The Kelkar Education Trust's
Vinayak Ganesh Vaze College of Arts, Science & Commerce
AUTONOMOUS
Mithaghar Road, Mulund East, Mumbai-400081, India College with Potential for Excellence
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Syllabus for B.Sc. Honors Programme:

Chemistry

Syllabus as per Choice Based Credit System (NEP-2020)

(June 2026 Onwards)

Submitted by

Department of Chemistry
KET's Vinayak Ganesh Vaze College of Arts, Science and Commerce (Autonomous)
Mithagar Road, Mulund (East) Mumbai-400081. Maharashtra, India.
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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 Chemistry

Sr. No.	Heading	Particulars
1	**Title of Programme**	**B.Sc. Honors in Chemistry: Semester VII and VIII**
2	**Eligibility for Admission**	The B.Sc. Honors degree examination of this university with chemistry 6 units or degree of any other university recognized as equivalent thereto. (with 120-132 Credits)
3	**Passing marks**	Minimum D Grade or equivalent minimum marks for passing at the Graduation level.
4	**Ordinances/Regulations (if any)**	---
5	**No. of Years/Semesters**	One year/Two semester
6	**Level**	UG 4th Year : Level-6
7	**Pattern**	Semester
8	**Status**	New
9	**To be implemented from Academic year**	2026 – 2027

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

Head, Dept. of Chemistry: Prof. (Dr.) Suresh S. Shendage

Preamble

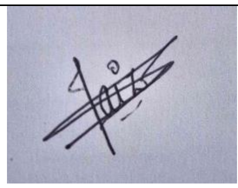
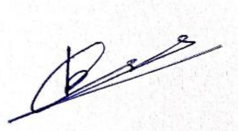
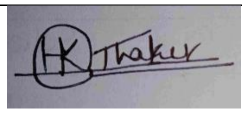
The Board of studies in Fourth Year B.Sc. Honors in Chemistry headed by Prof (Dr.) Suresh Shendage, the Chairman, Department of Chemistry, Vinayak Ganesh Vaze College of Arts, Science and Commerce (Autonomous), Mithagar Road, Mulund (East) Mumbai, University of Mumbai had the thorough discussions on the syllabus of VII and VIII semester Chemistry for B. Sc. Honors in 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 VII and VIII 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	

Under Graduate B.Sc. Honors Program in Chemistry

Year (2 Yr PG)	Level	Sem. (2 Yr)	Major: Mandatory*	Major: Electives Anyone	RM	OJT / FP	RP	Cum.Cr.	Degree
1	6.0	Sem-VII	For Chemistry						
			Course 1 Credits 4: Organic Chemistry-I Course 2 Credits 4: Analytical Chemistry- I Course 3 Credits 4: Inorganic Chemistry-I Course 4 Credits 2: Practicals (Organic Chemistry - I+ Analytical Chemistry-I)	**Credits 4 (2+2)** Course 1: Fundamentals of Physical Chemistry -I and Practicals: (Inorganic Chemistry-I + Physical Chemistry-I) **OR** Course 2: Fundamentals of Physical Chemistry - II and Practicals: (Inorganic Chemistry-I + Physical Chemistry-I)	04	--	--	22	PG Diploma (after 3 Year Degree)
		Sem-VIII	For Chemistry						
			Course 1 Credits 4: Organic Chemistry-II Course 2 Credits 4: Analytical Chemistry-II Course 3 Credits 4: Physical Chemistry-II Course 4 Credits 2: Practicals (Organic Chemistry-II + Analytical Chemistry-II)	**Credits 4 (2+2)** Course 1: Advance Inorganic and Organometallic Chemistry and Practicals: (Inorganic Chemistry-II + Physical Chemistry-II) **OR** Course 2: Inorganic aspect in Biological and Environmental Chemistry and Practicals: (Inorganic Chemistry-II + Physical Chemistry-II)	--	04	--	22	
Cum. Cr. for UG Diploma			**28**	**8**	**4**	**4**	**--**	**44**	
Exit option: PG Diploma (44 Credits) after Three Year UG Degree									

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. Honors (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 scientific information 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.

Curriculum

The total minimum credits required for completing the BSc Honors in Chemistry is **66**

SEMESTER –VII					
Code	**Course of Study**	**L**	**T**	**P**	**C**
VSCHH400	Organic Chemistry - I	4	-	-	4
VSCHH401	Analytical Chemistry - I	4	-	-	4
VSCHH402	Inorganic Chemistry - I	4	-	-	4
VSCHH403	**Practicals**	-	-	4	2
	Electives				
VSCHH404	Fundamentals of Physical Chemistry -I	2	-	-	2
VSCHH405	Elective Practicals - 1	-	-	4	2
VSCHH406	Fundamentals of Physical Chemistry - II	2	-	-	2
VSCHH407	Elective Practicals - 2	-	-	4	2
VSCHH408	**Research Methodology (RM)**	-	-	8	4
		-	-	-	**22**

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

SEMESTER – VIII					
Code	**Course of Study**	**L**	**T**	**P**	**C**
VSCHH450	Organic Chemistry - II	4	-	-	4
VSCHH451	Analytical Chemistry - II	4	-	-	4
VSCHH452	Physical chemistry - I	4	-	-	4
VSCHH453	**Practicals**	-	-	4	2
	Electives				
VSCHH454	Advance Inorganic and Organometallic Chemistry	2	-	-	2
VSCHH455	Elective Practicals - 1	-	-	4	2
VSCHH456	Inorganic aspect in Biological and Environmental Chemistry	2	-	-	2
VSCHH457	Elective Practicals - 2	-	-	4	2
VSCHH458	**OJT**	-	-	-	4
		-	-	-	**44**

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

Evaluation Pattern

Continuous Internal Assessment (CIA) 40 marks					End Semester Examination 60 Marks		Total Marks
Course	**Credit**	**CIA-1**	**CIA-2**	**CIA-3**	**Theory**	**Practical**	
Mandatory	4.0	15	15	10	60	100	100
Electives	2.0	15	15	10	60	100	100
Practicals	2.0	-	-	-	-	100	100
Research methodology(RM)/	4.0	15	15	10	60	100	100
OJT	4.0	--	--	--	--	100	100

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Proposed Draft Syllabus for B.Sc. Honors in Chemistry Semester VII and VIII Choice Based Credit System (NEP 2020)

(To be implemented from the academic year, 2026-2027)

Semester – VII

Paper I

Course Code: VSCHH400 **Credits: 4**

Organic Chemistry –I

Learning Objectives (LOs)

By the end of the unit, students will be able to:

LO1: Differentiate and predict the mechanisms of nucleophilic substitution reactions (SN1, SN2, SNi, SET, SNAr, benzyne, SNcA, SN1′, SN2′) and understand the role of neighboring group participation (NGP), ambident nucleophiles, and factors affecting reactivity.

LO2: Interpret aromaticity using structural, thermochemical, and magnetic criteria, apply Hückel's rule and Frost-Musulin diagrams to aromatic, antiaromatic, and non-aromatic systems, including heterocycles and fullerene (C_{60}).

LO3: Analyze stereochemical aspects of organic compounds, including chirality, axial and planar chirality, prochirality, stereogenic centers, and apply various projection formulas for configurational analysis.

LO4: Classify and explain oxidation and reduction reactions in organic chemistry with mechanistic insight using classical and modern reagents, focusing on selectivity and functional group transformations.

LO5: Investigate organic reaction mechanisms through kinetic and thermodynamic principles, including the use of transition states, isotope effects, and stereochemical evidence.

LO6: Evaluate acid–base behavior in organic molecules using factors such as resonance, inductive effects, hybridization, solvation, and apply pKa values and catalysis concepts in reaction analysis.

Course Outcomes (COs)

Upon successful completion of the course/module, students will be able to:

CO1: Demonstrate an advanced understanding of nucleophilic substitution mechanisms and predict product outcomes based on substrate structure, reaction conditions, and mechanistic pathways.

CO2: Apply the concept of aromaticity to identify and classify organic compounds and rationalize their reactivity and stability using quantum mechanical models and NMR data.

CO3: Solve stereochemical problems related to chirality, optical activity, and molecular configuration using modern nomenclature and stereochemical descriptors.

CO4: Select and justify suitable oxidation and reduction reagents for specific organic transformations, and explain their mechanistic behavior, chemoselectivity, and synthetic utility.

