Sr. No.	Heading	Particulars
1	Title of Programme	**Third Year B.Sc. Chemistry: Semester V and VI**
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. Credit in Second year
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	2026-2027

Date: 28th March 2026 **Signature:**

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

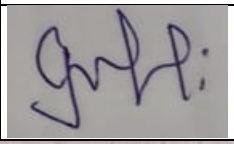
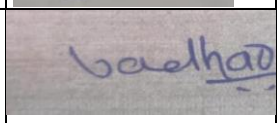
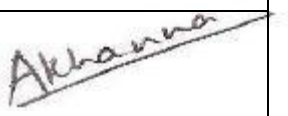
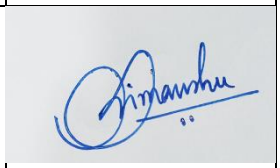
Preamble

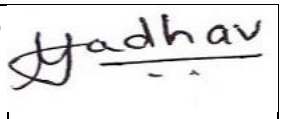
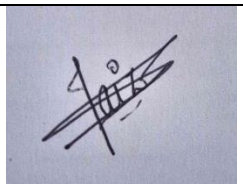
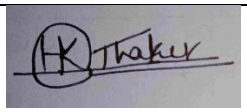
The Board of studies in Third Year Chemistry headed by Prof (Dr.) Suresh Shendage, the Chairman, Department of Chemistry, Vinayak Ganesh Vaze College of Arts, Science and Commerce (Autonomous), Mithagar Road, Mulund (East) Mumbai, University of Mumbai had the thorough discussions on the syllabus of V 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 2026-27. 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 10th March 2026. The final syllabus incorporating all the suggestions was finally approved by the members of the Board of Studies in Chemistry (UG) on 28th March 2026. 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. Himanshu Gupta
5. Mr. Gahininath Jadhav
6. Ms. Faiza Sayyed
7. Ms. Chirantani Sananse
8. Mr. Hitesh Thakur

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

BOS Members Present:

Name	Designation	Representation	
Prof. Suresh S. Shendage	Professor & Head, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E), Mumbai-400081	Chairman	
Prof. B. D. Aghav	Professor of Chemistry Changu Kana Thakur A.C.S. College, New Panvel (Autonomous	Vice-Chancellor's Nominee	
Prof. 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, Deaprtment of Chemistry, SIES College Sion Mumbai	Subject Expert From Outside college	
Mr. Aditya Khanna	Assitant Professor, Department of Chemistry, Satish Pradhan Dnyanasadhana College, Thane	Meritorious Alumni	
Dr. Ashok Awale	Associate Professor Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Dr. Paresh More	Associate Professor , Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Dr. Himanshu Gupta	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	

Mr. Gahininath Jadhav	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Ms. Faiza Sayyed	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Ms. Chirantani Sananse	(Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (Autonomous), Mulund (E),Mumbai-400081	Member of BOS	
Mr. Hitesh Thakur	Assistant Professor, Department of Chemistry KET'S V.G.Vaze college (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	
Sem - V	**MAJOR**	No. of Lectures	**VSC/SEC**	No. of Lectures
	Mandatory*Credits 10 (5 x 2)		**VSC** (Advanced Experimental Chemistry) **Credits 2**	
	Course 1 Cr. 2: Physical Chemistry-I	2L	Course 1 Cr. 2:Practical	4L
	Course 2 Cr. 2: Inorganic Chemistry-I	2L		
	Course 3 Cr. 2: Organic Chemistry-I	2L		
	Course 4 Cr. 2: Analytical Chemistry-I	2L		
	Course 5 Cr. 2: Practical (Practical Based on all Papers)	4L		
	Electives (selected anyone) Credits 4 (2+2)		**OJT/FP/CEP/CC/RP**	
	Course 1 Cr. 2:Industrial Chemistry- I	2L	**FP Credits 2**	
	Course 2 Cr. 2: Practical (Micro scale Preparation and Estimations)	4L	Course 1 Cr. 2:Practical	4L
	Course 3 Cr. 2:Medicinal and Green Chemistry	2L		
	Course 4 Cr. 2: Practical (Micro scale Preparation and Estimations	4L		
	MINOR Credits 4 (2+2)			
	Course 1 Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - I	2L		
	Course 2 Cr. 2: Practical	4L		

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

B. Sc. Program in Chemistry: Cumulative Credit Structure

Level	Sem.	MAJOR		MINOR	VSC	OJT / FP	Cum. Credits	Degree
		Mandatory*	Electives Anyone					
		For Chemistry						
5.5	**Sem-V**	**Credits 10 (4+4+4+2)** 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)	**Credits 4 (2+2)** Course 1 Cr. 2: Industrial Chemistry-I & Course 2 Cr. 2: Practical (Micro scale Preparation and Estimations OR Course1 Cr. 2: Medicinal and Green Chemistry & Course 2 Cr. 2: Practical (Micro scale Preparation and Estimations	**Credits 4 (2+2)** Course 1: Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - I & Course 2: Cr. 2: Practical	**Credits 2** Practical Based on Major Courses	**Credits 2**	**22**	**UG Degree** After 3-Yr UG

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

Programme Educational Objectives

PEO1	This course forms the basis of science and comprises of the subjects like, Physical Chemistry, Inorganic Chemistry, Organic Chemistry and Analytical Chemistry along with the skill-based courses like VSC and OJT/FP.
PEO2	Achievement of fundamentals of chemistry in a foundational level to the current knowledge
PEO3	Development of perceptive research skills at a level required to pursue higher education and placement after graduation.
PEO4	Understanding of experimentation, observation and data analysis suitable for any Chemistry based industry
PEO5	Familiarity with available instrumentation in the Institute laboratory and Industry for conducting specific scientific research
PEO6	To empower the students to exercise their abilities with great concern for the environment and society with moral and ethical values and contribute towards the development of the nation.

Programme Outcomes

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

PO1	To equip students with the comprehension of concepts, principles, theories and practical applications of Organic, Inorganic, Analytical and Physical Chemistry.
PO2	Students will have a broad foundation in the core subjects of their choice with critical thinking resulting in scientific reasoning, problem solving and analytical skills
PO3	Utilize modern laboratory techniques and instruments to conduct experiments, analyse data, and interpret results accurately.
PO4	Learners achieved skill from different experimental performance; provide them good opportunities for industrial Placement.
PO5	To facilitate the students in pursuing their higher studies in chemistry, to boost their career and employment options and to apply chemistry in their everyday life
PO6	Students develop the ability to effectively communicate scientificinformation in written and oral formats.

Programme Specific Outcomes

PSO1	Gain the knowledge of Chemistry through theory and practical.
PSO2	To understand various laws, concepts, formulae and develop problem solving skills in Chemistry.
PSO3	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.
PSO4	To explain nomenclature, stereochemistry, structures, reactivity, and mechanism of the chemical reactions.
PSO5	Create an intellectual curiosity and ability to think in a scientific manner and get sensitized to social and environmental realities.
PSO6	Apply laboratory skills, carry out experiments, record observations and inferences and analyze the results.
PSO7	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**

SEMESTER - V					
Code	**Course of Study - Major**	**L**	**T**	**P**	**Cr.**
VSCH300	Course 1 Cr. 2: Physical Chemistry-I	2	-	-	2
VSCH301	Course 2 Cr. 2: Inorganic Chemistry-I	2	-	-	2
VSCH302	Course 3 Cr. 2: Organic Chemistry-I	2	-	-	2
VSCH303	Course 4 Cr. 2: Analytical Chemistry-I	2	-	-	2
VSCH304	Course 5 Cr. 2: Practical (Practical Based on all Papers)	4	-	2	2
	Electives				
VSCH305	Course 1 Cr. 2: Industrial Chemistry- I	2	-	-	2
VSCH306	Course 2 Cr. 2: Practical (Micro scale Preparation and Estimations	-	-	4	2
VSCH307	Course 3 Cr. 2: Medicinal and Green Chemistry	2	-	-	2
VSCH308	Course 4 Cr. 2: Practical (Micro scale Preparation and Estimations	-	-	4	2
	Minor				
VSCH310	Course 1 Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - I	2	-	-	2
VSCH311	Course 2 Cr. 2: Practical	-	-	4	2
	VSC (Advanced Experimental Chemistry) Credits 2				
VSCH309	Course 1 Cr. 2: Practical	-	-	4	2
	FP Credits 2				
VSCH312	Course 1 Cr. 2: Practical	-	-	4	2
Total		18	-	22	**22**

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

SEMESTER - VI					
Code	**Course of Study - Major**	**L**	**T**	**P**	**C**
VSCH350	Course 1 Cr. 2: Physical Chemistry-II	2	-	-	2
VSCH351	Course 2 Cr. 2: Inorganic Chemistry-II	2	-	-	2
VSCH352	Course 3 Cr. 2: Organic Chemistry-II	2	-	-	2
VSCH353	Course 4 Cr. 2: Analytical Chemistry-II	2	-	-	2
VSCH354	Course 5 Cr. 2: Practical (Practical Based on all Papers)	4	-	2	2
	Electives				
VSCH355	Course 1 Cr. 2: Industrial Chemistry- II	2	-	-	2
VSCH356	Course 2 Cr. 2: Practical (Micro scale Prepn. &Estimation)	-	-	4	2
VSCH357	Course 3 Cr. 2: Chemistry of Dyestuffs and Green Chemistry	2	-	-	2
VSCH358	Course 4 Cr. 2: Practical (Micro scale Prepn. &Estimation)	-	-	4	2
	Minor **Credits 2**				
VSCH360	Course 1 Cr. 2: Modern Chemistry: Theory, Reactions, and Techniques - II	2	-	-	2
	VSC (Hands-on Advanced Laboratory Techniques: Synthesis, Analysis, and Sustainable methods) Credits 2				
VSCH359	Course 1 Cr. 2: Practical	-	-	4	2
	OJT Credits 4				
VSCH361	Course 1 Cr. 2: Practical	-	-	8	4
		18	-	22	**22**

***** **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.

Course Outcome

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

CO 1	Understand the concept of spectroscopic techniques including molecular, rotational vibrational, Raman and Electronic spectroscopy.
CO 2	To comprehend the concepts of chemical thermodynamics and chemical kinetics.
CO 3	To illustrate the importance of surface chemistry and colloidal state.
CO 4	To gain the knowledge of colloidal electrolytes and surfactants.

