Vivekanand Education Society's

College of Arts, Science and Commerce

(Autonomous)

Sindhi Society, Chembur, Mumbai, Maharashtra – 400 071.

Accredited by NAAC "A Grade" in 3rd Cycle - 2017
Best College Award – Urban Area, University of Mumbai (2012-13)
Recipient of FIST Grant (DST) and STAR College Grant (DBT)

Affiliated to the

University of Mumbai

Syllabus for

Program: M.Sc. (Chemistry)

(Program code: VESPSCH)

As per Choice Based Semester and Grading System (CBSGS)
with effect from Academic Year 2022 - 2023

Program Outcomes (PO):

A leaner completing M.Sc. Chemistry will be able to:

PO1 Demonstrate, solve and an understanding of major concepts in all disciplines of chemistry..

PO2 Carry out experiments and analyze results by measuring uncertainties in different quantities.

PO3 Demonstrate professional behavior of being unbiased, and truthful in all aspects of work as an individual as well as team.

Program Specific Outcomes (PSO's)

On completion of M.Sc. Chemistry program, learners will be enriched with knowledge and be able to

PSO1 Improve theoretical and practical knowledge in the field of Inorganic chemistry

PSO2 To understand the bonding models, structures, and applications of coordination complexes

PSO3 Predicting geometries of complexes

PSO4 Apply group theory to recognize and assign symmetry characteristics to molecules.

M.Sc. (CHEMISTRY)
(SEMESTER I)

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH 101	**Paper 01 Physical Chemistry**	**60**	**04**
	Unit I : Thermodynamics-I	**15 Lectures**	
	Unit II: Quantum Chemistry	**15 Lectures**	
	Unit III : Chemical Dynamics-I	**15 Lectures**	
	Unit IV : Electrochemistry	**15 Lectures**	

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH 102	**Paper 02 Inorganic Chemistry**	**60**	**04**
	Unit I : Chemical Bonding	**15 Lectures**	
	Unit II: Molecular Symmetry and Group Theory	**15 Lectures**	
	Unit III : Materials Chemistry and Nanomaterials	**15 Lectures**	
	Unit IV : Characterisation of Coordination compounds	**15 Lectures**	

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH103	**Paper 03 Organic Chemistry**	**60**	**04**
	Unit I : Physical Organic Chemistry	**15 Lectures**	
	Unit II: Nucleophilic substitution reactions and Aromaticity	**15 Lectures**	
	Unit III : Stereochemistry	**15 Lectures**	
	Unit IV : Oxidation and Reduction	**15 Lectures**	

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH 104	**Paper 04 Analytical Chemistry**	**60**	**04**
	Unit I : Language of Analytical Chemistry & Quality in Analytical Chemistry	**15 Lectures**	
	Unit II: Calculations based on Chemical Principles	**15 Lectures**	
	Unit III : Optical Methods	**15 Lectures**	
	Unit IV : Thermal Methods & Automation in chemical analysis	**15 Lectures**	

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures

Course title: Chemistry Paper 01 Physical Chemistry

Course code: VESPSCH 101

Objective: To understand and develop competence in use of Basic of physical chemistry

Learning Outcomes (LO):

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

LO1 To learn Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity and Maxwell thermodynamic Relations; it's significance and applications to ideal gases, Joule Thomson effect

LO2 Students will learn about aspect of quantum mechanics such as operator concept, Schrodinger's Time independent wave equation and applications of quantum mechanics

LO3 Students will learn Steady state Approximation, rate determining steps, kinetics of Polymerization reactions, Reaction in Gas Phase

LO4 Students will understand – basics of electrochemistry. Debye-Hückel theory, Debye-Hückel limiting law, Onsager equation, wein effect etc student will learn fuel cell and the concepts of Bio-electrochemistry

Course title: Chemistry Paper 1 **Course code: VESPSCH 101**

Unit no.	Details of topics	No of lectures
1	1.1. 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. [8L] 1.2. 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. [7L] [Ref 2 and 1,10,11,12 17]	15 Lectures
2	2.1. Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics. 2.2. Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions. 2.3. 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. 2.4. 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.	15 Lectures
3	**Chemical Dynamics-I** 3.1.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. 3.2.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. 3.3.Reaction in Gas Phase Unimolecular Reactions: Lindeman-Hinshelwood theory, Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory.	15 Lectures