Unit	CONTENT	Hrs.
Unit I	**Nucleophilic substitution reactions and Aromaticity**	**15**
	Nucleophilic substitution reactions: **Aliphatic nucleophilic substitution:** S_N1, S_N2, S_N^i reactions, mixed S_N1 and S_N2 and SET mechanisms. S_N reactions involving NGP - participation by aryl rings, α- and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. S_NcA, S_N1' and S_N2' reactions. S_N at sp^2 (vinylic) carbon. **Aromatic nucleophilic substitution:** S_NAr, S_N1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. **Ester hydrolysis:** Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples. **Aromaticity:** Structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity. Application of HMO theory to monocyclic conjugated systems. Frost-Musulin diagrams. Huckel‟s (4n+2) and 4n rules. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C_{60}).	
Unit II	**Stereochemistry** **Concept of Chirality:** Recognition of symmetry elements. **Molecules with tri- and tetra-coordinate centers:** Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centers, relative configurational stabilities. **Molecules with two or more chiral centers:** Constitutionally unsymmetrical molecules: erythro-threo and syn-anti systems of nomenclature. Interconversion of Fischer, Sawhorse, Newman and Flying wedge projections. Constitutionally symmetrical molecules with odd and even number of chiral centers: enantiomeric and meso forms, concept of stereogenic, chirotopic, and pseudoasymmetric centres. R-S nomenclature for chiral centres in acyclic and cyclic compounds. **Axial and planar chirality:** Principles of axial and planar chirality. Stereochemical features and configurational descriptors (R,S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spirans, biaryls buttressing effect) (including BINOLs and BINAPs), ansa compounds, cyclophanes, trans-cyclooctenes. **Prochirality:** Chiral and prochiral centres; prochiral axis and prochiral plane. Homotopic, heterotopic (enantiotopic and diastereotopic) ligands and faces. Identification using substitution and symmetry criteria. Nomenclature of stereoheterotopic ligands and faces. Symbols for stereoheterotopic ligands in molecules with i) one or more prochiral centres ii) a chiral as well as a prochiral centre, iii) a prochiral axis iv) a prochiral plane v) pro-pseudoasymmetric centre. Symbols for enantiotopic and diastereotopic faces.	**15**

Unit III	**Oxidation and Reduction:** **Oxidation:** General mechanism, selectivity, and important applications of the following: **Dehydrogenation:** Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ). **Oxidation of alcohols to aldehydes and ketones:** Chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-pyridine (Collin"s reagent), PCC (Corey"s reagent) and PDC (Cornforth reagent), hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation), Corey-Kim oxidation - advantages over Swern and limitations; and Pfitzner-Moffatt oxidation- DCC and DMSO and Oppenauer oxidation. **Oxidation involving C-C bonds cleavage:** Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using ozone, $KMnO_4$, CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$. **Oxidation involving replacement of hydrogen by oxygen:** oxidation of CH_2 to CO by SeO_2, oxidation of arylmethanes by CrO_2Cl_2 (Etard oxidation). **Oxidation of aldehydes and ketones:** with H_2O_2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) **Reduction:** General mechanism, selectivity, and important applications of the following reducing reagents: **Reduction of CO to CH_2 in aldehydes and ketones-** Clemmensen reduction, Wolff-Kishner reduction and Huang-Minlon modification. **Metal hydride reduction:** Boron reagents ($NaBH_4$, $NaCNBH_3$, diborane, 9-BBN, $Na(OAc)_3BH$, aluminium reagents ($LiAlH_4$, DIBAL-H, Red Al, L and K- selectrides). NH_2NH_2 (dIImide reduction) and other non-metal based agents including organic reducing agents (Hantzsch dihydropyridine). **Dissolving metal reductions:** using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.	15
Unit IV	**Physical Organic Chemistry:** **Thermodynamic and kinetic requirements of a reaction:** rate and equilibrium constants, reaction coordinate diagram, transition state (activated complex), nature of activated complex, Hammond postulate, Reactivity *vs* selectivity, Curtin- Hammett Principle, Microscopic reversibility, Kinetic *vs* thermodynamic control of organic reactions. **Determining mechanism of a reaction:** Product analysis, kinetic studies, use of isotopes (Kinetic isotope effect – primary and secondary kinetic isotope effect). Detection and trapping of intermediates, crossover xperiments and stereochemical evidence. **Acids and Bases:** Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity and solvation. Comparative study of acidity and basicity of organic compounds on the basis of pKa values, Leveling effect and non-aqueous solvents. Acid and base catalysis – general and specific catalysis with examples.	15

References:

1. Physical Organic Chemistry, Neil Isaacs
2. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty
3. Comprehensive Organic chemistry, Barton and Ollis, Vol 1
4. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
5. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.

6. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
7. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
8. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
9. March"s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
10. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
11. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
12. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
13. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic press.
14. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
15. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
16. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.
17. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan.

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Semester – VII

Paper II

Course Code: VSCHH401 **Credits: 4**

Analytical Chemistry -I

Learning Objectives (LOs)

After completing the course, students will be able to:

LO1: Explain key analytical chemistry terminology and differentiate between techniques, methods, procedures, and protocols.

LO2: Classify analytical methods and select appropriate techniques based on parameters such as accuracy, precision, sensitivity, and detection limits.

LO3: Identify sources of errors in analysis and apply statistical tools to minimize and interpret analytical uncertainties.

LO4: Apply calibration methods such as calibration curve, standard addition, and internal standard method in quantitative analysis.

LO5: Demonstrate understanding of quality systems including QMS, TQM, GLP, laboratory safety practices, and accreditation standards (ISO, ISI, Agmark).

LO6: Solve numerical problems related to concentration, stoichiometry, pH, redox reactions, equilibrium, and stability constants.

Course Outcomes (COs)

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

CO1: Understand the fundamental concepts, terminology, and analytical approaches used in analytical chemistry.

CO2: Apply principles of quality management, laboratory safety, accreditation standards, and Good Laboratory Practices (GLP) in analytical laboratories.

CO3: Perform quantitative chemical calculations and statistical treatment of analytical data for accurate interpretation of results.

CO4: Analyze and interpret data obtained from instrumental techniques such as UV-Visible, IR spectroscopy, thermal methods, and automated analytical systems.

Unit	CONTENT	Hrs.
Unit I	**Language of Analytical Chemistry** Analytical perspective, Common analytical problems, terms involved in analytical chemistry (analysis, determination, measurement, techniques, methods, procedures and protocol) **1.1** An overview of analytical methods, types of instrumental methods, instruments for analysis, data domains, electrical and non-electrical domains, detectors, transducers and sensors, selection of an analytical method, accuracy, precision, selectivity, sensitivity, detection limit and dynamic range.	**15**

	1.2 Errors, determinate and indeterminate errors. Types of determinate errors, tackling of errors, Statistical treatment of analytical data **1.3** Quantitative methods of analysis: calibration curve, standard addition and internal standard method **Quality in Analytical Chemistry:** **2.1 Quality Management System (QMS):** Evolution and significance of Quality Management, types of quality standards for laboratories, total quality management (TQM), philosophy implementation of TQM (reference of Kaizen, Six Sigma approach & 5S), quality audits and quality reviews, responsibility of laboratory staff for quality and problems. Significance of QA & QC in industries. **2.2 Safety in Laboratories**: Basic concepts of Safety in Laboratories, Personal Protection Equipment (PPE), OSHA, Toxic Hazard (TH) classifications, Hazardous Chemical Processes (including process calorimetry / thermal build up concepts). **2.3 Accreditations:** Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark) **2.4 Good Laboratory Practices (GLP):** Principle, Objective, OECD guidelines, The US FDA 21CFR58, Klimisch score	
Unit II	**Calculations based on Chemical Principles** The following topics are to be covered in the form of numerical problems only. a. Concentration of a solution based on volume and mass units. b. Calculations of ppm, ppb and dilution of the solutions, concept of mmol. c. Stoichiometry of chemical reactions, concept of kg mol, limiting reactant, theoretical and practical yield. d. Solubility and solubility equilibria, effect of presence of common ion. e. Calculations of pH of acids, bases, acidic and basic buffers. f. Concept of formation constants, stability and instability constants, stepwise formation constants. g. Oxidation number, rules for assigning oxidation number, redox reaction in term of oxidation number, oxidizing and reducing agents, equivalent weight of oxidizing and reducing agents, stoichiometry of redox titration (Normality of a solution of a oxidizing / reducing agent and its relationship with molarity).	**15**
Unit III	**Optical Methods** Recapitulation and FT Technique Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers. Laser as a source of radiation, Fibre optics Introduction of Fourier Transform **Molecular Ultraviolet and Visible Spectroscopy** Numericals are Expected Derivation of Beer- Lambert‟s Law and its limitations, factors affecting molecular absorption, types of transitions [emphasis on charge transfer absorption], pH, temperature, solvent and effect of substituents. **Applications of Ultraviolet and Visible spectroscopy:** 1) On charge transfer absorption 2) Simultaneous spectroscopy 3) Derivative Spectroscopy Dual spectrometry – Introduction, Principle, Instrumentation and Applications	**15**

	Infrared Absorption Spectroscopy Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument, **FTIR and its advantages** Applications of IR [Mid IR, Near IR, Far IR]: Qualitative with emphasis on "Finger print" region, Quantitative analysis, Advantages and Limitations of IR Introduction and basic principles of diffuse reflectance spectroscopy.	
Unit IV	**Thermal Methods:** **Introduction**, Recapitulation of types of thermal methods, comparison between TGA and DTA. **Differential Scanning Calorimetry**- Principle, comparison of DTA and DSC, Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting curves (sample size, sample shape, pressure). **Applications -** Heat of reaction, Specific heat, Safety screening, Polymers, liquid crystals, Percentage cystallinity, oxidative stability, Drug analysis, Magnetic transition. e.g. Analysis of Polyethylene for its crystallinity. **Automation in chemical analysis:** Need for automation, Objectives of automation, An overview of automated instruments and instrumentation, process control analysis, flow injection analysis, discrete automated systems, automatic analysis based on multilayered films, gas monitoring equipments, Automatic titrators.	**15**