Unit	CONTENT	No. of Hours
Unit I	**Molecular Spectroscopy**	
1.1	**1.1 - 1.1.1 Rotational spectroscopy** Introduction to dipole moment, polarization of a bond, bond moment. Definition, condition and selection rule of rotational spectra, Moment of inertia of simple diatomic molecule, Energy of rotational energy levels, Limitations of rotational spectra (Numericals expected) **1.1.2 Vibrational spectrum**: Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero-point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum. **1.1.3 Vibrational-Rotational spectrum of diatomic molecule**: Energy levels, selection rule, nature of spectrum, P and R branch lines. An-harmonic 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_2O and CO_2. **1.1.4 Raman Spectroscopy** 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_2 molecule.	**10**
Unit II	**Chemical Thermodynamics and Chemical kinetics**	
2.1	**2.1.1 Colligative properties of Dilute Solution:** Molarity, Normality, Mole fraction, ideal and non-ideal solutiuons, Vapor pressure and relative lowering of vapour pressure. Measurement of lowering of vapour pressure – Static and Dynamic method.	**03**
2.2	**Solutions of Solid in Liquid:** **2.2.1** Elevation in boiling point of a solution, thermodynamic derivation relating elevation in boiling point of the solution and molar mass of non-volatile solute. Depress ion 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. **2.2.2 Osmotic Pressure:** 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.	**04**
2.3	**Chemical Kinetics** **2.3.1Collision theory of reaction rates**: Postulates, advantages and failure of simple collision theory, Steady state approximation in reaction mechanisms; Application of collision theory to 1. Uni-molecular reaction Lindemann theory and 2. Bimolecular reaction. (derivation expected for both)	**03**

	2.3.2 Catalysis: Recapitulation of catalysis Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)	
Unit III	**Surface Chemistry**	**10**
3.1	**3.1.1 Adsorption:** 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. **3.1.2 Colloidal State** **Introduction to colloids**- Emulsions, Gels and Sols **Electrical Properties:** 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 **3.1.3 Colloidal electrolytes:** Introduction, micelle formation, **3.1.4 Surfactants:** Classification and applications of surfactants in detergents and food industry. **3.2 Nuclear chemistry** **3.2.1** Introduction: Basic terms-radioactive constants (decay constant, half life and average life) and units of radioactivity **3.2.2 Detection and Measurement of Radioactivity:** Types and characteristics of nuclear radiations, behavior of ion pairs in electric field, detection and measurement of nuclear radiations using G. M. Counter and Scintillation Counter.	

References:

1. Physical Chemistry, Ira Levine,5thEdition, 2002 Tata McGraw Hill Publishing Co. Ltd.
2. Physical Chemistry, P.C. Rakshit, 6thEdition,2001, Sarat Book Distributors, Kolkota.
3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3rdedition, John Wiley &Sons, Inc [part1]
4. Physical Chemistry, G. Castellan, 3rdedition, 5th Reprint,1995 Narosa Publishing House.
5. Modern Electrochemistry, J.O. M Bockris &A.K.N. Reedy, Maria Gamboa –Aldeco2nd Edition, 1st Indian reprint,2006 Springer
6. Fundamental of Molecular Spectroscopy, 4th Edn., Colin N Banwell and Elaine M Mc Cash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 200

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,

1. Discuss the symmetry elements present in a molecule and assign the point group for the molecule. Draw Molecular Orbital Diagram of triatomic (AB2) molecules and explain their shapes with the help of Walsh Correlation diagrams.
2. Discuss electrical properties of conductors, semiconductors based on Band Theory.
3. Understand the different types of packing in solids, stoichiometric defects in solids
4. Discuss superconductivity. types of superconductors and their applications.
5. Discuss the properties of aqueous, non-aqueous solvent, protic and aprotic solvent and memorize application of non-aqueous solvents
6. Write the electronic configuration of group 16 elements, recollect the preparation of H2SO4 by contact process, recite application of H2SO4, and understand catalysis in V2O5 and platinized asbestos.

Course Outcome

Upon completing the course, the student will be able to

CO 1	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.
CO 2	The learner can explain physical properties and trends in Lanthanides. Cn explain magnetic and spectral properties.
CO 3	The Concept of defects to understand various properties. Understand super capacitors with the working and application.
CO 4	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 H2SO4.

Unit	CONTENT	No. of Hours
Unit I	**Molecular Symmetry and Chemical Bonding**	
1.1	**Molecular Symmetry** **1.1.1** Introduction and Importance of symmetry in Chemistry **1.1.2** Symmetry elements and symmetry operations **1.1.3** Concept of a point group with illustrations using the following point groups: i) C∞v ii) D ∞h iii) C2v iv) C 3v v) C2h vi) D 3 h	**04**
1.2	**Molecular Orbital Theory** **1.2.1** Polyatomic species LCAO –MO for triatomic species: H3 + and H3 (correlation between Bond angle and Molecular orbitals) **1.2.2** Molecular orbital approach for bonding in AB2 molecules. Application of symmetry concepts for linear and angular species considering σ bonding only. Examples BeH2 and H2O (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.	**04**
1.3	**Metallic bonding** Band theory, Explanation of electrical properties of conductors, insulators, semiconductors, extrinsic and intrinsic semiconductor.	**02**
Unit II	**Solid State Chemistry and Superconductivity**	
2.1	**Structure of Solids.** **2.1.1** Explanation of terms, viz., crystal lattice, lattice points, unit cells and lattice constants **2.1.2** Closest packing of rigid spheres (hcp, ccp) , packing density in simple cubic, bcc, fcc and hcp lattices. (Numerical problems expected). Relationship between density of unit cell, lattice parameters (Numerical problems expected). **2.1.3** Stoichiometric Point defects in Solids: Discussion on Frenkel and Schottky defects expected.	**06**
2.2	**Superconductivity.** **2.2.1** Discovery of Superconductivity **2.2.2** Explanations of terms like superconductivity, transition temperature, Meissner effect **2.2.3** Different types of Superconductors viz, conventional Superconductors, alkali metal fullerides, High temperature Superconductors **2.2.4** Brief applications of superconductors	**04**
Unit III	**Some Selected Topics**	
3.1	**Chemistry of Non- Aqueous Solvents.** **3.1.1** Classification of solvents and importance of non-aqueous solvents. Characterization and study of Liq. NH3 as a non- aqueous solvent with respect to i) Acid base reactions and ii) redox reactions.	**05**
3.2	**Comparative Chemistry of Group 16.** **3.2.1** Electronic configurations, trends in physical properties, allotropy. Manufacture of sulphuric acid by contact process.Impact of H2SO4 on environment.	**03**

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

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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
4. Greenwood, N.N. & Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
5. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,.Ltd. (2002).
6. Purecell, K.F. and Kotz, J.C., Inorganic Chemistry W.B. Saunders Co. 1977
7. D.Banerjea, Coordination Chemistry, tata NcGraw Hill, New Delhi,1993
8. Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.
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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, 5th Edition, Oxford University Press.
16. Principles of Inorganic Chemistry. Puri, Sharma & Kalia, Milestone Publisher.
17. Inorganic Chemistry. Catherine Housecroft& Alan G. Sharp, 3rd 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, 6th 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. 7th 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**

Organic Chemistry-I

Learning Objectives

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

1. To identify the different organic reactions mechanisms and write the expected reaction products based on the type of reaction.
2. To introduce students to basic photochemistry and photochemical reactions involving carbonyl compounds and olefins.
3. To identify the symmetry elements in organic compounds and the optical activity of substituted cummulenes and biphenyls.
4. To predict the stereochemical outcome of nucleophilic substitution and electrophilic addition reactions.
5. To write the IUPAC nomenclature of given compound and draw the structure of compounds corresponding to a given IUPAC name.
6. 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.

Course Outcome

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

CO 1	The basics of reaction mechanism, the mechanistic concepts and photo induced electron transfer and excitation energy transfer,
CO 2	Understand the various types of rearrangement reactions and Determine the structure of organic compounds by analysing their spectral data.
CO 3	The Concept of Pericyclic reactions and their applications
CO 4	Predict the mechanism and stereochemical outcome of nucleophilic substitution reactions and electrophilic addition reactions.

Unit	CONTENT	No. of Hours
Unit I	**Mechanism of organic reactions** **1.1.1** The basic terms & concepts: bond fission, reaction intermediates, electrophiles & nucleophiles, ligand, base, electrophilicity vs. acidity & nucleophilicity vs basicity. **1.1.2** Neighboring group participation in nucleophilic substitution reactions: participation of lone pair of electrons, kinetics and stereochemical outcome. **1.1.3** Acyl nucleophilic substitution (Tetrahedral mechanism): Acid catalyzed esterification of carboxylic acids (AAC2) and base promoted hydrolysis of esters (BAC2). **1.1.4** Pericyclic reactions, classification and nomenclature **1.1.4.1** Electro cyclic reactions (ring opening and ring closing), cycloaddition, sigmatropic Rearrangement, group transfer reactions, cheletropic reaction (definition and one example of each type) **1.1.4.2** Pyrolytic elimination: Cope, Chugaev, pyrolysis of acetates	**07**
	1.2 Photochemistry **1.2.1** Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triplet states, allowed and forbidden transitions, fate of excited molecules, photosensitization. **1.2.2** Photochemical reactions of olefins: photoisomerization, photochemical rearrangement of 1,4- dienes (di- π methane) **1.2.3** Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages. Photo reduction (e.g. benzophenone to benzpinacol)	**03**
Unit II	**2.1 Stereochemistry I** **2.1.1** Molecular chirality and elements of symmetry: Mirror plane symmetry, inversion center, rotation -reflection (alternating) axis. **2.1.2** Chirality of compounds without a stereogenic center: cummulenes and biphenyls.	**05**
	2.2 Stereochemistry II **2.2.1** Stereoselectivity and stereospecificity: Idea of enantioselectivity (ee) and diastereoselectivity (de),Topicity: enantiotopic and diasterotopic atoms, groups and faces. **2.2.2** Stereochemistry of : i) Substitution reactions: SNi (reaction of alcohol with thionyl chloride) ii) Elimination reactions: E2–Base induced dehydrohalogenation of 1-bromo-1,2- diphenylpropane. iii) Addition reactions to olefins: a) bromination (electrophilic anti addition) b) syn hydroxylation with OsO_4 and $KMnO_4$ c) epoxidation followed by hydrolysis.	**05**
Unit III	**Spectroscopy** **3.1** Introduction: Electromagnetic spectrum, units of wavelength and frequency **3.2** UV visible spectroscopy: Basic theory, allowed and forbidden transitions, selection Rule, concept of chromophore, auxochrome, bathochromic and	**10**

	hypsochromic shifts, hyperchromic and hypochromic effects, chromophore-chromophore interactions and chromophore–auxochrome interactions; Woodward Fieser Rules for calculation of λ_{max} of simple polyenes. **3.3** IR spectroscopy: Basic theory, selection rule, fingerprint region and functional group region, characteristic IR peaks for different functional groups. **3.4** PMR spectroscopy: Basic theory of PMR, Internal standard, solvents chemical shift, factors affecting chemical shift, spin -sin coupling and coupling constant, Exchangeable protons, application of PMR in structure determination. **3.5** 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. **3.6** Problems of structure elucidation of simple organic compounds using individual or combined use of UV-VIS, IR, PMR and Mass spectral data.	