4	**Recapitulation – basics of electrochemistry.** 4.1.Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and it's extension to higher concentration (derivations are expected). 4.2.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. 4.3.Batteries: Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells] 4.4.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)	15 Lectures

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.
8. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
9. R.K. Prasad, *Quantum Chemistry*, 2nd Edn., New Age International Publishers, 2000.
10. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
11. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
12. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
13. Ira N. Levine, *Quantum Chemistry*, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
14. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
16. ***Bockris***, John O'M., ***Reddy***, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
17. Physical Chemistry by Gurtu and Gurtu

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures
Course title: Chemistry Paper 02 Inorganic Chemistry
Course code: VESPSCH 102
Objective: To understand and develop competence in use of Basic of inorganic chemistry and molecular symmetry

Learning Outcomes (LO):

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

LO1 Know that how orbital will forms, formation of hybrid orbital, concept of VBT and it's application,

LO2 Students will learn about basic knowledge of molecular symmetry and group theory, concept of matrix representation, character table and its application

LO3 Students will learn about Electronic structure of solids and band theory, fermi level structure of different types of compound, preparation of nanomaterials and it's application

LO4 Students will learn detail concept of Orgel and Tanabe-Sugano diagram, Inorganic Reaction Mechanism, Ligand substitution reactions and redox reaction

Course title: Chemistry Paper 2 Course code: VESPSCH 102

Unit no.	Details of topics	No of lectures
1	1. Chemical Bonding 1.1 Recapitulation of hybridization Derivation of wave functions for sp, sp^2 , sp^3 orbital hybridization types considering only sigma bonding. 1.2 Discussion of involvement of d orbitals in various types of hybridizations. Concept of resonance, resonance energy derivation expected. Formal charge with examples. 1.3 Critical analysis of VBT. 1.4 Molecular Orbital Theory for diatomic species of First transition Series. 1.5 Molecular Orbital Theory for Polyatomic species considering σ bonding for SF6, CO2, B2H6, I3 - molecular species. 1.6 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 Lectures
2	Molecular Symmetry and Group Theory 2.1. Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules. 2.2. Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups. 2.3. Representation of Groups: Matrix representation of symmetry	15 Lectures

	operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C2v, C3v and D2h, structure of character tables. 2.4. 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..	
3	3.1 Solid State Chemistry 3.1.1. Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones. 3.1.2. 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)]. 3.1.3. 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) 3.2 Nanomaterials 3.2.1. Preparative methods: Chemical methods, Solvothermal, Combustion synthesis, Microwave, Co-precipitation, Langmuir Blodgett(L-B) method, Biological methods: Synthesis using microorganisms. 3.2.2. Applications in the field of semiconductors, solar cells	15 Lectures
4	Characterisation of Coordination compounds [15L] 4.1. Formation, thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic methods. 4.2. Spectral calculations using Orgel and Tanabe-Sugano diagram, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio. 4.3. Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectral methods.	15 Lectures

References :

Unit I

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.
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12. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

13. Unit II

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

UNIT III

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

Unit IV

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

4. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, 2006.
5. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999,
6. B. Douglas, D. McDaniel and J. Alexander. *Concepts and Models of Inorganic Chemistry*(3rd edn.), John Wiley & Sons (1994).

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures
Course title: Chemistry Paper 03 Organic Chemistry
Course code: VESPSCH103
Objective: To understand and develop competence in use of Basic of Organic chemistry

Learning Outcomes (LO):

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

LO1	1. Understand the of kinetics and thermodynamics control of organic reactions. 2. To describe how experimental evidence helps to detect the presence of an intermediate or a product in a chemical reaction and to determine a given reaction mechanism. 3. Understand the concept of acidity and basicity of organic compounds and factors affecting the acidity and basicity.
LO2	1. To study different types of nucleophilic substitution reactions in aliphatic and aromatic substrates. To study mechanism of acid and base catalysed hydrolysis of esters. 2. To understand the concept of aromaticity, anti-aromaticity and homoaromaticity in annulenes, aromatic ions , metallocenes and heterocycles.
LO3	To study the Concept of chirality of different organic molecules.
LO4	To study general mechanism, selectivity, and important applications of oxidation and reduction reactions with different reagents.
LO5	Understand the Planning of synthesis, effect of reaction parameters including stoichiometry, safety aspects including MSDS and Purification of the product by crystallization.