References:

1. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5th Edition, Harcourt Asia Publisher. Chapter 6, 7.
2. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6 th Edition, CBS Publisher. Chapter 2.
3. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 8.
4. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5 th Edition, Harcourt Asia Publisher. Chapter 13, 14.
5. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6 th Edition, CBS Publisher. Chapter 2.
6. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 5.
7. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5 th Edition, McGraw Hill Publisher, Chapter 3.
8. M. Ito, The effect of temperature on ultraviolet absorption spectra and its relation to hydrogen bonding, J. Mol. Spectrosc. 4 (1960) 106-124.
9. A. J. Somnessa, The effect of temperature on the visible absorption band of iodine inseveral solvents, Spectrochim. Acta. Part A: Molecular Spectroscopy, 33 (1977) 525-528.
10. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5 th Edition, Harcourt Asia Publisher. Chapter 16, 17.
11. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 12
12. Z. M. Khoshhesab (2012). Infrared Spectroscopy- Materials Science, Engineering and Technology. Prof. Theophanides Theophile (Ed.). ISBN: 978-953- 51-0537- 4, InTech,(open access)
13. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. Graw Hill (1987): Chapter 27
14. Thermal Analysis-theory and applications by R. T. Sane, Ghadge, Quest Publications

15. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 25
16. Instrumental Analysis, 5 th Edition, Skoog, Holler and Nieman: Chapter 31
17. Quantitative Chemical Analysis, 6 th Edition, Vogel: Chapter 12
18. Analytical Chemistry by Open Learning: Thermal Methods by James W. Dodd & Kenneth H. Tonge
19. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 26
20. Instrumental Analysis, 5th Edition, Skoog, Holler and Nieman: Chapter 33
21. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. GrawHill (1987): Chapter 28

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Semester –VII

Paper III

Course Code: VSCHH402 **Credits: 4**

Inorganic Chemistry -I

Learning Objectives (LOs)

By the end of this unit/module, students will be able to:

LO1: Explain the concept and derivation of hybridized atomic orbitals (sp, sp^2, sp^3) and their role in sigma bonding.

LO2: Describe the role of d-orbitals in hybridization and apply the concept of resonance and formal charge in determining molecular stability.

LO3: Apply Molecular Orbital Theory (MOT) to diatomic and polyatomic species including SF_6, CO_2, B_2H_6, and I_3^- considering sigma bonding frameworks.

LO4: Identify and distinguish between various weak intermolecular forces such as hydrogen bonding, van der Waals forces, dipole-dipole, and London dispersion forces.

LO5: Analyze molecular symmetry using Group Theory: classify molecules into point groups and determine symmetry elements relevant to optical activity and dipole moment.

LO6: Utilize character tables, symmetry-adapted linear combinations (SALCs), and irreducible representations to understand molecular orbitals and vibrational modes in molecules like NH_3 and CH_4.

Course Outcomes (COs)

On successful completion of this course/module, students will be able to:

CO1: Apply quantum mechanical concepts to explain hybridization, resonance, and bonding in complex molecular structures.

CO2: Utilize Molecular Orbital Theory and symmetry principles to predict bonding characteristics and molecular behavior in both diatomic and polyatomic species.

CO3: Demonstrate an understanding of weak intermolecular forces and their implications on physical properties of compounds.

CO4: Solve chemical problems involving molecular symmetry using group theory, including the use of character tables, symmetry operations, and group-subgroup relations.

Unit	CONTENT	Hrs.
Unit I	**Chemical Bonding:** Recapitulation of hybridization: Derivation of wave functions for sp, sp^2, sp^3 orbital hybridization types considering only sigma bonding. Discussion of involvement of d orbitals in various types of hybridizations. Concept of resonance, resonance energy (derivation expected.) Formal charge with examples. Molecular Orbital Theory for diatomic species of First transition Series. Molecular Orbital Theory for Polyatomic species considering σ bonding for SF_6, CO_2, B_2H_6, I_3 - molecular species. Weak forces of attraction: Hydrogen bonding – concept, types, properties, methods of detection and importance. Van der Waal‟s forces, ion-dipole, dipole-dipole, London forces	**15**

Unit II	**Molecular Symmetry and Group Theory:** Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules. Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups. Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C_{2v}, C_{3v} and D_{2h}, structure of character tables. Applications of Group Theory (a) Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in ABn (Ammonia, CH4) molecule. (b) Determination of symmetry species for translations and rotations. (c) Mulliken"s notations for irreducible representations. (d) Reduction of reducible representations using reduction formula. (e) Group-subgroup relationships. (f) Descent and ascent in symmetry correlation diagrams showing relationship between different groups.	**15**
Unit III	**Materials Chemistry and Nanomaterials:** Solid State Chemistry Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones. Structures of Compounds of the type: AB [nickel arsenide (NiAs)], AB2 [fluorite (CaF2) and anti-fluorite structures, rutile (TiO2) structure and layer structure [cadmium chloride and iodide (CdCl2, CdI2)]. Methods of preparation for inorganic solids: Ceramic method, precursor method, sol-gel method (applications in Biosensors), microwave synthesis (discussion on principles, examples, merits and demerits are expected) Nanomaterials Preparative methods: Chemical methods, Solvothermal, Combustion synthesis, Microwave, Co-precipitation, Langmuir Blodgett(L-B) method, Biological methods: Synthesis using microorganisms. Applications in the field of semiconductors, solar cell	**15**
Unit IV	**Characterisation of Coordination compounds** Formation, thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic methods. Spectral calculations using Orgel and Tanabe-Sugano diagram, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio. Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectral methods.	**15**

References:

1. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
2. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.
3. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
4. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2nd Edition 2005.
5. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
6. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.
7. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989.

8. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
9. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.
10. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
11. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.
12. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

Unit II

13. F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd., 1989
14. .\2. H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1996.
15. R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
16. K. V. Reddy. Symmetry and Spectroscopy of Molecules, 2nd Edition, New Age International Publishers, New Delhi, 2009.
17. A. Salahuddin Kunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2012.
18. P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House. 2014.
19. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.

Unit III

20. Solid State Chemistry Introduction, Lesley E. Smart, Elaine A. Moore, ISBN 0-203- 49635-3, Taylor & Francis Group, LLC.
21. Nanomaterials & Nanochemistry, 2007, Catherine Brechignac, Philippe Houdy, Marcel Lahmani, ISBN 978-3-540-72992-1 Springer Berlin Heidelberg New York.
22. Nanomaterials Chemistry, Recent Developments and New Directions C.N.R. Rao, A. Muller, and A.K. Cheetham, ISBN 978-3-527-31664-9, 2007 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.
23. Nano-Surface Chemistry, 2001, Morton Rosoff, ISBN: 0-8247-0254-9, Marcel Dekker Inc. New York.
24. The Chemistry of Nanomaterials, CNR Rao, Muller Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004
25. Semiconductor Nanomaterials, Challa S.S.R. Kumar, ISBN: 978-3-527-32166-7, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010.

Unit IV

26. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006.
27. D. Banerjea ,Coordination Chemistry 3. Geary Coordination reviews

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Semester – VII

Practicals

Course Code: VSCHH403 **Credits: 2**

Organic Chemistry -I + Analytical Chemistry-I

Course Outcomes (COs)

CO1: Apply principles of organic synthesis to carry out one-step preparations, including planning of reactions, control of reaction parameters, and safe laboratory practices.

CO2: Demonstrate skills in purification and characterization techniques such as crystallization, thin layer chromatography (TLC), and determination of physical constants like melting point.

CO3: Perform quantitative analytical experiments using titrimetric and instrumental methods (e.g., EDTA titration, Volhard's method, ion exchange techniques) for accurate estimation of chemical species.

CO4: Analyze experimental data using appropriate statistical methods and interpret results in terms of accuracy, precision, and chemical significance.

Organic Chemistry Practical Paper

One step preparations (1.0 g scale)

1. Bromobenzene to p-nitrobromobenzene
2. Anthracene to anthraquinone
3. Benzoin to benzil
4. Anthracene to Anthracene maleic anhydride adduct
5. 2-Naphthol to BINOL
6. p-Benzoquinone to 1,2,4-triacetoxybenzene
7. Ethyl acetoacetate to 3-methyl-1-phenylpyrazol-5-one
8. *o*-Phenylenediamine to 2-methylbenzimidazole
9. *o*-Phenylenediamine to 2,3-diphenylqunooxaline
10. Urea and benzil to 5,5-diphenylhydantoin

Analytical Chemistry Practical

1. To carry out assay of the sodium chloride injection by Volhard"s method.
   Statistical method.
2. To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.
3. To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.
4. To determine the breakthrough capacity of a cation exchange resin.
5. To determine the lead and tin content of a solder alloy by titration with EDTA.
6. To determine amount of Cu(II) present in given solution containing a mixture of Cu(II) and Fe(II).
7. To determine number of nitro groups in the given compound using TiCl3.