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, 3rd 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

Semester – V

Paper IV

Course Code: VSCH303 **Credits: 2**

Analytical Chemistry-I

Learning Objectives:

1. Understanding Quality Fundamentals in Chemical Sciences: **Explain the** fundamental principles of Quality Management **in chemical industries, including the roles of** QA, QC, GMP, and TQM**, and understand their impact on** productivity and compliance**.**
2. Trace the Evolution and Implementation of Quality Standards: **Describe the** historical development of quality standards **and contributions of quality pioneers (Deming, Juran, Crosby), and understand the structure and significance of** ISO 9001, ISO 17025**, and regulatory frameworks (GMP, GLP).**
3. Apply Quality Assurance and Control Techniques: **Demonstrate knowledge of** QA/QC principles**, including** documentation, SOPs, calibration, validation, sampling techniques, and statistical tools **such as control charts, SPC, and Six Sigma relevant to chemical processes.**
4. Analyze Optical Spectroscopic Methods: **Explain the** principles, instrumentation, and applications **of** Flame Emission Spectroscopy (FES)**,** Atomic Absorption Spectroscopy (AAS)**, and** molecular fluorescence/phosphorescence**, and use them for chemical and environmental analysis.**
5. Evaluate Light Scattering and Chromatographic Techniques: **Understand the** theory and instrumentation **behind** Turbidimetry, Nephelometry, and HPLC**, compare them with other optical techniques, and apply them in** pharmaceutical, food, and environmental quality assessments**.**
6. Integrate Regulatory, Analytical, and Technological Aspects of Quality: **Discuss the** importance of audits, risk management (ICH Q9)**, recent** case studies **in quality failures, and** emerging trends **like** digital transformation, Industry 4.0, and sustainability **in quality control and analytical laboratories.**

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.

UNIT	CONTENT	No. of Hours
UNIT I : Fundamentals of Quality Management in Chemical Sciences		
1.1	**Introduction to Quality Management** **1.1.1 Fundamentals of Quality Management** 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 **1.1.2 Evolution of Quality Standards** Historical development of quality management Contributions of Deming, Juran, and Crosby Importance of international standards: ISO 9001, ISO 17025	**02**
1.2	**Quality Assurance & Quality Control in Chemical Sciences** **1.2.1 Quality Assurance (QA) Principles** Definition and scope of QA Role of documentation and standard operating procedures (SOPs) Key elements: validation, calibration, and qualification **1.2.2 Quality Control (QC) in Chemical Processes** Difference between QA and QC QC techniques in laboratories and manufacturing Sampling methods, test validation, and data integrity **1.2.3 Statistical Quality Control** Concept of variability in chemical processes Statistical Process Control (SPC) tools: Control charts, process capability analysis Application of Six Sigma in chemical industries	**03**
1.3	**Regulatory & Compliance Aspects** **1.3.1 Good Manufacturing Practices (GMP) and GLP** 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 **1.3.2 Audits & Quality Risk Management** Types of quality audits: Internal vs. external audits Risk management principles (ICH Q9) Corrective and Preventive Actions (CAPA)	**02**
1.4	**Case Studies & Industry Applications** **1.4.1 Case Studies in Chemical and Pharmaceutical Industries** Notable quality failures and lessons learned (e.g., thalidomide tragedy, Heparin contamination) Continuous improvement strategies **1.4.2 Quality in Analytical Laboratories** Importance of accuracy, precision, and reproducibility Role of laboratory accreditation and ISO 17025 **1.4.3 Future Trends in Quality Management** Digital transformation in quality management (AI, big data) Industry 4.0 and smart quality control Sustainability and green chemistry in quality assurance	**03**
UNIT II: OPTICAL METHODS		
2.1	**Introduction to Atomic Spectroscopy** Basic principles of atomic spectroscopy Types of atomic spectroscopic methods Comparison of emission, absorption, and fluorescence spectroscopy	**01**

2.2	**Flame Emission Spectroscopy (FES)** **2.2.1 Principle of Flame Emission Spectroscopy** Excitation of atoms in the flame Emission of characteristic radiation Relationship between emission intensity and concentration **2.2.2 Instrumentation of FES** Radiation source (flame as an excitation source) Monochromator and wavelength selection Detector and signal processing **2.2.3 Applications of Flame Emission Spectroscopy** Determination of alkali and alkaline earth metals (Na, K, Ca, Li) Clinical and environmental analysis Agricultural and food analysis **2.2.4 Limitations of FES** Interference (spectral, ionization, chemical) Sensitivity and detection limits	**03**
2.3	**Atomic Absorption Spectroscopy (AAS)** **2.3.1 Principle of Atomic Absorption Spectroscopy** Absorption of specific wavelengths by ground-state atoms Beer-Lambert's law and its application Relationship between absorbance and concentration **2.3.2 Instrumentation of AAS** Radiation source (Hollow Cathode Lamp, Electrodeless Discharge Lamp) Atomization methods (Flame Atomization, Graphite Furnace Atomization) Monochromator and wavelength selection Detector (Photomultiplier tube, photodiode) **2.3.3 Applications of AAS** Environmental monitoring (heavy metal analysis in water, soil) Clinical and pharmaceutical analysis (trace metal detection in biological samples) Food and agricultural analysis **2.3.4 Advantages and Limitations of AAS** High sensitivity and specificity Limited to metals and metalloids Sample preparation requirements	**03**
2.4	**Molecular Fluorescence and Phosphorescence Spectroscopy Syllabus** **2.4.1 Introduction and Theory of Molecular Fluorescence and Phosphorescence** Comparison of fluorescence, phosphorescence, and other spectroscopic techniques Jablonski diagram and electronic transitions Singlet and triplet states **2.4.2 Instrumentation for Fluorescence and Phosphorescence Spectroscopy** **Light sources:** Xenon lamps, LED sources, lasers **Monochromators and filters:** Grating monochromators, interference filters **Detectors:** Photomultiplier tubes (PMTs), charge-coupled devices (CCDs) **Fluorometers and spectrofluorometers** **2.4.3 Factors Affecting Fluorescence and Phosphorescence** Molecular structure and conjugation Solvent effects and environmental influences pH and temperature dependence Quenching mechanisms (dynamic and static quenching)	**03**

	Concentration effects and self-absorption **2.4.4 Applications of Fluorescence and Phosphorescence Spectroscopy** **Biochemical and clinical applications:** DNA/RNA analysis, enzyme assays, medical diagnostics **Environmental analysis:** Detection of pollutants and toxins **Pharmaceutical applications:** Drug analysis and quality control **Material science applications:** Fluorescent dyes and nanomaterials	
UNIT-III Optical and Separation Techniques in Chemical Analysis		
3.1	**Optical Techniques – Turbidimetry & Nephelometry** **3.1.1 Principles of Light Scattering Techniques** Interaction of light with suspended particles Basic principles of **Turbidimetry and Nephelometry** Factors affecting light scattering (particle size, concentration, wavelength) **3.1.2 Instrumentation & Working Principles** Light sources, detectors, sample cells Sensitivity and limitations of both techniques **3.1.3 Applications in Chemical and Biological Analysis** Environmental monitoring (water quality, air pollution) Pharmaceutical and biochemical applications **3.1.4 Comparison with Other Spectroscopic Techniques** Differences between Turbidimetry, Nephelometry, and UV-Vis Spectroscopy	**04**
3.2	**Separation Techniques – High-Performance Liquid Chromatography (HPLC)** **3.2.1 Introduction to Separation Methods** Importance of separation in chemical analysis Physical and chemical properties affecting separation **3.2.2 Principles of High-Performance Liquid Chromatography (HPLC)** **Fundamental Concepts** Mobile phase, stationary phase, column packing Retention time, resolution, and efficiency **Instrumentation** Pump, injector, column, detector, and data system **3.3.3 Applications of HPLC in Chemical Analysis** **Pharmaceutical Analysis** Drug purity, stability testing, bioavailability studies **Environmental Analysis** Detection of pollutants, pesticide residues, and toxins **Food and Beverage Industry** Quality control of additives, preservatives, and contaminants **3.3.4 Case Studies and Recent Advances** Comparative study of HPLC with other chromatographic techniques Advances in **Ultra-High-Performance Liquid Chromatography (UHPLC)** Automation and software applications in modern HPLC	**06**

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.
4. Christian, G. D. (2013). *Analytical Chemistry*. Wiley.
5. Snyder, L. R., Kirkland, J. J., & Dolan, J. W. (2011). *Introduction to Modern Liquid Chromatography*. Wiley.
6. Meyer, V. R. (2013). *Practical High-Performance Liquid Chromatography*. Wiley.
7. 3000 solved problems in Chemistry, David E. Goldberg, PhD., Schaums Outline
8. Instrumental methods of Analysis, by Dr Supriya S Mahajan, Popular Prakashan Ltd.
9. Quality in the Analytical Chemistry Laboratory, Elizabeth Prichard, Neil T. Crosby, Florence Elizabeth Prichard, John Wiley and Sons, 1995

PRACTICALS

SEMESTER V

COURSE CODE: VSCH304 **CREDITS: 2**

Learning Objectives (LOs)

LO1: To understand phase behavior of ternary systems and construct and interpret phase diagrams of water–chloroform–acetic acid system.

LO2: To study reaction kinetics and evaluate the effect of ionic strength on reaction rate constants.

LO3: To investigate surface phenomena and verify adsorption isotherms such as Freundlich adsorption isotherm.

LO4: To determine physicochemical parameters such as solubility product, dissociation constants (pKa), isoelectric point, and rate constants using electroanalytical methods.

LO5: To develop skills in inorganic synthesis, quantitative estimation, and qualitative analysis of chemical compounds.

LO6: To apply analytical and instrumental techniques for real sample analysis including water quality assessment, pharmaceutical analysis, and environmental monitoring.

Course Outcome

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

CO1: Understand and apply fundamental principles of physical chemistry including phase equilibria, kinetics, adsorption, and electrochemistry through experimental investigations.

CO2: Develop analytical skills using classical and instrumental techniques such as potentiometry, conductometry, pH-metry, spectrophotometry, and titrimetric methods for qualitative and quantitative analysis.

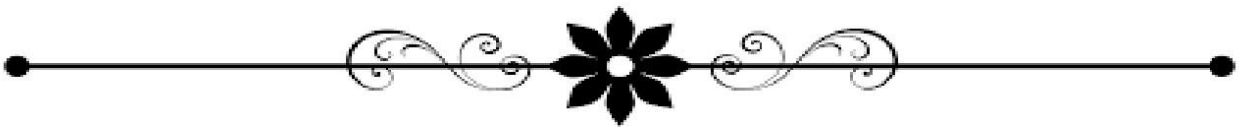
CO3: Demonstrate competency in inorganic synthesis, separation of organic mixtures, environmental analysis, and interpretation of experimental data with accuracy and precision.

Subject	Sr. No.	Experiment
Physical Chemistry	1	**Phase rule:** To study phase diagram of three component system water –chloroform-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	**Potentiometry** To determine the solubility product and solubility of AgCl potentiometrically using chemical cell.
	5	Titrate potentiometrically a phosphoric acid solution against NaOH and calculate pk1, pk2 and pk3 of the acid.
	6	**Conductometry** To determine the velocity constant of alkaline hydrolysis of ethylacetate by conductometric method.
	7	**pH-metry** To determine acidic and basic dissociation constant of amino acid and hence to calculate isoelectric point.
Inorganic Chemistry	8	Inorganic preparations and characterization Preparation of tris(ethylenediamine) nickel (II) thiosulphate. (Estimation of nickel complexometrically)
	9	Inorganic preparations and characterization Preparation of tetraamine copper (II) sulphate (Estimation of copper iodometric ally)
	10	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)
	11	To perform the assay of the given sample of boric acid (alkalimetry method)
	12	Inorganic preparations To prepare Bis(tetraethyl ammonium) tetrachloro cuprate (II)
Organic Chemistry	13	**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.
Analytical Chemistry	14	Determination of percentage purity of a sample of common salt using a cation exchange Resin Amberlite IRA-120.
	15	Determination of Copper ion in given solution by calibration curve method.
	16	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

	17	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.
	18	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.
	19	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.
	20	Turbidimetric Determination of Sulfate in Water Samples: Measure sulfate concentration in water samples by precipitation with barium chloride and nephelometric analysis.