Course title: Chemistry Paper 3 Course code: VESPSCH103

Unit no.	Details of topics	No of lectures
1	Physical Organic Chemistry: (15 L) 1.1. 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. 1.2. 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 experiments and stereochemical evidence. 1.3. 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 Lectures
2	Nucleophilic substitution reactions and Aromaticity 2.1. Nucleophilic substitution reactions: (9 L) 2.1.1. Aliphatic nucleophilic substitution: SN1, SN2, SN i reactions, mixed SN1 and SN2 and SET mechanisms. SN reactions involving NGP - participation by aryl rings, αand pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. SNcA, SN1‟ and SN2‟ reactions. SN at sp2 (vinylic) carbon. 2.1.2. Aromatic nucleophilic substitution: SNAr, SN1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. 2.1.3. Ester hydrolysis: Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples. Aromaticity: (6 L) 2.2.1. Structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity. 2.2.2. Application of HMO theory to monocyclic conjugated systems. Frost-Musulin diagrams. Huckel‟s (4n+2) and 4n rules. 2.2.3. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C60)	15 Lectures
3	Stereochemistry: (15 L) 3.1. Concept of Chirality: Recognition of symmetry elements. 3.2. Molecules with tri- and tetra-coordinate centers: Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centers, relative configurational stabilities. 3.3. 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. 3.4. Axial and planar chirality: Principles of axial and planar chirality.	15 Lectures

	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. 3.5. 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.	
4	Oxidation and Reduction: (15 L) 4.1. Oxidation: General mechanism, selectivity, and important applications of the following: 4.1.1. Dehydrogenation: Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ). 4.1.2. Oxidation of alcohols to aldehydes and ketones: Chromium reagents such as K2Cr2O7/H2SO4 (Jones reagent), CrO3-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. 4.1.3. Oxidation involving C-C bonds cleavage: Glycols using HIO4; cycloalkanones using CrO3; carbon-carbon double bond using ozone, KMnO4, CrO3, NaIO4 and OsO4; aromatic rings using RuO4 and NaIO4. 4.1.4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH2 to CO by SeO2, oxidation of arylmethanes by CrO2Cl2 (Etard oxidation). 4.1.5. Oxidation of aldehydes and ketones: with H2O2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) 4.2. Reduction: General mechanism, selectivity, and important applications of the following reducing reagents: 4.2.1. Reduction of CO to CH2 in aldehydes and ketones- Clemmensen reduction, WolffKishner reduction and Huang-Minlon modification. 4.2.2. Metal hydride reduction: Boron reagents (NaBH4, NaCNBH3, diborane, 9-BBN, Na(OAc)3BH, aluminium reagents (LiAlH4, DIBAL-H, Red Al, L and K- selectrides). 4.2.3. NH2NH2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzsch dihydropyridine). 4.2.4. Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.	15 Lectures

REFERENCES THEORY

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.
18. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures

Course title: Chemistry Paper 04 Analytical Chemistry

Course code: VESPSCH 104

Objective: To understand and develop competence in use of Basic of Analytical chemistry

Learning Outcomes (LO):

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

LO1	To understand language of analytical chemistry, types of errors, Quality Management System (QMS), Safety in Laboratories and Accreditation of Laboratories
LO2	To learn numerical problems of ppm, ppb and dilution of the solutions, concept of mmol, Stoichiometry of chemical reactions and Concept of formation constants etc
LO3	To study Molecular Ultraviolet and Visible Spectroscopy, Infrared Absorption Spectroscopy and FT-IR
LO4	To study thermal method such as Differential Scanning Calorimetry and Automation in chemical analysis
LO5	To learn principle working of gas chromatography, HPLC, X-ray spectroscopy and mass spectrometry
LO6	To study Surface Analytical Techniques such as Scanning Electron Microscopy (SEM), Scanning Tunneling Microscopy (STM), Transmission Electron Microscopy (TEM), electroanalytical Methods.