References:

1. **Vogel, A. I.** (2012). *Vogel's Textbook of Practical Organic Chemistry* (5th ed.). London: Pearson Education.
2. **Furniss, B. S., Hannaford, A. J., Smith, P. W. G., & Tatchell, A. R.** (2005). *Vogel's Textbook of Practical Organic Chemistry* (5th ed.). Pearson Education.
3. **Shriner, R. L., Hermann, C. K. F., Morrill, T. C., Curtin, D. Y., & Fuson, R. C.** (2004). *The Systematic Identification of Organic Compounds* (8th ed.). Wiley.
4. **Pavia, D. L., Lampman, G. M., Kriz, G. S., & Engel, R. G.** (2015). *Introduction to Organic Laboratory Techniques: A Microscale Approach* (5th ed.). Cengage Learning.
5. **Ahluwalia, V. K., & Aggarwal, R.** (2008). *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*. Universities Press.
6. **Mendham, J., Denney, R. C., Barnes, J. D., & Thomas, M. J. K.** (2019). *Vogel's Textbook of Quantitative Chemical Analysis* (6th ed.). Pearson Education.
7. **Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R.** (2014). *Fundamentals of Analytical Chemistry* (9th ed.). Cengage Learning.
8. **Harris, D. C.** (2020). *Quantitative Chemical Analysis* (10th ed.). W.H. Freeman and Company.
9. **Christian, G. D., Dasgupta, P. K., & Schug, K. A.** (2014). *Analytical Chemistry* (7th ed.). Wiley.
10. **Willard, H. H., Merritt, L. L., Dean, J. A., & Settle, F. A.** (2004). *Instrumental Methods of Analysis* (7th ed.). CBS Publishers.

Proposed Draft Syllabus for B.Sc. Honors in Chemistry Semester VII and VIII Choice Based Credit System (NEP 2020)

(To be implemented from the academic year, 2026-2027)

Semester – VIII

Paper I

Course Code: VSCHH450 **Credits: 4**

Organic Chemistry –II

Learning Objectives (LOs)

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

LO1: Explain the generation and regioselectivity of enolates, enamines, and related nucleophilic carbon intermediates, and apply these in alkylation and conjugate addition (e.g., Michael reaction).

LO2: Illustrate and analyze the mechanisms and stereochemistry of key named organic reactions and rearrangements, including both cationic and anionic pathways.

LO3: Apply the Molecular Orbital (MO) and Frontier Molecular Orbital (FMO) theory to organic reactions, including cycloadditions and nucleophilic additions, using concepts like HOMO-LUMO interactions, orbital symmetry, and donor-acceptor behavior.

LO4: Interpret UV-visible, IR, NMR, and mass spectra to deduce structural features of organic molecules, with emphasis on functional group identification and spectral correlations.

LO5: Use Woodward-Fieser rules for UV absorption maxima predictions and analyze IR spectra based on vibrational modes and functional group characteristics.

LO6: Solve structure elucidation problems through combined spectral data (UV, IR, NMR, MS), including complex organic molecules with multiple functional groups.

Course Outcomes (COs)

Upon successful completion of the course/module, students will be able to:

CO1: Design and predict outcomes of alkylation and condensation reactions involving enolates, enamines, and carbon nucleophiles in complex organic syntheses.

CO2: Analyze and explain the mechanism, stereochemical outcomes, and synthetic applications of a wide range of organic rearrangement reactions.

CO3: Apply MO and FMO theories to rationalize reactivity, regioselectivity, and stability in organic reactions, including cycloadditions and SN2 reactions.

CO4: Interpret spectral data (UV, IR, NMR, MS) to determine structures of organic compounds, including the use of advanced correlation techniques and fragmentation analysis.

Unit	CONTENT	Hrs
Unit I	**Alkylation of Nucleophilic Carbon Intermediates:** Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation. Alkylation of aldehydes, ketones, esters, amides and nitriles. Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines. Alkylation of carbon nucleophiles by conjugate addition (Michael reaction). **Reaction of carbon nucleophiles with carbonyl groups:** Mechanism of Acid and base catalyzed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol reaction and Robinson annulation. Addition reactions with amines and iminium ions; Mannich reaction. Amine catalyzed condensation reaction: Knoevenagel reaction. Acylation of carbanions.	**15**
Unit II	**Reactions and Rearrangements:** Mechanisms, stereochemistry (if applicable) and applications of the following: **Reactions:** Baylis-Hilman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction. **Concerted rearrangements:** Hofmann, Curtius, Lossen, Schmidt, Wolff, Boulton-Katritzky. **Cationic rearrangements:** Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein. **Anionic rearrangements:** Brook, Neber, Von Richter, Wittig, Gabriel–Colman, Payne.	**15**
Unit III	**Introduction to Molecular Orbital Theory for Organic Chemistry:** **Molecular orbitals:** Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allyl cation, anion and radical. Concept of nodal planes and energies of π-MOs **Introduction to FMOs:** HOMO and LUMO and significance of HOMO-LUMO gap in absorption spectra as well as chemical reactions. MOs of formaldehyde: The effect of electronegativity perturbation and orbital polarization in formaldehyde. HOMO and LUMO (π and π* orbitals) of formaldehyde. A brief description of MOs of Nucleophiles and electrophiles Concept of" donor-acceptor‟ interactions in nucleophilic addition reactions on formaldehyde. Connection of this HOMO-LUMO interaction with „curved arrows‟ used in reaction mechanisms. The concept of hardness and softness and its application to electrophiles and nucleophiles. Examples of hard and soft nucleophiles/ electrophiles. Identification of hard and soft reactive sites on the basis of MOs. Application of FMO concepts in (a) $S_N{}^2$ reaction, (b) Lewis acid base adducts (BF- NH_3 complex), (c) ethylene dimerization to butadiene, (d) Diels-Alder cycloaddition, (e) regioselective reaction of allyl cation with allyl anion (f) addition of hydride to formaldehyde.	**15**

	Applications of UV and IR spectroscopy: **Ultraviolet spectroscopy:** Recapitulation, UV spectra of dienes, conjugated polyenes (cyclic and acyclic), carbonyl and unsaturated carbonyl compounds, substituted aromatic compounds. Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, and solvent polarity. Calculation of absorption maxima for above classes of compounds by Woodward-Fieser rules (using Woodward-Fieser tables for values for substituents). **Infrared spectroscopy:** Fundamental, overtone and combination bands, vibrational coupling, factors affecting vibrational frequency (atomic weight, conjugation, ring size, solvent and hydrogen bonding). Characteristic vibrational frequencies for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides, lactones, lactams and conjugated carbonyl compounds.	
Unit IV	**NMR spectroscopy and Mass spectrometry** **Proton magnetic resonance spectroscopy:** Principle, Chemical shift, Factors affecting chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence, Chemical shift values and correlation for protons bonded to carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal and long range coupling (allylic and aromatic). First order spectra, Karplus equation. **^{13}C NMR spectroscopy:** Theory and comparison with proton NMR, proton coupled and decoupled spectra, off-resonance decoupling. Factors influencing carbon shifts, correlation of chemical shifts of aliphatic, olefin, alkyne, aromatic and carbonyl carbons. **Mass spectrometry:** Molecular ion peak, base peak, isotopic abundance, metastable ions. Nitrogen rule, Determination of molecular formula of organic compounds based on isotopic abundance and HRMS. Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels-Alder reaction, ortho effect. Structure determination involving individual or combined use of the above spectral techniques.	**15**

References:

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no. 713-769, and B, Plenum Press.
3. March"s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
4. Organic Chemistry, R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, Pearson Publication (7th Edition)
5. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
6. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
7. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
8. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.

10. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
11. Mechanism in Organic Chemistry, Peter Sykes, 6th edition.
12. Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley
13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks.
14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, John Wiley and Sons.
15. Organic Spectroscopy, William Kemp, W.H. Freeman & Company.
16. Organic Spectroscopy-Principles and Applications, Jagmohan, Narosa Publication.
17. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co.
18. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.
19. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parasher, Alpha Science International, 2011.
20. Reactions, Rearrangements and Reagents by S. N. Sanyal
21. Name Reactions, Jie Jack Li, Springer
22. Name Reactions and Reagents in Organic Synthesis, Bradford P. Mundy, M.G. Ellerd, and F.G. Favaloro, John Wiley & Sons.

Semester – VIII

Paper II

Course Code: VSCHH451 **Credits: 4**

Analytical Chemistry -II

Learning Objectives (LOs)

After completing the course, students will be able to:

LO1: Classify chromatographic techniques and explain detector systems used in liquid and gas chromatography along with their applications.

LO2: Apply plate theory and rate theory concepts, including Van Deemter equation, to optimize chromatographic separations.

LO3: Describe the instrumentation, working principles, and applications of Gas Chromatography (GC) and High Performance Liquid Chromatography (HPLC).

LO4: Explain the principles and applications of advanced analytical techniques such as X-ray spectroscopy, mass spectrometry, and radioanalytical methods.

LO5: Demonstrate understanding of surface analytical techniques (SEM, TEM, STM, ESCA, Auger) and atomic spectroscopy methods.

LO6: Solve numerical problems and apply concepts related to electroanalytical techniques such as ion-selective electrodes, polarography, electrogravimetry, and coulometry.