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
7. Systematic experimental physical chemistry Dr. T.K Chondhekar and S.W. Rajbhoj Anjali publications.



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.

Course Outcome

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

CO 1	To introduce classification of polymers ,types of molar masses and light emitting polymers
CO 2	To know basics of quantum chemistry, concepts of progressive and standing waves, operators and eigen vaules
CO 3	To get basics of Nuclear Magnetic resonance and electron spin resonance spectroscopy
CO 4	To introduce various concepts of electrochemistry and applied electrochemistry.

Unit	CONTENT	No. of Hours
Unit I	**Electrochemistry**	**10**
1.1	1.1.1 Debye Hückel-Onsager equation; Ionic velocities, mobilities, transference numbers; Applications of conductance measurement; Electromotive force of a cell, **1.1.2 Activity and Activity Coefficient** 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). **1.1.3 Classification of cells** Chemical cells and Concentration cells. Chemical cells with and without transference, Electrode Concentration cells, Electrolyte concentration cells with and without transference (derivations are expected), **1.1.4 Applied Electrochemistry** **Polarization**: Concentration polarization and its elimination **Decomposition Potential and Overvoltage**: Introduction, experimental determination of decomposition potential, factors affecting decomposition potential. Tafel's equation for hydrogen overvoltage, experimental determination of over –voltage.	

Unit II	**Polymers**	**10**
2.1	**2.1.1 Basic terms: macromolecule**, monomer, repeat unit, degree of polymerization. **2.1.2 Classification of polymers:** Classification based on source, structure, thermal response and physical properties. **2.1.3 Molar masses of polymers:** Number average, Weight average, Viscosity Average molar mass, Mono-dispersity and Poly-dispersity **2.1.4 Method of determining molar masses of polymers:** Viscosity method using Ostwald Viscometer. (derivation expected) **2.1.5 Light Emitting Polymers:** Introduction, Characteristics, Method of preparation and applications. **2.1.6 Antioxidants and Stabilizers:** Antioxidants, Ultraviolet stabilizers, Colourants, Antistatic agents and Curing agents.	
Unit III	**Basics of Quantum Chemistry**	
3.1	**3.1.1 Classical mechanics**: Introduction, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect. **3.1.2 Quantum mechanics:** Introduction, Planck's theory of quantization, Wave particle duality, de–Broglie's equation, Heisenberg's uncertainty principle. **3.1.3 Progressive and standing waves-**Introduction, boundary conditions, Schrodinger's time independent wave equation (no derivation expected), interpretation and properties of wave function. **3.1.4 Quantum mechanics** State function and its significance, Concept of operators - definition, addition, subtraction and multiplication of operators, commutative and non - commutative operators, linear operator, Hamiltonian operator, Eigen function and Eigen value.	**07**
3.2	**Electron Spin Resonance Spectroscopy:** **Principle:** Fundamental equation, g-value dimensionless constant or electron g-factor, hyperfine splitting. **Instrumentation**: ESR spectrometer, ESR spectrum of hydrogen and deuterium.	**03**

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1. Physical Chemistry, Ira Levine,5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
2. Physical Chemistry, P.C. Rakshit, 6thEdition, 2001, Sarat Book Distributors, Kolkota.
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SEM- VI

Paper II

Course Code: VSCH351 **Credits: 2**

Inorganic Chemistry-II

Learning Objectives

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

1. Crystal Field theory and its application to explain variation in properties of coordination compounds.
2. Experimental evidence suggesting covalence in metal -ligand bond
3. Application of Molecular Orbital Theory to explain properties of octahedral complexes.
4. Stability, reactivity and electronic spectra of metal complexes to understand the properties of the metal complexes.
5. The concept of synthesis and application of organometallic compounds and Sandwich type of compounds.
6. 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.

Course Outcome

Upon completing the course, the student will be able to

CO 1	Understand variation in properties like color, magnetic moment etc, distortion in geometry of octahedral complexes based on Crystal Field Theory.
CO 2	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
CO 3	Distinguish between homogeneous and heterogeneous catalysis, understand the mechanism of catalysis, write mechanism of Wilkinson's catalyst in hydrogenation of alkenes.
CO 4	Define nanomaterial, write different methods of synthesis of nanomaterial, recite application of nanomaterials

Unit I	**CONTENT**	**No of. Hours**
1.1	**Crystal field Theory (CFT) for coordination compounds** **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 / Δ, 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 d0 - d 10 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	**06**

	1.1.7 Limitations of CFT: Evidences for covalence in metal complexes: i) intensities of d-d transitions, ii) ESR spectrum [Ir Cl6] 2- iii) Nephelauxetic effect.	
1 .2	**Molecular Orbital theory for Coordination Compounds** **1 .2.1** Identification of central metal orbitals and their symmetry suitable for formation of σ and π bonds with ligand orbitals. **1.2.2** Construction of Ligand Group orbitals 1.2.3 Construction of σ Molecular orbitals for ML6 complexes. 1.2.4 Effect of π bonding on Δ values 1.2.5 Molecular Orbital diagram for complexes: $[Ti(H_2O)_6]^{+3}$ $[Fe(CN)_6]^{-3}$, $[Fe(F)_6]^{-3}$, $[Fe(CN)_6]^{-4}$, $[Fe(F)_6]^{-4}$, $[Co(NH_3)_6]^{+3}$, $[Co(F)_6]^{-3}$	**04**
Unit II	**Properties of complexes**	
2.1	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	**04**
2.2	**Reactivity of Metal Complexes.** 2.2.1 Types of reactions in metal complexes 2.2.2 Inert and Labile complexes: Correlation between electronic configurations and lability of complexes. 2.2.3 Ligand substitution reactions: Associative and Dissociativemechanisms. 2.2.4 Acid hydrolysis, base hydrolysis and anation reaction.	**03**
2.3	**Electronic Spectra.** 2.3.1 Origin of electronic spectrum 2.3.2 Types of electronic transitions in coordination compounds; Intrametal, intraligand, charge transfer. 2.3.3 Selection rules for electronic transitions. 2.3.4 Electronic configuration and electronic microstates, Terms and Term symbols for transition metal ions, rules for determination of ground state Terms. 2.3.5 Determination of Terms for p2 and d2 electronic configurations. Orgel Diagram for D and F Terms (in octahedral crystal field)	**03**
Unit III	**Organometallic Chemistry.**	
3.1	**Organometallic Compounds of Main Group Metals.** **3.1.1** General Characteristics of various types of organometallic compounds i.e. ionic, σ- bonded and electron deficient compounds. **3.1.2** 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. **3.1.3** 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.	**04**

3.2	**Catalysis.** **3.2.1** Comparison between homogeneous and heterogeneous catalysis. **3.2.2** Basic steps involved in catalysis reactions i) Oxidative addition ii) Reductive elimination iii) Insertion reaction iv) Application of EAN rule/ 18 electron rule. **3.2.3** Catalytic Reactions i) Wilkinson catalyst ii) Suzuki Coupling iii) Heck Reactions.	**03**
3.3	**Nanomaterials** **3.3.1** Introduction and importance of nanomaterials. **3.3.2** Properties (Comparison between bulk and nanomaterials): i) Optical properties ii) Electrical conductivity iii) Melting points, and iv) Mechanical properties. **3.3.3** Forms of nanomaterials: nanofilms, nanolayers, nanotubes, nanowires and nano particles. **3.3.4** Synthesis of nanoparticles using colloidal route	**03**

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SEM- VI

Paper III

Course Code: VSCH352 **Credits: 2**

Organic Chemistry-II

Learning Objectives

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

1. To inculcate knowledge about synthesis, reactivity & importance of heterocyclic compounds.
2. To learn about general structure, configuration, synthesis of amino acids, polypeptides and proteins, nucleic acid and their applications
3. To identify, write mechanism and product of name reactions involving rearrangements
4. To learn about monosaccharides- linear and ring structures of ribose, glucose, fructose and mannose, physical and chemical properties of glucose and fructose
5. To identify and classify terpenoids, determine structure of citral.
6. To identify alkaloids and the different methods for structure determination of alkaloids; structure determination of nicotine and understand hormones and their physiological action

Course Outcome

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

CO 1	Various methods of ring synthesis, reactivity and applications of heterocyclic compounds.
CO 2	Structural features of mono saccharides, Interconversion of different forms; Anomers, stability of anomers epimers and Reactions of D-Glucose and D-fructose
CO 3	Design synthesis of organic compounds using organometallic reagents.
CO 4	Predict the mechanism and stereochemical outcome of reactions involving enolates

UNIT	CONTENT	No. of Hours
Unit I	**1.1 Heterocyclic Chemistry** 1.1.1 Pyridine: Hantzsch synthesis; basicity; reduction; Chichibabin reaction 1.1.2 Pyridine N-Oxide: preparation, electrophilic and nucleophilic reactions 1.1.2 Quinoline: Preparation by Skraup synthesis and reactions of quinoline with electrophiles and nucleophiles 1.1.3 Isoquinoline: Preparation by Bischler Napieralski and reactions of isoquinoline with electrophiles and nucleophiles. **1.2 Carbohydrates** 1.2.1 Introduction: Classification, reducing and non-reducing sugars, D/L notation 1.2.2 Structures of mono saccharides: Fischer projection (4-6 carbon mono-saccharides), Haworth formula (Furanose and pyranose forms), Chair conformation for monosaccharides with six carbon atoms, Interconversion of different forms; Anomers, stability of anomers epimers 1.2.3 Mutarotation and its mechanism 1.2.4 Chain lengthening and chain shortening reactions 1.2.5 Reactions of D-Glucose and D-fructose 1.2.6 Introduction to glycosides	**04** **06**