Course title: Chemistry Paper 4 **Course code: VESPSCH 104**

Unit no.	Details of topics	No of lectures
1	1.1 Language of Analytical Chemistry [8 L] 1.1.1 Analytical perspective, Common analytical problems, terms involved in analytical chemistry (analysis, determination, measurement, techniques, methods, procedures and protocol) 1.1.2 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. 1.1.3 Errors, determinate and indeterminate errors. Types of determinate errors, tackling of errors. 1.1.4 Quantitative methods of analysis: calibration curve, standard addition and internal standard method. 1.2 Quality in Analytical Chemistry: [7 L] 1.2.1 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. 1.2.2 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). 1.2.3 Accreditations: Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark) 1.2.4 Good Laboratory Practices (GLP) Principle, Objective, OECD guidelines, The US FDA 21CFR58, Klimisch score.	15 Lectures
2	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 Lectures
3	3.1 Recapitulation and FT Technique [3 L] 3.1.1 Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers. 3.1.2 Laser as a source of radiation, Fibre optics 3.1.3 Introduction of Fourier Transform 3.2 Molecular Ultraviolet and Visible Spectroscopy [6 L] NUMERICALS ARE EXPECTED 3.2.1 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 3.2.2 Dual spectrometry – Introduction, Principle, Instrumentation and Applications 3.3 Infrared Absorption Spectroscopy [6 L]	15 Lectures

	3.3.1 Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument05 L 3.3.2 FTIR and its advantages 3.3.3 Applications of IR [Mid IR, Near IR, Far IR]: Qualitative with emphasis on "Finger print" region, Quantitative analysis, Advantages and Limitations of IR 3.3.4 Introduction and basic principles of diffuse reflectance spectroscopy	
4	4.1 Thermal Methods: [9 L] 4.1.1 Introduction, Recapitulation of types of thermal methods, comparison between TGA and DTA. 4.1.2 Differential Scanning Calorimetry- Principle, comparison of DTA and DSC, Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting curves (sample size, sample shape, pressure). 4.1.3 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. 4.2 Automation in chemical analysis: [6 L] 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 Lectures

Unit I

1. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education
2. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 1.
3. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004, Ch: 5.
4. Undergraduate Instrumental Analysis, 6th Edition, J W Robinson, Marcel Dekker, Ch:1.
5. ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Chapter: 3 & 4) (Free download).
6. Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, Ch: 5, Ch: 6 &Ch: 7.
7. Quality Management, Donna C S Summers, Prentice-Hall of India, Ch:3.
8. Quality in Totality: A Manager's Guide To TQM and ISO 9000, ParagDiwan, Deep & Deep Publications, 1st Edition, 2000.
9. Quality Control and Total Quality Management - P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5.
10. Industrial Hygiene and Chemical Safety, M H Fulekar, Ch:9, Ch:11 & Ch:15.
11. Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher, Ch:4, Ch:5 & Ch:19.
12. Staff, World Health Organization (2009) Handbook: Good Laboratory Practice (GLP)
13. OECD Principles of Good Laboratory Practice (as revised in 1997)". OECD Environmental Health and Safety Publications. OECD. **1**. 1998.
14. Klimisch, HJ; Andreae, M; Tillmann, U (1997). "A systematic approach for evaluating the quality of experimental toxicological and eco-toxicological data". doi:10.1006/rtph.1996.1076. PMID 9056496.

Unit II

1. 3000 solved problems in chemistry, Schaums Solved problem series, David E. Goldbers, Mc Graw Hill international Editions, Chapter 11,15,16,21,22

Unit III

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)

Unit IV

1. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. Graw Hill (1987): Chapter 27
2. Thermal Analysis-theory and applications by R. T. Sane, Ghadge, Quest Publications
3. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 25
4. Instrumental Analysis, 5 th Edition, Skoog, Holler and Nieman: Chapter 31
5. Quantitative Chemical Analysis, 6 th Edition, Vogel: Chapter 12
6. Analytical Chemistry by Open Learning: Thermal Methods by James W. Dodd & Kenneth H. Tonge
7. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 26
8. Instrumental Analysis, 5th Edition, Skoog, Holler and Nieman: Chapter 33
9. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. GrawHill (1987): Chapter 28