Course Outcomes (COs)

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

CO1: Understand and apply the principles, theories, and instrumentation of chromatographic techniques such as GC and HPLC for qualitative and quantitative analysis.

CO2: Analyze and interpret data from advanced analytical techniques including X-ray spectroscopy, mass spectrometry, and radioanalytical methods.

CO3: Evaluate the performance and optimization of analytical methods using parameters like resolution, efficiency, selectivity, and detector response.

CO4: Apply electroanalytical, atomic, and surface analytical techniques for chemical analysis in research, industrial, and environmental applications.

Unit	CONTENT	Hrs.
Unit I	**Chromatography** **Recapitulation of basic concepts in chromatography:** Classification of chromatographic methods, requirements of an ideal detector, types of detectors in LC and GC, comparative account of detectors with reference to their applications (LC and GC respectively), qualitative and quantitative analysis. **Concept of plate and rate theories in chromatography:** Efficiency, resolution, selectivity and separation capability. Van Deemter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions. **Gas Chromatography:** Instrumentation of GC with special reference to sample injection systems – split/splitless, column types, solid/ liquid stationary phases, column switching techniques, temperature programming, Thermionic and mass spectrometric detector, Applications. **High Performance Liquid Chromatography (HPLC):** Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. Chiral and ion chromatography.	**15**
Unit II	**X-ray spectroscopy:** principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. **Mass spectrometry:** recapitulation, instrumentation, ion sources for molecular studies, electron impact, field ionization, field absorption, chemical ionization and fast atom bombardment sources. Mass analyzers: Quadrupole, time of flight and ion trap. Applications. **Radioanalytical Methods** : Recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications.	**15**
Unit III	**Surface Analytical Techniques** Introduction, Principle, Instrumentation and Applications of: Scanning Electron Microscopy (SEM) Scanning Tunneling Microscopy (STM) Transmission Electron Microscopy (TEM) Electron Spectroscopy (ESCA and Auger) **Atomic Spectroscopy** Advantages and Limitations of AAS Atomic Spectroscopy based on plasma sources – Introduction, Principle, Instrumentation and Applications.	**15**
Unit IV	**Electroanalytical Methods (Numericals are Expected)** **Ion selective potentiometry and Polarography:** Ion selective electrodes and their applications (solid state, precipitate, liquid – liquid, enzyme and gas sensing electrodes), ion selective field effect transistors, biocatalytic membrane electrodes and enzyme based biosensors. **Polarography:** Ilkovic equation, derivation starting with Cottrell equation, effect of complex formation on the polarographic waves. **Electrogravimetry:** Introduction, principle, instrumentation, factors affecting the nature of the deposit, applications. **Coulometry:** Introduction, principle, instrumentation, coulometry at controlled potential and controlled current	**15**

References:

1. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5th Edition, Harcourt Asia Publisher. Chapter 6, 7.
2. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6 th Edition, CBS Publisher. Chapter 2.
3. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 8.
4. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5 th Edition, Harcourt Asia Publisher. Chapter 13, 14.
5. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6 th Edition, CBS Publisher. Chapter 2.
6. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 5.
7. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5 th Edition, McGraw Hill Publisher, Chapter 3.
8. M. Ito, The effect of temperature on ultraviolet absorption spectra and its relation to hydrogen bonding, J. Mol. Spectrosc. 4 (1960) 106-124.
9. A. J. Somnessa, The effect of temperature on the visible absorption band of iodine inseveral solvents, Spectrochim. Acta. Part A: Molecular Spectroscopy, 33 (1977) 525-528.
10. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5 th Edition, Harcourt Asia Publisher. Chapter 16, 17.
11. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 12
12. Z. M. Khoshhesab (2012). Infrared Spectroscopy- Materials Science, Engineering and
    a. Technology. Prof. Theophanides Theophile (Ed.). ISBN: 978-953- 51-0537- 4, InTech,(open access)
13. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. Graw Hill (1987): Chapter 27
14. Thermal Analysis-theory and applications by R. T. Sane, Ghadge, Quest Publications
15. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 25
16. Instrumental Analysis, 5 th Edition, Skoog, Holler and Nieman: Chapter 31
17. Quantitative Chemical Analysis, 6 th Edition, Vogel: Chapter 12
18. Analytical Chemistry by Open Learning: Thermal Methods by James W. Dodd & Kenneth H. Tonge
19. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 26
20. Instrumental Analysis, 5th Edition, Skoog, Holler and Nieman: Chapter 33
21. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. GrawHill (1987): Chapter 28

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Semester – VIII

Paper III

Course Code: VSCHH452 **Credits: 4**

Physical Chemistry -I

Learning Objectives (LOs)

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

LO1: Explain the concept of fugacity and its determination from real gas equations and graphical methods; apply it to calculate equilibrium constants for real gases and mixing thermodynamics.

LO2: Analyze thermodynamic properties of real and non-ideal solutions using partial molar quantities, excess functions, and apply equations such as Gibbs-Duhem and Margules to describe solution behavior.

LO3: Interpret surface phenomena thermodynamically through derivations of Laplace equation, Kelvin equation, Gibbs adsorption isotherm, and BET isotherm.

LO4: Solve the Schrödinger wave equation for rigid rotors and hydrogen atoms using spherical coordinates; derive and interpret quantum numbers, probability density functions, and orbital shapes.

LO5: Apply chemical kinetics to both homogeneous (solution phase) and heterogeneous (solid state) reactions, enzyme-catalyzed mechanisms, and reaction dynamics using rate laws and kinetic models.

LO6: Understand the thermodynamics of point and extended defects in solids and construct phase diagrams for two- and three-component systems using the Gibbs phase rule and equilibrium concepts.

Course Outcomes (COs)

Upon successful completion of the course/module, students will be able to:

CO1: Apply advanced thermodynamic and quantum mechanical principles to describe the behavior of real gases, solutions, and molecular systems.

CO2: Analyze molecular and atomic systems using quantum chemistry, interpret orbital behavior, and solve systems using exact or approximate methods (e.g., Hückel MO theory).

CO3: Investigate and model chemical kinetics and solid-state reactions using appropriate rate laws and mathematical expressions, including enzyme kinetics and surface reactions.

CO4: Construct and interpret phase diagrams and defect structures in solids, and evaluate the thermodynamic basis of phase transitions and equilibrium in multi-component systems.

Unit	CONTENT	Hrs.
Unit I	**Chemical Thermodynamics II** Fugacity of real gases, Determination of fugacity of real gases using graphical method and from equation of state. Equilibrium constant for real gases in terms of fugacity. Gibbs energy of mixing, entropy and enthalpy of mixing. Real solutions: Chemical potential in non ideal solutions excess functions of non ideal solutions calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation. Thermodynamics of surfaces, Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected). Bioenergetics: standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.	**15**
Unit II	**Quantum Chemistry:** Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates, separation of the variables, the phi equation, wavefunction, quantum number, the theta equation, wave function, quantization of rotational energy, spherical harmonics. Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, the R the * and the equations, solution of the requation, introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots., points of maximum probability, expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen. Application of the Schrödinger equation to two electron system, limitations of the equation, need for the approximate solutions, methods of obtaining the approximate solution of the Schrödinger wave equation. Hückel Molecular Orbitals theory for ethylene , 1,3-butadiene and benzene. (Derivation expected)	**15**
Unit III	**Chemical Kinetics and Molecular Reaction Dynamics** Elementary Reactions in Solution:- Solvent Effects on reaction rates, Reactions between ions- influence of solvent Dielectric constant, influence of ionic strength, Linear free energy relationships Enzyme action Kinetics of reactions catalyzed by enzymes -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses. Inhibition of Enzyme action: Competitive, Noncompetitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes. Kinetics of reactions in the Solid State:- Factors affecting reactions in solids Rate laws for reactions in solid: The parabolic rate law, The first order rate Law, the contracting sphere rate law,Contracting area rate law, some examples of kinetic studies. (Ref: 7 and 2)	**15**
Unit IV	**Solid State Chemistry and Phase Equilibria: Solid State Chemistry** Recapitulation: Structures and Defects in solids. Types of Defects and Stoichiometry a) Zero dimensional (point) Defects b) One dimensional (line) Defects c) Two dimensional (Planar) Defects d) Thermodynamics of formation of defects (Mathematical derivation to find concentration of defects and numerical problems based on it) (Ref: 17, 18 and19) **Phase equilibria** Recapitulation: Introduction and definition of terms involved in phase rule. Thermodynamic derivation of Gibbs Phase rule.	**15**

	Two component system: a) Solid –Gas System : Hydrate formation, Amino compound formation b) Solid – Liquid System: Formation of a compound with congruent melting point, Formation of a compound with incongruent melting point . (with suitable examples) **Three component system** Type-I : Formation of one pair of partially miscible liquids Type-II: Formation of two pairs of partially miscible liquids Type-III: Formation of three pairs of partially miscible liquids (Ref: 4, 6, 11, 12 ,13,16, 24)	

References:

1. Peter Atkins and Julio de Paula, Atkin"s Physical Chemistry, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, Physical Chemistry, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, Physical Chemistry, 3rd Edn., Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, Text Book of Physical Chemistry, 2nd Edn., McMillan and Co. Ltd., London, 1962.
7. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.
8. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.
9. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.
10. R.K. Prasad, Quantum Chemistry, 2nd Edn., New Age International Publishers, 2000.
11. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.
12. W.G. Davis, Introduction to Chemical Thermodynamics – A Non – Calculus Approach, Saunders, Philadelphia, 19772.
13. Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.
14. Ira N. Levine, Quantum Chemistry, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
15. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
16. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
17. Solid State Chemistry [An Introduction], 3rd Ed., Lesley E. Smart & Elaine A. Moore, Taylor & Francis, 2010.
18. The Physics and „Chemistry of Solids, Stephen Elliott, Willey India, 2010
19. Principles of the Solid State, H.V. Keer, New Age International Publishers, 2011.
20. Solid State Chemistry, D.K. Chakrabarty, New Age International Publishers, 1996.
21. Principles of physical Chemistry, Marrown and Prutton 5th edition

Semester – VIII

Practicals

Course Code: VSCHH453 **Credits: 2**

Organic Chemistry -II + Analytical Chemistry-II

Course Outcomes (COs)

CO1: Apply micro-scale techniques for the systematic separation of binary mixtures using physical and chemical methods.