Unit II	**2.1 Molecular rearrangements:** Mechanism of the following rearrangements with examples and stereochemistry wherever applicable 2.1.1 Wagner Meerwein rearrangement 2.1.2 Pinacol-pinacolone rearrangement 2.1.3 Beckman rearrangement 2.1.4 Favorskii rearrangement 2.1.5 Baeyer Villiger Oxidation **2.2 Organometallic chemistry** 2.2.1 Introduction: Carbon-metal bond Nature, types and reactivity. 2.2.2 Organo magnesium Compounds: Grignard reagent: Reaction with compounds containing acidic hydrogen, carbonyl compounds, cyanides and CO_2. 2.2.3 Organolithium Compounds: Preparation using alkyl/aryl halides. Reactions with compounds containing acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO_2. Lithium dialkyl cuprates: Preparation and reactions with aliphatic /aromatic/vinylic halides. 2.2.4 Organozinc compounds: Preparation of dialkyl zinc. Reaction with water, acid chlorides and alkyl halides. Reformatsky reaction (with mechanism). 2.2.5 Organocopper reagents: Ullman reaction	**04** **06**
Unit III	**3.1 Chemistry of enolates** 3.1.1 Introduction: generation of enolates, kinetically controlled and thermodynamically controlled enolates 3.1.2 Mechanism and applications of the following reactions i) Aldol reaction ii) Knoevenagel reaction iii) Michael reaction iv) Robinson annulations v) Wittig reaction vi) Cannizzaro reaction vii) Claisen ester condensation and Dieckmann condensation viii) Claisen -Scmidt reaction **3.2 Catalysts and reagents** Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism) 3.2.1 **Catalysts for hydrogenation** i. Raney Nickel ii. Pt & PtO_2 (C=C, CN, NO_2, aromatic ring) iii. Pd/C(C=C, COCl to CHO (Rosenmund reduction) iv. Lindlar catalyst (alkynes) 3.2.2 **Reagents** i) $LiAlH_4$ (reduction of CO, COOR, CN, NO_2) ii) $NaBH_4$ (reduction of CO) iii) SeO_2 (Oxidation of CH_2 alpha to CO) iv) mCPBA (epoxidation of C=C) **v)** NBS (allylic and benzylic bromination)	**06** **04**

References:

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2. Handbook of Heterocyclic Chemistry, 2nd Edition, Alan R. Katritzky and Alexander F. Pozharskii, Elsevier Science Ltd, 2000.
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6. Lehninger Principles of Biochemistry 7 th Ed., David Nelson and Michael Cox, Publisher W. H. Freeman
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16. Chemistry of natural products by Meenakshi Sivakumar and Sujata Bhat.
17. Organic chemistry by Morrision and Boyd,7th edition.
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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. Oranic 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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SEM- VI

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. **Understand the fundamental principles of electroanalytical techniques** such as conductometry, potentiometry, coulometry, and voltammetry, including their instrumentation and applications.
2. **Identify and compare various advanced separation techniques** (e.g., electrophoresis, ion-exchange chromatography, membrane-based methods) used for the isolation and purification of chemical components.
3. **Explain the theory and working principles of thermal analysis methods** such as Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC).
4. **Demonstrate the ability to select suitable electroanalytical or separation techniques** for quantitative and qualitative analysis based on sample type, analyte, and required sensitivity.
5. **Interpret experimental data obtained from thermal analysis and electroanalytical instruments** to evaluate thermal stability, composition, and electrochemical behavior of compounds.
6. **Appreciate the role of modern separation and analytical methods** in pharmaceutical, environmental, food, and materials chemistry, focusing on accuracy, precision, and regulatory compliance.

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.

UNIT	CONTENT	No. of Hours
Unit 1: Introduction to Electroanalytical techniques		
1.1	**Introduction to Electroanalytical Techniques** Overview of **electrochemical techniques** **Basic electrode processes and redox reactions** Classification of **electroanalytical methods** Advantages and limitations of **polarography and amperometry**	**01**
1.2	**Polarography** **1.2.1 Fundamentals of Polarography** Principle of **polarographic analysis** **Ilkovic equation** and its significance **Dropping Mercury Electrode (DME)**: Properties and role in	**06**

	polarography	
	1.2.2 Instrumentation and Types of Polarography Components of a **polarographic system** **Classical DC Polarography** and its limitations Advanced polarographic techniques: **Differential Pulse Polarography (DPP)** **Square Wave Polarography (SWP)** **1.2.3 Applications of Polarography** **Quantitative analysis** of metal ions (e.g., Pb, Cd, Zn) **Pharmaceutical applications** (drug stability and degradation studies) **Environmental monitoring** (pollutant analysis in water and soil) **Polarographic titrations** (redox and complexometric titrations)	
1.3	**Amperometry** **1.3.1 Fundamentals of Amperometry** Principle of **amperometric detection** Comparison with **voltammetry and potentiometry** **Faraday's Law** and its role in current measurement **1.3.2 Amperometric Techniques & Instrumentation** **Single and dual electrode systems** **Amperometric titrations**: Concept and methodology Industrial applications in **corrosion monitoring and food analysis** **1.3.3 Applications of Amperometry** **Biomedical applications** (enzyme-based glucose biosensors) **Environmental applications** (detection of pesticides and pollutants) **Industrial applications** (oxygen sensors and gas analysis)	**03**
UNIT II:	**Methods of Separation - II**	
2.1	**Gas Chromatography (GC)** **2.1.1 Fundamentals of Gas Chromatography** **Principle of GC**: Separation based on volatility and boiling point Types of GC: **Gas-Liquid Chromatography (GLC) & Gas-Solid Chromatography (GSC)** Comparison with **HPLC and other chromatographic techniques** **2.1.2 Instrumentation & Methodology** **Components of GC system**: Carrier gas, injectors, columns, detectors **Stationary phases** and column selection (Capillary vs. Packed columns) Sample injection techniques: **Split, splitless, and on-column injection** **2.1.3 Detectors & Data Interpretation** **Types of detectors**: Flame Ionization Detector (FID), Thermal Conductivity Detector (TCD), Electron Capture Detector (ECD), Mass Spectrometry (GC-MS) Interpretation of **chromatograms** and qualitative/quantitative analysis **2.1.4 Applications of GC** **Pharmaceutical industry**: Analysis of volatile drugs and residual solvents **Food and beverage industry**: Detection of **flavors, additives, and contaminants** **Environmental monitoring**: Analysis of **pesticides and air pollutants**	**05**
2.2	**Ion Exchange Chromatography (IEC)** **2.2.1 Fundamentals of Ion Exchange Chromatography** **Basic principles**: Separation based on ion exchange equilibria Types of ion exchangers: **Cation exchangers & Anion exchangers** Factors affecting separation: **pH, ionic strength, and temperature** **2.2.2 Instrumentation & Resin Properties** **Types of ion exchange resins** (Strong/weak acid and base exchangers) **Column packing and selection of eluents**	**05**

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

References:

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PRACTICALS

SEMESTER VI

COURSE CODE: VSCH354 **CREDITS: 2**

Learning Objectives (LOs)

LO1: To determine molecular properties such as molecular weight of polymers using viscosity measurements and interpret the results.

LO2: To understand and analyze acceptable and non-acceptable wave functions through graphical representation and theoretical criteria.

LO3: To apply electroanalytical techniques such as potentiometry and conductometry for estimation of ions, determination of reaction parameters, and analysis of mixtures.

LO4: To evaluate conductance behavior of electrolytes and verify theoretical models such as Onsager's equation.

LO5: To develop proficiency in inorganic synthesis, including green synthesis methods, and perform quantitative estimation of prepared compounds.

LO6: To apply separation techniques and instrumental methods (colorimetry, spectrophotometry, ion-exchange) for analysis of environmental and industrial samples.

Course Outcome

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

CO1: Understand and apply principles of physical chemistry, electrochemistry, and quantum chemistry concepts such as viscosity, wave functions, and conductance through experimental approaches.

CO2: Develop competence in advanced analytical techniques including potentiometry, conductometry, colorimetry, and spectrophotometry for qualitative and quantitative analysis of chemical systems.

CO3: Demonstrate skills in inorganic synthesis, green chemistry approaches, separation techniques, and real sample analysis with accuracy, safety, and environmental awareness.

Subject	Sr. No.	Experiment
Physical Chemistry	1	To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by Viscosity measurement.
	2	To study acceptable and non-acceptable wavefunctions by graphical representations.
	3	Potentiometry: To determine the amount of iodide, bromide and chloride in the mixture by potentiometric titration with silver nitrate.
	4	To determine the number of electrons in the redox reaction between ferrous ammonium sulphate and ceric sulphate potentiometrically.
	5	Conductometry: To titrate a mixture of weak acid and strong acid against strong base and estimate The amount of each acid in the mixture conductometrically.
	6	Determine the equivalent conductance of strong electrolyte at several concentrations and hence verify Onsager"s equation.
	7	Colorimetry To estimate the amount of Fe(III) in the complex formation with salicylic acid by Static Method.
Inorganic Chemistry	8	Inorganic preparations Preparation of Tris(acetylacetonate) iron(III)
	9	Inorganic preparations Green synthesis of bis(dimethylglyoximes) nickel (II) complex using nickel carbonate and sodium salt of dmg.
	10	Preparation of potassium trioxalato aluminate (III)
	11	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)
	12	Preparation of ferrous ethylene diammonium sulphate
Organic Chemistry	13	**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.
Analytical Chemistry	14	Spectrophotometric Estimation of Chromium in Water Samples: Understand how to determine chromium concentration in water

		using the Diphenylcarbazide reagent and UV-Vis spectrophotometry.
	15	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.
	16	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
	17	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.
	18	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.

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.

Semester – 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

1. Importance of chemical industry,
2. Meaning of the terms involved,
3. Comparison between batch and continuous process,
4. Knowledge of various industrial aspects
5. Concept of basic chemicals,
6. Their uses and manufacturing process.

Course Outcome

Upon completing the course, the student will be able to

CO 1	Explain the basics of small-scale industry right from its setting to the various operations and processes used in different chemical manufacturing processes.
CO 2	Explore the process of manufacture of fertilizers, agrochemicals and brief account of perfumes, flavours and sweeteners
CO 3	Demonstrate the process of preparation and uses of Industrial solvents
CO 4	Outline the safe handling of chemicals and environmental issues for the betterment of mankind.

COURSE CONTENT

UNIT	CONTENT	No. Of Hours
Unit I	1.1 **Introduction to Chemical Industry**. Explanation of the terms Heavy (Bulk) and Fine (Speciality) Chemicals. 1.2 **Silicates:** a) Introduction to silicates: Properties, structure and types of silicates. Preparation of sodium silicate. 1.3 **Manufacture and applications of the following:** a) Talcum powder b) Nitric acid c) Sodium dichromate d) Chromium trioxide	**02** **03** **05**
Unit II	**2.1 Fertilizers:** Preparation, properties and uses of a) Normal superphosphate b) Triple Superphosphate c) Ammonium nitrate d) Ammonium Sulphate **2.2 Industrial solvents** Manufacture and uses of ethyl acetate, isopropyl alcohol, Acetone, Acetic acid, Dimethyl formamide, Brief idea of green solvents.	**04** **06**

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

References:

1. Industrial Chemistry, B. K. Sharma, Goel publishing House, 18th Ed. (2014)
2. Faith Keyes and Clerk's Industrial Chemicals, 4thEdn., 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' 5th Edition, G. T. Oustin, McGraw Hill.
9. Riegel's Hand Book of Industrial Chemistry, 9th 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' 5th Edition, G. T. Austin, McGraw Hill, 1984.

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Semester – V

Practicals–Elective-1

Course Code: VSCH306 **Credits: 2**

(Micro scale Preparation and Estimations)

Learning Objectives (LOs)

LO1: To synthesize inorganic and organic compounds such as ferrous sulphate, Mohr's salt, aspirin, Schiff's base, and dyes using standard laboratory procedures.

LO2: To understand and apply green chemistry principles through solvent-free and environmentally benign synthetic methods.

LO3: To perform volumetric and back titration techniques for estimation of substances such as iodine, methyl salicylate, acetic acid, glycine, and calcium.

LO4: To carry out oxidation, nitration, and condensation reactions and understand their underlying reaction mechanisms.