M.Sc. (CHEMISTRY)
(SEMESTER I) PRACTICAL

PHYSICAL PRACTICALS **Semester I**

LO1 Students will be able to learn heat of solution (ΔH) of a sparingly soluble acid using solubility measurements
LO2 Learner will study the reaction between Iodine and Acetone
LO3 Students will be able to identify acceptable or non-acceptable function by Plotting graph of mathematical functions
LO4 Learner will understand to determine pKa values of phosphoric acid by potentiometry
LO5 Student will understand the use of EMF method to deermine mean ionic activity coefficient of an electrolyte

Unit no.	Details of topics	No of lectures
	Non – instrumental: 1. Polar plots of atomic orbitals such as 1*s*, 2□□ and 3□□2orbitals 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 PRACTICAL
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.

CHEMISTRY INORGANIC PRACTICALS **Semester I**

LO1 Students will be able to estimate important element from alloy
LO2 Learner will study the ore opening reaction and metallurgical processes
LO3 Students will be able to handle potentiometer for estimating metals

Unit no.	Details of topics	No of lectures
	Ores and Alloys 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	

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

ORGANIC CHEMISTRY PRACTICALS **Semester I**

LO1 learner will perform various method of organic preparations
LO2 learner will know the practical approach toward one step preparation of organic compound
LO3 Planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS should be learnt
LO4 Purify the product by crystallization. Formation and purity of the product should be checked by TLC

Unit no.	Details of topics	No of lectures
	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	
	Learning points: 1. 3. Report mass and melting point of the purified product	

REFERENCES PRACTICAL
1. Systematic Qualitative organic analysis, H. Middleton (Orient Longman) 2. A Handbook of Organic Analysis, H.T. Clark (Orient Longman) 3. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York) 4. Practical Organic Chemistry by Mann and Saunders. 5. Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication

ANALYTICAL CHEMISTRY PRACTICALS **Semester I**

LO1 Student will understand use of ion exchange method in the determination of ion exchange capacity, exchange efficiency and breakthrough capacity of cation exchange resin.

LO2 Student will learn volhards method for the assay of sodium chloride from saline

LO3 Learner will understand determination of lead and tin content from solder alloy using complex metric titration

Unit no.	**Details of topics**	**No of lectures**
	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 the given solution containing a mixture of Cu(II) and Fe(II). 7. To determine number of nitro groups in the given compound using TiCl3.	

M.Sc. (CHEMISTRY)
(SEMESTER II)

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH 201	**Paper 01 Physical Chemistry**	**60**	**04**
	Unit I : Chemical Thermodynamics II	**15 Lectures**	
	Unit II: Quantum Chemistry II	**15 Lectures**	
	Unit III : Chemical Kinetics and Molecular Reaction Dynamics	**15 Lectures**	
	Unit IV : Solid State Chemistry and Phase Equilibria	**15 Lectures**	

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH 202	**Paper 02 Inorganic Chemistry**	**60**	**04**
	Unit I : Inorganic Reaction Mechanism	**15 Lectures**	
	Unit II: Organometallic Chemistry of Transition metals	**15 Lectures**	
	Unit III : Environmental Chemistry	**15 Lectures**	
	Unit IV : Bioinorganic Chemistry	**15 Lectures**	

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH203	**Paper 03 Organic Chemistry**	**60**	**04**
	Unit I : Alkylation of Nucleophilic Carbon Intermediates: (7 L) Reaction of carbon nucleophiles with carbonyl groups: (8 L)	**15 Lectures**	
	Unit II: Reactions and Rearrangements:	**15 Lectures**	
	Unit III : Introduction to Molecular Orbital Theory for Organic Chemistry: (7 L) Applications of UV and IR spectroscopy: (8 L)	**15 Lectures**	
	Unit IV : NMR spectroscopy and Mass spectrometry	**15 Lectures**	

Course Code	Title	Credits & Lectures per Semester	Lectures per Week
VESPSCH 204	**Paper 04 Analytical Chemistry**	**02**	**04**
	Unit I : Chromatography	**15 Lectures**	
	Unit II: instrumental method	**15 Lectures**	
	Unit III : Surface Analytical Techniques & Atomic Spectroscopy	**15 Lectures**	
	Unit IV : Electroanalytical Methods (Numericals are Expected)	**15 Lectures**	