CO2: Perform purification, characterization, and identification of organic compounds using chemical tests, derivative preparation, and determination of physical constants.

CO3: Carry out quantitative analysis using instrumental techniques such as pH-metry, potentiometry, conductometry, spectrophotometry, and flame photometry.

CO4: Interpret experimental data to determine composition, purity, and concentration of chemical species with accuracy and precision.

Organic Chemistry Practical

Separation of Binary mixture using micro-scale technique

1. Separation of binary mixture using physical and chemical methods.
2. Characterization of one of the components with the help of chemical analysis and confirmation of the structure with the help of derivative preparation and its physical constant.
3. Purification and determination of mass and physical constant of the second component. The following types are expected:
   (i) Water soluble/water insoluble solid and water insoluble solid,
   (ii) Non-volatile Liquid-Non-volatile liquid (chemical separation)
   (iii) Water-insoluble Solid-Non-volatile liquid.

(Minimum three mixtures from each type and a total of ten mixtures are expected.)

Analytical Chemistry Practical

1. To determine percentage purity of sodium carbonate in washing soda pH metrically.
2. To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically.
3. To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titration with perchloric acid in a non-aqueous medium using glass calomel system potentiometrically.
4. To determine the amount of nitrite, present in the given water sample colorimetrically.
5. To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically.
6. Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically.
7. To determine the percentage composition of HCl and H2SO4 on weight basis in a mixture of two by conductometric titration with NaOH and BaCl2.
8. To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.

Proposed Draft Syllabus for B.Sc. Honors in Chemistry Semester VII and VIII

Choice Based Credit System (NEP 2020)

(To be implemented from the academic year, 2026-2027)

ELECTIVE COURSE

Semester –VII

Elective Paper I

Course Code: VSCHH404 **Credits: 2**

Fundamentals of Physical Chemistry -I

Learning Objectives (LOs)

After completing the course, students will be able to:

LO1: Explain the need for quantum mechanics and describe wave functions, operators, eigen values, and postulates of quantum mechanics.

LO2: Apply normalization, orthogonality, and operator algebra to solve basic quantum mechanical problems.

LO3: Derive and interpret solutions of Schrödinger equation for systems like free particle and particle in one, two, and three-dimensional boxes.

LO4: Describe harmonic oscillator model, including energy levels, wave functions, and significance of Hermite polynomials.

LO5: Analyze kinetics of complex reactions such as consecutive, chain, and polymerization reactions using steady state approximation and rate laws.

LO6: Interpret mechanisms of gas phase and unimolecular reactions using theories such as Lindemann–Hinshelwood, RRK, and RRKM.

Course Outcomes (COs)

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

CO1: Understand the fundamental principles of quantum mechanics and explain the limitations of classical mechanics.

CO2: Apply quantum mechanical models to simple systems such as free particle, particle in a box, and harmonic oscillator to determine energy and wave functions.

CO3: Analyze chemical reaction kinetics including composite reactions, chain reactions, and polymerization mechanisms using appropriate theoretical models.

CO4: Evaluate gas phase reactions and unimolecular reaction theories (Lindemann, RRK, RRKM) for interpreting reaction mechanisms and dynamics.

Unit	CONTENT	Hrs.
Unit I	**Quantum Chemistry:** Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics. Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions. Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system such as, position, linear momentum, angular momentum, total energy, eigen functions, eigen values and eigen value equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system, Postulates of Quantum Mechanics, Schrodinger"s Time independent wave equation from Schrodinger"s time dependent wave equation. Application of quantum mechanics to the following systems: a) Free particle, wave function and energy of a free particle. b) Particle in a one, two and three dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula. [Ref 7, 8 and 9]	**15**
Unit II	**Chemical Dynamics-I** **Composite Reactions:** Recapitulation: Rate laws, Differential rate equations Consecutive reactions, Steady state Approximation, rate determining steps, Microscopic Reversibility and Detailed Balanced Chain reactions-chain initiation processes. Some inorganic mechanisms: formation and decomposition of phosgene, decomposition of ozone, Reaction between Hydrogen and Bromine and some general examples. Organic Decompositions: Decomposition of ethane, decomposition of acetaldehyde Gas phase combustion: Reaction between hydrogen and oxygen, Semenov – Hinshelwood and Thompson mechanism, Explosion limits and factors affecting explosion limits. Polymerization reactions: Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization, Kinetic chain length and estimation of average no .of monomer units in the polymer produced by chain polymerization. Reaction in Gas Phase Unimolecular Reactions: Lindeman-Hinshelwood theory, Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory. [Ref. 2 and 15, 17, 18]	**15**

References:

1. Peter Atkins and Julio de Paula, Atkin"s Physical Chemistry, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, Physical Chemistry, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, Physical Chemistry, 3rd Edn., Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, Text Book of Physical Chemistry, 2nd Edn., McMillan and Co. Ltd., London, 1962
7. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.

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Semester – VII

Practicals

Course Code: VSCHH405 **Credits: 2**

Elective Paper – 1: Inorganic -I and Physical-I

Course Outcomes (COs)

CO1: Apply classical analytical techniques for the quantitative analysis of inorganic materials such as alloys and minerals.

CO2: Perform instrumental analytical methods (potentiometry, conductometry, EMF measurements) for accurate estimation of chemical species.

CO3: Determine thermodynamic and kinetic parameters such as heat of solution, solubility product, activity coefficients, and reaction rates through experimental methods.

CO4: Analyze and interpret experimental data using graphical methods and validate theoretical principles such as equilibrium, ionic strength effects, and dissociation constants.

Inorganic Chemistry Practical

Inorganic Analysis

1. Analysis of Devarda"s alloy
2. Analysis of Cu – Ni alloy
3. Analysis of Tin Solder alloy
4. Analysis of Limestone

Instrumentation

1) Estimation of Copper using Iodometric method Potentiometrically.

2) Estimation of Fe+3 solution using Ce(IV) ions Potentiometrically

Physical Chemistry Practical

Non – Instrumental:

1. To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperature.
2. To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of CaSO4 at room temperature.
3. To investigate the reaction between acetone and iodine.
4. To study the variation in the solubility of Ca(OH)2 in presence of NaOH and hence to determine the solubility product of Ca(OH)2 at room temperature.
5. Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?

Instrumental:

1. To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.
2. To study the effect of substituent on the dissociation constant of acetic acid conductometrically.
3. To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
4. To verify Ostwald"s dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.

References:

1. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
2. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.
3. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

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Semester – VII

Elective Paper - 2

Course Code: VSCHH406 **Credits: 2**

Fundamentals of Physical Chemistry -II

Learning Objectives (LOs)

After completing the course, students will be able to:

LO1: Explain state functions, exact differentials, and derive Maxwell thermodynamic relations with their physical significance.

LO2: Analyze Joule–Thomson expansion and calculate inversion temperature using van der Waals constants.

LO3: Apply the Third Law of Thermodynamics to determine entropy changes, absolute entropies, and residual entropy.

LO4: Derive and interpret Debye–Hückel limiting law and its extensions for activity coefficients in electrolyte solutions.

LO5: Explain ionic conductance behavior using Debye–Hückel–Onsager equation and describe deviations such as Wien and Debye–Falkenhagen effects.

LO6: Describe working principles and applications of electrochemical systems including fuel cells and bio-electrochemical processes like membrane potentials and enzyme electrodes.

Course Outcomes (COs)

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

CO1: Understand and apply thermodynamic concepts such as state functions, Maxwell relations, and the Third Law to chemical systems.

CO2: Analyze real gas behavior using Joule–Thomson effect and evaluate thermodynamic parameters like inversion temperature and entropy.

CO3: Apply electrochemical theories including Debye–Hückel and Onsager equations to explain ionic interactions and conductance behavior in solutions.

CO4: Evaluate electrochemical systems such as batteries and bio-electrochemical processes, including membrane potentials and electron transfer mechanisms.