LO5: To apply spectrophotometric techniques for determination of λmax, verification of Beer–Lambert law, and study of pH effects on absorption spectra.

LO6: To develop skills in data analysis, result interpretation, and accuracy evaluation in chemical experiments.

Course Outcomes

Upon completing the course, the student will be able to

CO1: Understand and apply principles of organic and inorganic synthesis, including reaction mechanisms, green chemistry approaches, and purification techniques.

CO2: Develop skills in quantitative chemical analysis using titrimetric, complexometric, and spectrophotometric methods for accurate estimation of chemical species.

CO3: Demonstrate the ability to perform synthesis, characterization, and analysis of compounds while interpreting experimental data and ensuring laboratory safety and sustainability.

Subject	Sr. No.	Experiment
Group-I	1	Preparation of Ferrous sulphate heptahydrate from Iron turnings.
	2	Preparation of Aspirin (Acetylation of Salicyclic acid)
	3	Green synthesis: Solvent free synthesis of benzillic acid from benzil
	4	Estimation of tincture iodine (amount of iodine present by titrating against standard $Na_2S_2O_3$ solution using starch indicator)
Group-II	5	Estimation of methyl salicylate. (Back titration method)
	6	Estimation of acetic acid in a sample of vinegar (Titrimetric)
	7	Preparation of Mohr salt (Ferrous Ammonium Sulphate) using $FeSO_4$
	8	Preparation of Ammonium Copper sulphate (Double salt) using $CuSO_4$
Group-III	9	Preparation of Schiff's base using benzaldehyde and aniline.
	10	Oxidation of benzaldehyde to benzoic acid by alkaline KMnO4
	11	Preparation of m-Nitro benzoic acid from Benzoic acid.
	12	Preparation of Orange II dye from Sulphanilic acid.
Group-IV	13	Determination of λmax and Beer-Lambert law verification for a colored compound (Congo Red dye or any other dye).
	14	Estimation of Calcium in milk by complexometric titration .
	15	Estimation of Glycine volumetrically in a given sample
	16	Study the effect of pH on λmax for colored organic dye.

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: VSCH307 **Credits: 2**

Medicinal and Green Chemistry

Learning Objectives

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

1. Importance of pharmaceutical industry,
2. Meaning of the different terms involved in medicinal chemistry, their uses and manufacturing process.
3. Raising an awareness on the potential toxic effects of different chemicals and problems related to waste generation.
4. Inculcating the need to practice green chemistry as it is the only way to meet the global challenges the world is facing today.
5. 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.
6. 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

CO 1	Understand the basic understanding of drugs, Sources of Drugs, classification and terminology involved in pharmacopeia
CO 2	Designing and uses of different drugs used in the common diseases
CO 3	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
CO 4	Creatively redesign traditional experiments with a green focus (using the various principles of green chemistry)

UNIT	CONTENT	No. Of Hours
Unit I	**Medicinal Chemistry**	
	1.1 :General Introduction to Drugs: Sources of Drugs, Requirement of an Ideal Drug, Classification of Drugs, Nomenclature of Drugs, Definition of Some Medicinal Terms, Pharmacopoeia **1.1.2 Synthesis and uses of the following drugs:** 1) Ethambutol 2) Mebendazole 3) Benadryl 4) Ibuprofen 5) Miconidazole 6) Diazepam	**04** **04**

	1.1.3 Fluoroaromatics: Introduction, important reagents used for fluorination, Halex reaction, Super Halex reaction, Preparation of ortho-fluorotoluene and 3-chloro-4-fluoro anilines.	**02**
Unit II	**2.1 Routes of Drug Administration and Dosage Forms** Oral and Parenteral routes with advantages and disadvantages. Formulations and combination formulation, Different dosage forms (including Patches and Adhesives, emphasis on Sustained release formulations and Enteric coated tablets). **2.2 Pharmacodynamic Agents** A brief introduction of the following pharmacodynamic agents and the study with respect to their chemical structure, chemical class, therapeutic uses, and side effects. **2.3Analgesics, Antipyretics and Anti-inflammatory Drugs** **Analgesics and Antipyretics** • Morphine (Phenanthrene alkaloids) • Tramadol (Cyclohexanols) **(Synthesis from salicylicacid)** • Aspirin(Salicylates) • Paracetamol (p-Amino phenols) **Anti-inflammatory Drugs** Mechanism of inflammation and various inflammatory conditions. • Steroids: Prednisolone, Betamethasone • Sodium Diclofenac, Aceclofenac (N-Aryl anthranilicacids) (Synthesis from 2,6-dichlorodiphenyl amine) **Antihistaminic Drugs** • Diphenhydramine (Ethanolamines) • Cetrizene (Piperazine) (Synthesis from 4-Chlorobenzhydryl chloride) • Chlorpheniramine maleate (Ethyl amines) • Pantoprazole(Benzimidazoles)	**02** **03** **05**
Unit III	**Green chemistry - I**	
	3.1 Introduction, basic principles of green chemistry and synthesis: 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_2 iv) Green catalysts: Bio catalysts. **3.2 Accelerating Innovations through Emerging Green Technologies** **3.2.1** Green Energy, Global Warming (Climate Change), Renewable energy **3.2.2** Microwave Assisted Synthesis; Ultrasound Assisted Synthesis **3.2.3 Green Solvents** Problems associated with traditional solvents, Water as a green solvent, Ionic Liquids, Supercritical CO_2 **3.2.4 Green Catalysts** General Introduction to Catalysis, Types of Catalysts, Green Catalyst, Nano catalyst: Advantages and Disadvantages of Nano catalysts	**04** **06**

References:

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' 5th 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

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Semester – V

Practicals–Elective-2

Course Code: VSCH308 Credits**: 2**

(Micro scale Preparation and Estimations)

Learning Objectives (LOs)

LO1: To synthesize inorganic and organic compounds such as ferrous sulphate, Mohr's salt, aspirin, Schiff's base, and dyes using standard laboratory procedures.

LO2: To understand and apply green chemistry principles through solvent-free and environmentally benign synthetic methods.

LO3: To perform volumetric and back titration techniques for estimation of substances such as iodine, methyl salicylate, acetic acid, glycine, and calcium.

LO4: To carry out oxidation, nitration, and condensation reactions and understand their underlying reaction mechanisms.

LO5: To apply spectrophotometric techniques for determination of λmax, verification of Beer–Lambert law, and study of pH effects on absorption spectra.

LO6: To develop skills in data analysis, result interpretation, and accuracy evaluation in chemical experiments.

Course Outcomes

Upon completing the course, the student will be able to

CO1: Understand and apply principles of organic and inorganic synthesis, including reaction mechanisms, green chemistry approaches, and purification techniques.

CO2: Develop skills in quantitative chemical analysis using titrimetric, complexometric, and spectrophotometric methods for accurate estimation of chemical species.

CO3: Demonstrate the ability to perform synthesis, characterization, and analysis of compounds while interpreting experimental data and ensuring laboratory safety and sustainability.

Subject	Sr. No.	Experiment
Group-I	1	Preparation of Ferrous sulphate heptahydrate from Iron turnings.
	2	Preparation of Aspirin (Acetylation of Salicyclic acid)
	3	Green synthesis: Solvent free synthesis of benzillic acid from benzil
	4	Estimation of tincture iodine (amount of iodine present by titrating against standard $Na_2S_2O_3$ solution using starch indicator)
Group-II	5	Estimation of methyl salicylate. (Back titration method)
	6	Estimation of acetic acid in a sample of vinegar (Titrimetric)
	7	Preparation of Mohr salt (Ferrous Ammonium Sulphate) using $FeSO_4$
	8	Preparation of Ammonium Copper sulphate (Double salt) using $CuSO_4$
Group-III	9	Preparation of Schiff's base using benzaldehyde and aniline.
	10	Oxidation of benzaldehyde to benzoic acid by alkaline KMnO4
	11	Preparation of m-Nitro benzoic acid from Benzoic acid.
	12	Preparation of Orange II dye from Sulphanilic acid.
Group-IV	13	Determination of λmax and Beer-Lambert law verification for a colored compound (Congo Red dye or any other dye).
	14	Estimation of Calcium in milk by complexometric titration .
	15	Estimation of Glycine volumetrically in a given sample
	16	Study the effect of pH on λmax for colored organic dye.

References:

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

Learning Objectives

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

1. Importance of chemical industry,
2. Meaning of the terms involved,
3. Comparison between batch and continuous process,
4. Knowledge of various industrial aspects
5. Concept of basic chemicals,
6. Their uses and manufacturing process.

Course Outcome

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

CO 1	Various methods of refrigeration and cold storage systems.
CO 2	Manufacturing process, properties and applications of bulk chemicals and composite materials.
CO 3	Concept of Small-Scale Industries, rules and regulations and R and D technology in industry.
CO 4	General idea of the common unit operations used in chemical Industries

CONTENT

UNIT		**No. Of Hours**
Unit-I	**Bulk Chemicals**	
	1.1 Refrigeration: System, media used for cold transfer (i.e. brine and other) **1.2 Manufacturing process properties and applications of:** a) Sulphuric acid (Contact Process) b) Ammonia (Haber's process) c) Sodium hydroxide **1.3 Zeolites, Clays and Ion-exchange resins** **1.4 Design of vessel:** Classification of chemical reactors, pressure vessels for internal or external pressure, Maintenance, storage vessels for liquids and gases **1.5 Industrial preparation of Inorganic Fine chemicals:** $KMnO_4$, $FeSO_4.10H_2O$	**02** **02** **02** **02** **02**
Unit-II	**2.1 Composite materials**: Introduction, Constitution of composites, Classification of composites, Particle Reinforced composites, Fiber reinforced composites, Structural composites or Layered composites, Applications of composite materials**.** **2.2 Unit Operations:** General idea of the following operations used in Industries; **a. Filtration:** Introduction, factors affecting the rate of Filtration, Filtration Processes. a) Plate and frame filter Press b) Rotary Drum filter **b. Distillation:** Introduction, Distillation methods a) Bubble cap column	**03** **07**

	distillation b) Fractional distillation **c. Crystallization: Introduction**, Solubility, Super saturation, Nucleation, Crystal growth**,** Crystallization process, a) Agitated Tank Crystallizer, b) Swenson Walker Crystallizer **d. Centrifugation**: Introduction, Centrifugation process used in Industry.	
Unit III	**Small Scale Industries**	
	3.1 Small Scale Industries and R and D technology: 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, **3.2 Manufacture of soaps:** Raw materials, Preparation, properties and types of soaps, Continuous process for the manufacture of soap. **3.3 Oils and Fats:** 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 **3.4 Detergents:** Introduction, classification, manufacture of DDBS, industrial applications.	**04** **02** **02** **02**

References:

1. Industrial Chemistry, B. K. Sharma, Goel publishing House, 18th Ed. (2014)
2. Faith Keyes and Clerk's Industrial Chemicals, 4thEdn., 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' 5th Edition, G. T. Oustin, McGraw Hill.
9. Riegel's Hand Book of Industrial Chemistry, 9th 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' 5th Edition, G. T. Austin, McGraw Hill, 1984.