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures

Course title: Chemistry Paper 01 Physical Chemistry

Course code: VESPSCH 201

Objective: To understand and develop competence in use of Basic of Physical chemistry

LO1 Learner will be able to understand Thermodynamic terms such as Gibbs energy of mixing, entropy and enthalpy of mixing ,fugacity,equilibrium constant and will be able to understand Thermodynamics of surfaces and Bioenergetics

LO2 Learner will understand application of the Schrödinger equation to two electron system and expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots., points of maximum probability,

LO3 Students will Understand Rate laws for reactions in solid, Kinetics of reactions catalyzed by enzymes**,** Enzyme activation by metal ions and Solvent Effects on reaction rates,

LO4 Students will able to understand Types of Defects and Stoichiometry in Solid State Chemistry Students will learn concept of Phase equilibria ,Phase rule , Two and Three component system

Unit no.	Details of topics	No of lectures
1	1. **Chemical Thermodynamics II** (15L) 1.1. 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. 1.2. **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.	15 Lectures

	1.3. **Thermodynamics of surfaces**, Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected). 1.4. Bioenergetics : standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP. .	
2	**Quantum Chemistry II [15 L]** **2.1.** 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. 2.2. Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, the R the θ * and the φ 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. 2.3. 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. ***2.4.*** Hückel Molecular Orbitals theory for ethylene , 1,3-butadiene and benzene. ***(Derivation expected)***	15 Lectures
3	**Chemical Kinetics and Molecular Reaction Dynamics [15 L]** 3.1. **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 **3.2. Kinetics of reactions catalyzed by enzymes** -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses**.** 3.3. **Inhibition of Enzyme action**: Competitive, Noncompetitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes. 3.4. **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 Lectures
4	**Solid State Chemistry and Phase Equilibria [15 L]** **4.1 : Solid State Chemistry** **4.1.1. 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	15 Lectures

	d) Thermodynamics of formation of defects (Mathematical derivation to find concentration of defects and numerical problems based on it) (Ref: 17, 18 and19) **4.2 Phase equilibria** 4.2.1. **Recapitulation:** Introduction and definition of terms involved in phase rule. Thermodynamic derivation of Gibbs Phase rule. **4.2.2. 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) **4.2.3. 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	

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
22. Essentials of Physical Chemistry , Arun Bahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.
23. Introduction of Solids L.V Azaroff , Tata McGraw Hill .
24. A Text book of physical Chemistry ; Applications of thermodynamics vol III, Mac Millan Publishers India Ltd ,2011
25. New directions in solid state Chemistry, C.N.R. Rao and J Gopalkrishnan , Cambridge University Press.

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures

Course title: Chemistry Paper 02 Inorganic Chemistry

Course code: VESPSCH 202

Objective: To understand and develop competence in use of Basic of inorganic chemistry and metallurgical operations

LO1 Students will learn inorganic reaction mechanism and spectrophotometric methods

LO2 Learner will able to apply EAN and certain inorganic complexes.

LO3 Learner will gain in sight to environmental aspects with reference to toxicity of some compounds.

LO4 Students will able to gain knowledge of bio-inorganic chemistry with special reference to Hemoglobin and significance of Hill constant and medicinal application of complexes

Unit no.	Details of topics	No of lectures
1	2. Inorganic Reaction Mechanism 1.1 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). 1.2 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. 1.3 Redox reactions: inner and outer sphere mechanisms, complimentary and noncomplimentary reactions. 1.4 Stereochemistry of substitution reactions of octahedral complexes. (Isomerization and racemization reactions and applications.)	15 Lectures
2	2. Organometallic Chemistry of Transition metals: [15 L] 2.1. Eighteen and sixteen electron rule and electron counting with examples. 2.2. 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)	15 Lectures

	Allyl derivatives of nickel (f) Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo. 2.3 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)..	
3	Environmental Chemistry:[15 L] 3 3.1. Conception of Heavy Metals: Critical discussion on heavy metals 3.2. 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. 3.3. Case Studies: (a) Itai-itai disease for Cadmium toxicity, (b) Arsenic Poisoning in the Indo-Bangladesh region. 3.4. 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 Lectures
4	Bioinorganic Chemistry:[15 L] 4.1. 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. 4.2. 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. 4.3. Copper containing enzymes- superoxide dismutase, tyrosinase and laccase: catalytic reactions and the structures of the metal binding site 4.4. Nitrogen fixation-nitrogenase, hydrogenases 4.5. Metal ion transport and storage:Ionophores, transferrin, ferritin and metallothionins 4.6. Medicinal applications of cis-platin and related compounds	15 Lectures

REFERENCES

Unit

I

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th 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. 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.