Unit	CONTENT	Hrs.
Unit I	**Thermodynamics - I** State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; it's significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants. Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity, standard molar entropies and their dependence on molecular mass and molecular structure, residual entropy. [Ref 2 and 1,10,11,12 17]	**15**
Unit II	**Electrochemistry** Recapitulation – basics of electrochemistry. Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and it's extension to higher concentration (derivations are expected). Electrolytic conductance and ionic interaction, relaxation effect, Debye-Hückel-Onsager equation (derivation expected). Validity of this equation for aqueous and non- aqueous solution, deviations from Onsager equation, Debye -Falkenhagen effect (dispersion of conductance at high frequencies), Wien effect. Batteries: Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells] Bio-electrochemistry: Introduction, cells and membranes, membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems, adsorption of proteins onto metals from solution, electron transfer from modified metals to dissolved protein in solution, enzymes as electrodes, electrochemical enzyme-catalysed oxidation of styrene. Goldmann equation. (derivations are expected) [Ref: 14 and 16, 17, 18]	**15**

References:

1. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.
2. W.G. Davis, Introduction to Chemical Thermodynamics–A Non–Calculus Approach, Saunders,
   a. Philadelphia, 19772.
3. Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.
4. Ira N. Levine, Quantum Chemistry, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
5. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
6. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
7. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
8. Physical Chemistry by Gurtu and Gurtu
9. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2nd Edn.

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Semester – VII

Practicals

Course Code: VSCHH405 **Credits: 2**

Elective Paper – 1: Inorganic -I and Physical-I

Course Outcomes (COs)

CO1: Apply classical analytical techniques for the quantitative analysis of inorganic materials such as alloys and minerals.

CO2: Perform instrumental analytical methods (potentiometry, conductometry, EMF measurements) for accurate estimation of chemical species.

CO3: Determine thermodynamic and kinetic parameters such as heat of solution, solubility product, activity coefficients, and reaction rates through experimental methods.

CO4: Analyze and interpret experimental data using graphical methods and validate theoretical principles such as equilibrium, ionic strength effects, and dissociation constants.

Inorganic Chemistry Practical

Inorganic Analysis

1. Analysis of Devarda‟s alloy
2. Analysis of Cu – Ni alloy
3. Analysis of Tin Solder alloy
4. Analysis of Limestone

Instrumentation

1. Estimation of Copper using Iodometric method Potentiometrically.
2. Estimation of Fe+3 solution using Ce(IV) ions Potentiometrically

Physical Chemistry Practical

Non – Instrumental:

1. To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperature.
2. To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of CaSO4 at room temperature.
3. To investigate the reaction between acetone and iodine.
4. To study the variation in the solubility of Ca(OH)2 in presence of NaOH and hence to determine the solubility product of Ca(OH)2 at room temperature.
5. Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?

Instrumental:

1. To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.
2. To study the effect of substituent on the dissociation constant of acetic acid conductometrically.
3. To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
4. To verify Ostwald‟s dilution law and to determine the dissociation constant of a weak mono-

basic acid conductometrically.

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1. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
2. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.
3. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

Proposed Draft Syllabus for B.Sc. Honors in Chemistry Semester VII and VIII

Choice Based Credit System (NEP 2020)

(To be implemented from the academic year, 2026-2027)

Semester – VIII

Paper I

Course Code: VSCHH454 **Credits: 2**

Elective Paper-1: Advance Inorganic and Organometallic Chemistry

Learning Objectives (LOs)

LO1: Explain factors affecting reaction rates and apply various techniques (spectrophotometric, electrochemical, flow methods) for determining reaction kinetics.

LO2: Describe mechanisms of ligand substitution reactions in octahedral and square planar complexes, including isotopic labeling and trans-effect theories.

LO3: Differentiate between inner-sphere and outer-sphere redox mechanisms and identify their applications.

LO4: Analyze stereochemical aspects of substitution reactions such as isomerization and racemization in coordination complexes.

LO5: Apply 16- and 18-electron rules to predict stability and reactivity of organometallic compounds.

LO6: Explain structure and bonding in organometallic compounds using Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT).

Course Outcomes (COs)

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

CO1: Understand the kinetics and mechanisms of inorganic reactions, including ligand substitution and redox processes.

CO2: Analyze substitution reactions in coordination complexes with respect to geometry, stereochemistry, and influencing factors such as trans-effect.

CO3: Apply electron counting rules (16 and 18 electron rules) and bonding theories (VBT and MOT) to explain the structure and stability of organometallic compounds.

CO4: Evaluate preparation, properties, and reactivity of organometallic compounds of transition metals such as Pd, Pt, Ni, Fe, Cr, Mo, and W.

Unit	CONTENT	Hrs.
Unit I	**Inorganic Reaction Mechanism:** Rate of reactions, factors affecting the rate of reactions, techniques for determination of rate of reaction (Direct chemical analysis, spectrophotometric method, electrochemical and flow methods) Ligand substitution reactions of: a. Octahedral complexes without breaking of metal-ligand bond (Use of isotopic labelling method) b. Square planar complexes, trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions. Redox reactions: inner and outer sphere mechanisms, complimentary and non-complimentary reactions. Stereochemistry of substitution reactions of octahedral complexes. (Isomerization and racemization reactions and applications.)	**15**
Unit II	Eighteen and sixteen electron rule and electron counting with examples. Preparation and properties of the following compounds: (a) Alkyl and aryl derivatives of Pd and Pt complexes (b) Carbenes and carbynes of Cr, Mo and W (c) Alkene derivatives of Pd and Pt (d) Alkyne derivatives of Pd and Pt (e) Allyl derivatives of nickel (f) Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo. Structure and bonding on the basis of VBT and MOT in the following organometallic compounds: Zeise' s salt, bis(triphenylphosphine) diphenylacetylene platinum(0) [Pt(PPh3)2(HC≡CPh)2], diallylnickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl (η2 -butadiene) iron(0)..	**15**

References:

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5 th Ed., Oxford University Press, 2010.
2. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.
3. W. H. Malik, G. D./ Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd
4. . 4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002
6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house, 2012.
7. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
8. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.
9. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001. 10. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd Ed., Oxford University Press 2008.

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Semester – VIII Practicals

Course Code: VSCHH455 **Credits: 2**

Elective Paper – 1 Inorganic -II and Physical-II

Course Outcomes (COs)

CO1: Synthesize coordination compounds using appropriate laboratory techniques and understand the role of ligands, metal ions, and reaction conditions in their formation.

CO2: Characterize inorganic complexes using physicochemical methods such as conductance measurements and equilibrium constant determination.

CO3: Perform physical chemistry experiments to determine thermodynamic and kinetic parameters including rate constants, equilibrium constants, and phase behavior.

CO4: Apply instrumental techniques such as potentiometry, conductometry, spectrophotometry, and pH measurement to analyze chemical systems and interpret experimental data accurately.

Inorganic Chemistry Practical Paper

(Synthesis and Characterization)

1) Bis-(tetraethylammonium) tetrachloro Cuprate (II) $(Et_4N)_2[CuCl4]$
2) Bis-(tetraethylammonium) tetrachloro Nickelate (II) $(Et_4N)_2[NiCl_4]$
3) Bis-(tetraethylammonium) tetrachloro Cobaltate (II) $(Et_4N)_2$ $[CoCl_4]$ (Any two from above preparations)
4) Tetrammine monocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$
5) Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$
6) Hydronium dichloro bis(dimethylglyoximato) Cobaltate(III) $H[Co(dmgH)_2Cl_2]$

Instrumentation

1) Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^- system
2) Determination of Electrolytic nature of inorganic compounds by Conductance measurement.

Physical Chemistry Practical

Non – instrumental:

1. Polar plots of atomic orbitals such as 1s, and 3 orbitals by using angular part of hydrogen atom wave functions.
2. To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.
3. To study phase diagram of three component system water – chloroform /toluene -acetic acid.
4. To determine the rate constant of decomposition reaction of diacetone alcohol by dialtometric method.

Instrumental:

1. To determine the formula of silver ammonia complex by potentiometric method.
2. To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.
3. To determine Hammette constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.
4. To determine the Michaelis – Menten‟s constant value (Km) of the enzyme Beta Amylase spectrophotometrically.

References:

1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)
2. Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, Thomas, Pearson education
3. Standard methods of chemical analysis, F. J. Welcher
4. Standard Instrumental methods of Chemical Analysis, F. J. Welcher
5. W.W.Scott."Standard methods of Chemical Analysis",Vol.I, Van Nostrand Company,Inc.,1939.
6. E.B.Sandell and H.Onishi,"Spectrophotometric Determination of Traces of Metals",Part-II, 4th Ed.,A Wiley Interscience Publication,New York,1978
7. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
8. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn. Longman Group Ltd., 1974.
9. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

Semester – VIII
Elective Paper - 2

Course Code: VSCHH456 **Credits: 2**

Inorganic aspect in Biological and Environmental Chemistry

Learning Objectives (LOs)

After completing the course, students will be able to:

LO1: Describe the concept of heavy metals and explain the toxicity, sources, and biochemical effects of metals such as Hg, Pb, Cd, As, Cu, and Cr.

LO2: Interpret environmental case studies such as Itai-itai disease and arsenic contamination, and suggest appropriate control measures.