Semester – VI

Practicals–Elective-1

Course Code: VSCH356 Credits**: 2**

(Micro scale Preparation and Estimations)

Learning Objectives (LOs)

LO1: To synthesize organic and inorganic compounds such as paracetamol, p-nitroaniline, fluorescein, anthraquinone, and copper sulphate using standard laboratory methods.

LO2: To perform volumetric and back titration methods for estimation of substances such as phosphoric acid, ibuprofen, and magnesium hydroxide.

LO3: To apply complexometric and gravimetric techniques for analysis of metal ions in alloys such as Devarda's alloy, magnesium alloy, and steel.

LO4: To carry out colorimetric estimation of dyes such as Eriochrome Black T and Congo Red and understand their analytical significance.

LO5: To understand dyeing processes and apply principles of textile chemistry through dyeing of cotton with azo dyes.

LO6: To correlate laboratory experiments with industrial practices through analysis of commercial samples and industrial visits.

Course Outcomes:

CO1: Understand and apply principles of organic synthesis, inorganic preparation, and industrial chemistry in the preparation and processing of chemical compounds and dyes.

CO2: Develop proficiency in quantitative chemical analysis using volumetric, complexometric, gravimetric, and colorimetric techniques for pharmaceutical and alloy analysis.

CO3: Demonstrate the ability to analyze industrially relevant samples, interpret experimental data, and relate laboratory practices to real-world chemical and industrial processes.

Subject	Sr. No.	Experiment
Group-I	1	Preparation of Copper sulphate pentahydrate
	2	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).
	3	Preparation of Paracetamol from p-Aminophenol
	4	Determination of the amount of magnesium hydroxide in a commercial sample of milk of magnesia
Group-II	5	Estimation Ibuprofen in the Given Sample (Back Titration Method)
	6	Analysis of Devarda's Alloy To Analyze the Given Sample Of Devarda's Alloy For Its Copper Content By EDTA
	7	Analysis of Magnelium Alloy Determine The Percentage of Magnesium In The Given Sample Of Magnesium Alloy.(Mg Content By Complexometric Method.)
	8	Analysis of Steel Nickel Analyze The Given Sample Of Steel For Its Nickel Content By Homogenous Precipitation Method.
Group-III	9	Preparation of P-Nitroaniline From P-Nitroacetanilide
	10	Preparation of Fluorescein From Phthalic Anhydride
	11	Preparation of Anthraquinone From Anthracene
	12	Dyeing Cotton Fibre With Congo Red
Group-IV	13	Estimation of Eriochrome Black T Colorimetrically
	14	Estimation of Congo Red Colorimetrically
	15	Industrial Visit

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.

References:

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.

Semester – VI

Paper V: Electives-2

Course Code: VSCH357 **Credits: 2**

Chemistry of Dyestuffs and Green Chemistry

Learning Objectives

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

1. Importance of Dyestuffs industry,
2. Meaning of the different terms involved in Dyestuffs industry,
3. Their uses and manufacturing process.
4. Inculcating the need to practice green chemistry as it is the only way to meet the global challenges the world is facing today.
5. Providing a basis and framework for pursuing science in the most creative, innovative and responsible manner possible.
6. 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

CO 1	Understand the basic understanding of dyes, sources of dyes, classification and terminology involved in Dyestuffs industry
CO 2	Designing and uses of different dyes used for dyeing different fibers.
CO 3	Learn about the green trends being practiced in pharmaceutical industries through depiction of some interesting industrial case studies
CO 4	Learn about academic-industrial collaborations and the potential these relationships hold in furthering green chemistry and making our planet Earth greener

UNIT	**CONTENT**	**No. of Hours**
Unit-1	**Introduction to the Dye-stuff Industry**	
	Definition of dyes, Requirements of a good dye, Chromophore and Auxochrome, Solubility, Economic viability. Definition of fastness and its properties and Mordants with examples **Natural Dyes:** 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. **Synthetic dyes:** Definition of synthetic dyes, primaries and intermediates. Important milestones in the development of synthetic dyes – Emphasis on Name of the Scientist and dyes.	**03** **03**

	Classification of Dyes based on Applications and Dyeing Classification of dyes based on applicability on substrates (examples with structures). a) Acid Dyes – Orange II b) Basic Dyes – Methyl Violet c) Direct Cotton Dyes – Benzofast Yellow 5GL d) Azoic Dyes – Diazo components; Fast Yellow G, Fast Orange R e) Mordant Dyes – Eriochrome Black A, Alizarin f) Vat Dyes – Indanthrene Brown RRD g) Sulphur Dyes – Sulphur Black T (no structure) h) Disperse Dyes – Celliton Fast Brown 3R i) Reactive Dyes – Cibacron Brilliant Red B	**04**
Unit II	**2.1 Substrates for Dyes:** 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, van der-waals forces. **2.2 Dyeing methods** **Basic operations involved in dying process:** (i) Preparation of fibres (ii) Preparation of dyebath (iii)Application of dyes (iv) Finishing **Dyeing method of Cotton Fibres:** (i) Direct dyeing (ii) Vat dyeing (iii) Mordant dyeing (iv) Disperse dyeing **2.3 Synthesis and applications of the following dyes:** 1) Indigo 2) Alizarin 3) Eriochrome Black-T 4) Auramine-O 5) Procion-red 6) Congo red	**04** **03** **03**
Unit III	**Green chemistry-II**	
	3.1 Green Chemistry solutions for water pollution (Current Green Technologies employed in Water Treatment) ➢ Water Pollution and root causes ➢ Catalytic Degradation of organic water pollutants ➢ Photo-oxidation technologies ➢ Removal of heavy metals (inorganic pollutants) via new adsorption technology **3.2 Green Chemistry in Pharmaceutical Industry** ➢ Green Trends being followed in Pharmaceutical Industry ➢ Industrial Case Studies: Ranitidine, Celecoxib, Ibuprofen, Sertraline ➢ Special Recognition: US Presidential Green Challenge Awards **3.3 New Technological Developments:** New Avenues for the Green Economy and Sustainable Future of Science and Technology Future Prospectives	**04** **04** **02**

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' 5th 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**

(Micro scale Preparation and Estimations)

Learning Objectives (LOs)

LO1: To synthesize organic and inorganic compounds such as paracetamol, p-nitroaniline, fluorescein, anthraquinone, and copper sulphate using standard laboratory methods.

LO2: To perform volumetric and back titration methods for estimation of substances such as phosphoric acid, ibuprofen, and magnesium hydroxide.

LO3: To apply complexometric and gravimetric techniques for analysis of metal ions in alloys such as Devarda's alloy, magnesium alloy, and steel.

LO4: To carry out colorimetric estimation of dyes such as Eriochrome Black T and Congo Red and understand their analytical significance.

LO5: To understand dyeing processes and apply principles of textile chemistry through dyeing of cotton with azo dyes.

LO6: To correlate laboratory experiments with industrial practices through analysis of commercial samples and industrial visits.

Course Outcomes:

CO1: Understand and apply principles of organic synthesis, inorganic preparation, and industrial chemistry in the preparation and processing of chemical compounds and dyes.

CO2: Develop proficiency in quantitative chemical analysis using volumetric, complexometric, gravimetric, and colorimetric techniques for pharmaceutical and alloy analysis.

CO3: Demonstrate the ability to analyze industrially relevant samples, interpret experimental data, and relate laboratory practices to real-world chemical and industrial processes.

Subject	Sr. No.	Experiment
Group-I	1	Copper sulphate pentahydrate
	2	Determination of the amount of. phosphoric acid from a given sample using 1-naphtholphthalein and phenolphthalein indicator. (Students to prepare succinic acid solution for standardizationof NaOH).
	3	Paracetamol from p-Aminophenol
	4	Determination of the amount of magnesium hydroxide in a commercial sample of milk of magnesia
Group-II	5	Estimation Ibuprofen In The Given Sample (Back Titration Method)
	6	Analysis Of Devarda's Alloy To Analyze the Given Sample Of Devarda's Alloy For Its Copper Content By EDTA
	7	Analysis of Magnelium Alloy Determine The Percentage of Magnesium In The Given Sample Of Magnesium Alloy.(Mg Content By Complexometric Method.)
	8	Analysis of Steel Nickel Analyze The Given Sample Of Steel For Its Nickel Content By Homogenous Precipitation Method.
Group-III	9	Preparation of P-Nitroaniline From P-Nitroacetanilide
	10	Preparation of Fluorescein From Phthalic Anhydride
	11	Preparation of Anthraquinone From Anthracene
	12	Dyeing Cotton Fibre With Congo Red
Group-IV	13	Estimation of Eriochrome Black T Colorimetrically
	14	Estimation of Congo Red Colorimetrically
	15	Industrial Visit

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.

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) (60 Hrs Practicals)		Course Code: VSCH309	
Periods per week (1 period 120 minutes)			
Credits		**2**	
Evaluation System		**Hours**	**Marks**
	Practical Examination	**-**	**100**

Learning Objectives (LOs)

LO1: To determine the composition and purity of chemical samples such as soaps, salts, ores, and pharmaceutical products using standard analytical methods.

LO2: To study surface and solution chemistry concepts including Critical Micelle Concentration (CMC) and the effect of ionic strength on reaction kinetics.

LO3: To apply electroanalytical techniques such as pH-metry and conductometry for estimation of analytes like vitamin C and reaction parameters.

LO4: To perform gravimetric, complexometric, and iodometric estimations for determination of metal ions such as Ba^{2+}, Ca^{2+}, Mg^{2+}, and Cu^{2+}.

LO5: To utilize instrumental methods such as spectrophotometry and chromatography for analysis of sugars, metal ions, and separation of mixtures.

LO6: To carry out extraction, synthesis, and characterization techniques and analyze environmental parameters such as dissolved oxygen in water.

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Understand and apply physicochemical and analytical principles such as surface chemistry, kinetics, electrochemistry, and gravimetry in chemical analysis.

CO2: Develop proficiency in classical and instrumental analytical techniques including titrimetry, conductometry, pH-metry, spectrophotometry, chromatography, and photometric titration.

CO3: Demonstrate skills in qualitative and quantitative analysis of real samples (pharmaceuticals, environmental samples, ores, and commercial products) with accuracy and reliability.

Subject	Sr. No.	Experiment
Group I	1	To determine the amount of chlorides in given soap sample.
	2	Conductometric determination of Critical Micelle Concentration (CMC) of a surfactant
	3	pH-metry: To determine vitamin C content of a given tablet by titration with NaOH pH-metrically
	4	To study the effect of ionic strength on the kinetics of the reaction between potassium persulphate and potassium iodide.
Group II	5	To Characterize Bis(tetraethyl ammonium)tetrachloro cuprate (II) (Preparation in Inorganic Practical and same compound to be used for characterization)
	6	Preparation of tetraamine copper (II) sulphate (Estimation of copper iodometric ally) II.
	7	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)
	8	Gravimetric Estimation of Barium as Barium Sulphate – Understanding precipitation gravimetry.
Group III	9	Extraction of Essential Oil from Citrus Peels using Steam Distillation
	10	Acid Neutralizing Capacity of a given antacid (Gelucil tablet) by Acid-Base titration
Group IV	11	To estimate the amount of reducing sugar by DNSA method spectrophotometrically by calibration curve method.
	12	Separation and identification of cations like Fe(III) , Ni(II) and Cu(II) in a sample by paper chromatography
	13	To determine Ca/Mg content of Dolomite ore using EDTA titration
	14	To determine the DO (Dissolved Oxygen) in the given water sample
	15	Estimation of Cu using Cu-EDTA by photometric titration.