LO3: Explain the interaction of radiation with biological systems and its effects on cells, including applications in diagnosis and therapy.

LO4: Describe the structure and function of biological oxygen carriers (hemoglobin, myoglobin, hemocyanin, hemerythrin) and explain oxygen binding mechanisms.

LO5: Explain the role of metal ions in enzymatic reactions, including oxygen activation and functions of copper-containing enzymes and nitrogenase.

LO6: Discuss metal ion transport, storage systems, and medicinal applications of metal complexes such as cisplatin.

Course Outcomes (COs)

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

CO1: Understand the sources, distribution, speciation, and toxicological effects of heavy metals and their impact on the environment and human health.

CO2: Analyze environmental case studies and evaluate control and remediation strategies for heavy metal pollution and radioactive contamination.

CO3: Explain the role of metal ions in biological systems, including oxygen transport, enzyme catalysis, and nitrogen fixation.

CO4: Evaluate the applications of bioinorganic chemistry in medicine, including metal-based drugs and diagnostic techniques.

Unit	CONTENT	Hrs.
Unit I	**Environmental Chemistry:** Conception of Heavy Metals: Critical discussion on heavy metals Toxicity of metallic species: Mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, biochemical effects and toxicology, control and treatment. Case Studies: (a) Itai-itai disease for Cadmium toxicity, (b) Arsenic Poisoning in the Indo-Bangladesh region. Interaction of radiation in context with the environment, Sources and biological implication of radioactive materials. Effect of low level radiation on cells- Its applications in diagnosis and treatment, Effect of radiation on cell proliferation and cancer.	**15**
Unit II	**Bioinorganic Chemistry:** Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine structure of metal active center and differences in mechanism of oxygen binding, Differences between hemoglobin and myoglobin: Cooperativity of oxygen binding in hemoglobin and Hill equation, pH dependence of oxygen affinity in hemoglobin and myoglobin and it‟s implications. Activation of oxygen in biological system with examples of mono oxygenases, and oxidases- structure of the metal center and mechanism of oxygen activation by these enzymes Copper containing enzymes- superoxide dismutase, tyrosinase and laccase: catalytic reactions and the structures of the metal binding site Nitrogen fixation-nitrogenase, hydrogenases Metal ion transport and storage:Ionophores, transferrin, ferritin and metallothionins Medicinal applications of cis-platin and related compounds	**15**

References:

1. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000.
2. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.
3. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd.
4. Environmental Chemistry 5th edition, Colin Baird Michael Cann, W. H. Freeman and Company, New York, 2012.
5. Environmental Chemistry 7th edition, Stanley E. Manahan, CRC Press Publishers
6. Environmental Contaminants, Daniel A. Vallero, ISBN: 0-12-710057-1, Elsevier Inc., 2004.
7. Environmental Science 13th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN10: 0-495- 56016-2, Brooks/Cole, Cengage Learning, 2010.
8. Fundamentals of Environmental and Toxicological Chemistry 4th edition, Stanley E. Manahan, ISBN: 978-1-4665-5317-0, CRC Press Taylor & Francis Group, 2013.
9. Living in the Environment 17th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10: 0-538- 49414-X, Brooks/Cole, Cengage Learning, 2011
10. Poisoning and Toxicology Handbook, Jerrold B. Leikin, Frank P. Paloucek, ISBN: 1- 4200-4479-6, Informa Healthcare USA, Inc. 8. Casarett and Doull‟s Toxicology- The Basic Science of Poisons 6th edition, McGrawHill, 2001.
11. R. W. Hay, Bioinorganic Chemistry, Ellis Harwood, England, 1984.

12. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First South Indian Edition, Viva Books, New Delhi, 1998.)
13. J. A. Cowan, Inorganic Biochemistry-An introduction, VCH Publication, 1993.
14. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Publications, Mill Valley, Caligronic, 1994.

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Semester – VIII Practicals

Course Code: VSCHH457 **Credits: 2**

Elective Paper – 2: Inorganic -II and Physical-II

Course Outcomes (COs)

CO1: Synthesize coordination compounds using appropriate laboratory techniques and understand the role of ligands, metal ions, and reaction conditions in their formation.

CO2: Characterize inorganic complexes using physicochemical methods such as conductance measurements and equilibrium constant determination.

CO3: Perform physical chemistry experiments to determine thermodynamic and kinetic parameters including rate constants, equilibrium constants, and phase behavior.

CO4: Apply instrumental techniques such as potentiometry, conductometry, spectrophotometry, and pH measurement to analyze chemical systems and interpret experimental data accurately.

Inorganic Chemistry Practical Paper

(Synthesis and Characterization)

1. Bis-(tetraethylammonium) tetrachloro Cuprate (II) $(Et_4 N)_2[CuCl4]$
2. Bis-(tetraethylammonium) tetrachloro Nickelate (II) $(Et_4 N)_2 [NiCl_4]$
3. Bis-(tetraethylammonium) tetrachloro Cobaltate (II) $(Et_4 N)_2$ $[CoCl_4]$ (Any two from above preparations)
4. Tetrammine monocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$
5. Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$
6. Hydronium dichloro bis(dimethylglyoximato) Cobaltate(III) $H[Co(dmgH)_2Cl_2]$

Instrumentation

1. Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^- system
2. Determination of Electrolytic nature of inorganic compounds by Conductance measurement.

Physical Chemistry Practical

Non – instrumental:

1. Polar plots of atomic orbitals such as 1s, and 3 orbitals by using angular part of hydrogen atom wave functions.
2. To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.
3. To study phase diagram of three component system water – chloroform /toluene -acetic acid.
4. To determine the rate constant of decomposition reaction of diacetone alcohol by dialtometric method.

Instrumental:

5. To determine the formula of silver ammonia complex by potentiometric method.
6. To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.
7. To determine Hammette constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.
8. To determine the Michaelis – Menten‟s constant value (Km) of the enzyme Beta Amylase spectrophotometrically.

References:

1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)
2. Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, Thomas, Pearson education
3. Standard methods of chemical analysis, F. J. Welcher
4. Standard Instrumental methods of Chemical Analysis, F. J. Welcher
5. W.W.Scott."Standard methods of Chemical Analysis",Vol.I, Van Nostrand Company,Inc.,1939.
6. E.B.Sandell and H.Onishi,"Spectrophotometric Determination of Traces of Metals",Part-II, 4th Ed.,A Wiley Interscience Publication,New York,1978
7. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
8. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn. Longman Group Ltd., 1974.
9. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

Proposed Draft Syllabus for B.Sc. Honors in Chemistry

Semester VII and VIII

Choice Based Credit System (NEP 2020)

(To be implemented from the academic year, 2026-2027)

RESEARCH METHODOLOGY COURSE

Semester – VII

Course Code: VSCHH408 **Credits: 4**

Research Methodology Paper – I

Learning Objectives (LOs)

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

LO1: Identify and differentiate between primary, secondary, and tertiary sources of chemical information, including print and digital formats.

LO2: Understand and utilize various scientific databases and indexing services such as *Chemical Abstracts, Beilstein, Scopus, SciFinder*, and *Google Scholar* for literature surveys and referencing.

LO3: Develop the ability to evaluate digital journal metrics such as *Impact Factor*, *H-index*, *TOC alerts*, and *Citation Index* for assessing the quality of research articles.

LO4: Apply basic and advanced statistical tools, such as regression analysis, ANOVA, and chemometric techniques, for effective data analysis and result interpretation.

LO5: Gain hands-on experience in scientific writing including lab reports, literature reviews, oral/poster presentations, and ethical publication practices including plagiarism avoidance.

LO6: Understand and implement best practices for laboratory safety, chemical hazard management, waste disposal, and ethical handling of chemicals in compliance with safety protocols.

Course Outcomes (COs)

Upon successful completion of this course, students will be able to:

CO1: Retrieve, analyze, and cite chemical information efficiently using both print and digital scientific resources.

CO2: Demonstrate competency in designing experiments, analyzing scientific data, and applying statistical tools for accurate interpretation of results.

CO3: Prepare well-structured scientific reports and presentations with adherence to ethical writing and publishing standards.

CO4: Practice safe laboratory behavior through proper handling, storage, and disposal of chemicals, ensuring a hazard-free environment in accordance with national and institutional guidelines.

Unit	CONTENT	Hrs.
Unit I	**Print:** Primary, Secondary and Tertiary sources. **Journals:** Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index and other Indices with examples. **Digital:** Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus. **Information Technology and Library Resources:** The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	**15**
Unit II	**DATA ANALYSIS** **The Investigative Approach:** Making and recording Measurements, SI units and their use, Scientific methods and design of experiments. **Analysis and Presentation of Data:** Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.	**15**
Unit III	**METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS** Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation. **Writing Scientific Papers:** Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.	**15**

Unit IV	**CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS** Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressur, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	**15**

References

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), Practical skills in Chemistry, 2 nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press.
3. Topping, J., (1984) Errors of Observation and their Treatment 4 th Ed., Chapman Hill, London.
4. Harris, D. C. (2007) Quantative Chemical Analysis 6 th Ed., Freeman Chapters 3-5
5. Levie, R. De. (2001) How to use Excel in Analytical Chemistryand in general scientific data analysis Cambridge Universty Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

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