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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T.Y.B.Sc. CHEMISTRY (Six Units):Choice Based Credit System			
Semester - VI			
PAPER – IV: VSC (Hands-on Advanced Laboratory Techniques: Synthesis, Analysis, and Sustainable methods)			
Course Name: Vocational Skill Course in Chemistry (SEC) (60 Hrs Practicals)		Course Code: VSCH359	
Periods per week (1 period 120 minutes)			
Credits		**2**	
Evaluation System		**Hours**	**Marks**
	Practical Examination	**-**	**100**

Learning Objectives (LOs)

LO1: To determine optical properties such as specific rotation of optically active substances using polarimetry.

LO2: To apply spectrophotometric and colorimetric methods for estimation of metal ions and organic compounds in various samples.

LO3: To perform volumetric and back titration techniques for estimation of compounds such as acetamide, formaldehyde, aniline, and free acids in oils.

LO4: To analyze pharmaceutical and food samples for constituents such as paracetamol, glucose, and fatty matter using standard analytical procedures.

LO5: To evaluate physicochemical parameters such as iodine value and nitrate content relevant to quality control and environmental analysis.

LO6: To understand and implement green chemistry approaches such as nanoparticle synthesis and assess their analytical applications.

Course Outcomes (COs)

By the end of this course, students will be able to:

CO1: Understand and apply principles of optical activity, spectroscopy, and titrimetric analysis in quantitative chemical estimation.

CO2: Develop analytical skills using instrumental techniques such as polarimetry, spectrophotometry, and photometric titration for pharmaceutical, food, and environmental samples.

CO3: Demonstrate the ability to perform chemical estimations, green synthesis, and interpret analytical data with accuracy, precision, and relevance to real-world applications.

Subject	Sr. No.	Experiment
Group-I	1	Polarimetry: To determine the specific rotation of cane sugar/glucose
	2	To determine total fatty matter (TFM) present in given soap sample.
	3	Spectrophotometric Estimation of Iron using 1,10-Phenanthroline
	4	Estimation of Nitrate in Drinking Water by using spectrophotometer
Group-II	5	Synthesis of Nanoparticles using Green Chemistry Approach
	6	Estimation of Acetamide by back titration.
	7	Estimation of formaldehyde by Iodometric titration
	8	Estimation of Aniline by Iodometric titration
Group-III	9	Estimation of Methyl Orange by Colorimetry
	10	Determination of paracetamol in tablets by using spectrophotometric method.
	11	Estimation of free acid in vegetable oil (Castor oil, olive oil, coconut oil,or groundnut oil) by back titration method
Group-IV	12	To determine Iodine value by Wij's method for given oil sample
	13	To determine the amount of Fe (III) in given solution by photometric titration using EDTA
	14	To determine the amount of Fe present in given Vitamin tablet colorimetrically
	15	To determine amount of glucose in given solution by Folin Wu method.

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).

T.Y.B.Sc. Chemistry: Choice Based Credit System			
Semester-V			
Course Name: Modern Chemistry: Theory, Reactions, and Techniques - I (30Lectures)			**Course Code** VSCH310
Periods per week(1period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**-**	**60**
	Theory Internal	**-**	**40**

Learning Objectives:

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.
2. Analyze Chemical Equilibria – Describe dynamic equilibrium in chemical systems, apply Le Chatelier's Principle, Understand Chemical Kinetics –Understand the factors affecting rate of reaction analyze energy profiles and transition states in reaction pathways. Use arrhenius equation and learn effect of temperature on reaction rate
3. Learn purification methods used for solid and liquid compounds. Understand selection of solvent and assembly used for recrystallization, principle and procedures of distillation and Chromatographic techniques.
4. 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.

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

CO 1	Understand spontaneity of reaction based on thermodynamic parameters, Apply le Chatelier's principle to predict shift in equilibrium. Understand energy of activation. Learn purification methods and chromatographic techniques.
CO 2	Understand stereochemistry and conformationally analysis. Learn about various functional groups in organic compounds
CO 3	Understand coordination chemistry, transition metals and solid state chemistry.

Unit	CONTENT	No. of Hours
Unit-I	Unit- I 1.1 Stoichiometry 1.1.1 Mole concept and Avogadro's constant. 1.1.2 Expressing concentration of solutions: Normality, molality, molarity, mole fractions, 1.1.3 Concept of primary and secondary standard substances, Preparation of standard solution (Numericals expected) 1.2 Ionic equilibrium 1.2.1 Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization 1.2.2 Ionization constant, Ostwald's dilution law, common ion effect.(Numericals expected)	**10**
Unit-II	2.1 Stereoisomerism and conformational analysis of alkanes and cycloalkanes. Chirality, R/S Nomenclature, homotopic and heterotopic faces and ligands, Introduction to elements of symmetry. 2.2 Chemistry of Functional Group Alcohols, Carbonyl compounds, Amines and Aromatic sulphonic acid (General introduction, preparation, properties and reactions of the above functional groups to be discussed)	**10**
Unit-III	**3.1 Coordination Chemistry** 3.1.1Introduction of Ligands, coordination numbers, and crystal field theory (Only theory, application need not be discussed) 3.1.2 Applications of coordinated complexes in catalysis and medicine **3.2 Introduction to Transition Elements** 3.2.2 Biological and industrial importance of transition metals **3.3 Solid State Chemistry** 3.3.1 Crystal structures, defects, and band theory 3.3.2 Nanomaterials	**10**

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., Holler, F. J., & Crouch, S. R. (2017). *Principles of Instrumental Analysis*. Cengage Learning.
5. Vogel, A. I. (2008). *Vogel's Textbook of Quantitative Chemical Analysis*. Pearson.

Practicals (Minor)

Semester: V

COURSE CODE: VSCH311 **CREDITS: 2**

Learning Objectives (LOs)

LO1: To apply potentiometric and conductometric titration methods for estimation of acids and redox systems.

LO2: To investigate reaction kinetics and compare the strength of acids through hydrolysis reactions.

LO3: To synthesize coordination compounds of transition metals and understand their composition and properties.

LO4: To perform systematic qualitative analysis of organic compounds based on preliminary tests, solubility, and elemental analysis.

LO5: To identify functional groups and determine physical constants (melting/boiling point) for characterization of organic compounds.

LO6: To interpret experimental observations and write balanced chemical reactions for identification and analysis of compounds

Course Outcomes:

CO1: Understand and apply principles of electroanalytical methods, chemical kinetics, and coordination chemistry through experimental investigations.

CO2: Develop proficiency in quantitative analysis using potentiometric and conductometric techniques for accurate estimation of chemical species.

CO3: Demonstrate skills in inorganic synthesis and systematic qualitative analysis of organic compounds, including identification and characterization based on functional groups.

Subject	Sr. No.	Experiment
Physical Chemistry	1	**Potentiometry** To determine the amount of HCl in the given sample potentiometrically.
	2	Estimation of Fe (II) in the given solution by titrating against K2Cr2O7 potentiometrically
	3	**Conductometry** Estimation of given acid by conductometric titration with strong base
	4	Chemical kinetics To compare the strength of HCl and H2SO4 by studying kinetics of acid hydrolysis of methyl acetate
Inorganic Chemistry	5	Inorganic Preparations Potassium diaqua bis(oxalato) cuprate(II)
	6	Inorganic Preparations Bis ethylenediamine copper (II) sulphate.
	7	Inorganic Preparations Sodium Hexanitrocobaltate (III)
	8	Inorganic Preparations Tris (Ethylene diamine) Nickel (II)Thiosulphate
	9	Tris(thiourea)copper(I)chloride,
Organic Chemistry	10	Qualitative Analysis of organic compounds including bi-functional groups on the basis of 1. Preliminary examination 2. Solubility profile. 3. Detection of elements C, H, (O), N, S, X. 4. Detection of functional groups 5. Determination of physical constants(M.P./B.P.) Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysis to be given: Carboxylic acids, phenol, carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halide. Students are expected to write balanced chemical reactions wherever necessary. **(Minimum 6 compounds to be analyzed)**

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			
PAPER-I			
Course Name: Modern Chemistry: Theory, Reactions, and Techniques - II (30Lectures)			**Course Code** VSCH360
Periods per week(1period 60 minutes)			**02**
Credits			**02**
Evaluation System		**Hrs**	**Marks**
	Theory Examination	**2.0**	**60**
	Theory Internal		**40**

Learning Objectives:

1. **Compare Collision and Transition State Theories** – Differentiate between **collision theory** and **transition state theory**, explaining their role in **reaction rate determination**.
2. **Analyze Unimolecular and Bimolecular Reactions** – Interpret the kinetics of **unimolecular and bimolecular reactions**, Use steady state approximation in Lindemann's mechanism derivation. **Explore Heterocyclic Chemistry in Pharmaceuticals** – Synthesize and analyze the reactions of **furan, thiophene, and pyrrole**, and explore their role in **drug development**.
3. **Understand Metal-Ligand Interactions** – Explain the **spectrochemical series, ligand field stabilization energy (LFSE)**, and their influence on **coordination complexes**.
4. **Apply Organometallic Chemistry in Catalysis** – Describe the structure and reactivity of **metal-carbonyl complexes**, and compare **homogeneous and heterogeneous catalysis** in **industrial applications**.
5. **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):

CO 1	Apply nernst equation, and calculate thermodynamic properties using EMF data, Understand reaction rate theories and Advanced instrumental techniques of chromatography.
CO 2	Analyze organic reaction mechanisms and their industrial or pharmaceutical applications
CO 3	Interpret coordination and organometallic chemistry concepts for catalysis and material synthesis

Unit	CONTENT	No. of Hours
Unit-I	**1.1 Electrochemistry** 1.1.1 Nernst equation and its importance, Types of electrodes, Standard electrode potential,(Numericals expected). 1.1.2 Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from Emf data. (Numericals expected) **1.2 Chemical Kinetics** 1.2.1 Collision theory and transition state theory. 1.2.2 Lindemann's mechanism for Unimolecular and bimolecular reactions 1.3 **Instrumental Techniques**: 1.3.1 Gas Chromatography (GC) 1.3.2 High-Performance Liquid Chromatography (HPLC)	**10**
Unit-II	**2.1 Heterocyclic Chemistry** 2.1.1 Nomenclature, structure and aromaticity of five membered heterocyclic compound containing one heteroatom. 2.1.2 Synthesis and reactions of furan, thiophene, and pyrrole 2.1.3 Reactivity of pyrrole, furan and thiophene towards electrophilic aromatic substitution reactions.	10
Unit-III	**3.1 Coordination Chemistry and Metal-Ligand Bonding** Spectrochemical series and ligand field stabilization energy (With Examples) **3.2 Organometallic Chemistry and Catalysis** 3.2.1 Synthesis of Metal-carbonyl complexes 3.2.2 Homogeneous and heterogeneous catalysis (Application not expected)	10

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.