Unit II

1. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.
2. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded, New Age International Pvt Ltd, 2000.
3. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000.
4. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.
5. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd

Unit III

1. Environmental Chemistry 5th edition, Colin Baird Michael Cann, W. H. Freeman and Company, New York, 2012.
2. Environmental Chemistry 7th edition, Stanley E. Manahan, CRC Press Publishers,
3. Environmental Contaminants, Daniel A. Vallero, ISBN: 0-12-710057-1, Elsevier Inc., 2004.
4. Environmental Science 13th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN- 10: 0-495-56016-2, Brooks/Cole, Cengage Learning, 2010.
5. Fundamentals of Environmental and Toxicological Chemistry 4th edition, Stanley E. Manahan, ISBN: 978-1-4665-5317-0, CRC Press Taylor & Francis Group,

2013.

6. 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
7. 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, McGraw- Hill, 2001.

Unit IV

1. R. W. Hay, *Bioinorganic Chemistry,* Ellis Harwood, England, 1984.
2. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First South Indian Edition, Viva Books, New Delhi, 1998.
3. J. A. Cowan, *Inorganic Biochemistry-An introduction,* VCH Publication, 1993.
4. S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry,* University Science Publications, Mill Valley, Caligronic, 1994.
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10. JM. D. Yudkin and R. E. Offord *A Guidebook to Biochemistry*, Cambridge University Press, 1980.

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures

Course title: Chemistry Paper 03 Organic Chemistry

Course code: VESPSCH203

Objective: To understand and develop competence in use of Basic of organic chemistry

LO1	Understand the of kinetics and thermodynamics control of organic reactions. To study different types of nucleophilic substitution reactions in aliphatic and aromatic substrates.
LO2	To describe how experimental evidence helps to detect the presence of an intermediate or a product in a chemical reaction and to determine a given reaction mechanism
LO3	Understand the concept of acidity and basicity of organic compounds and factors affecting the acidity and basicity
LO4	To study mechanism of acid and base catalysed hydrolysis of esters. To understand the concept of aromaticity, anti-aromaticity and homoaromaticity in annulenes, aromatic ions , metallocenes and heterocycles. To study the Concept of chirality of different organic molecules.
LO5	To study general mechanism, selectivity, and important applications of oxidation and reduction reactions with different reagents.

Unit no.	Details of topics	No of lectures
1	1.1. Alkylation of Nucleophilic Carbon Intermediates: (7 L) 1.1.1. Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. 1.1.2. Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation. 1.1.3. Alkylation of aldehydes, ketones, esters, amides and nitriles. 1.1.4. Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines. 1.1.5. Alkylation of carbon nucleophiles by conjugate addition (Michael reaction). 1.2. Reaction of carbon nucleophiles with carbonyl groups: (8 L) 1.2.1. 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. 1.2.2. Addition reactions with amines and iminium ions; Mannich reaction. 1.2.3. Amine catalyzed condensation reaction: Knoevenagel reaction. 1.2.4. Acylation of carbanions. [Reference Books: 1-11]	15 Lectures
2	Reactions and Rearrangements: (15 L) Mechanisms, stereochemistry (if applicable) and applications of the following: 2.1. Reactions: Baylis-Hilman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction. 2.2. Concerted rearrangements: Hofmann, Curtius, Lossen, Schmidt, Wolff, BoultonKatritzky. 2.3. Cationic rearrangements: Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein. 2.4. Anionic rearrangements: Brook, Neber, Von Richter, Wittig, Gabriel–Colman, Payne. [Reference Books: 19-22]	15 Lectures
3	3.1. Introduction to Molecular Orbital Theory for Organic Chemistry: (7 L) 3.1.1. 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 3.1.2. 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. 3.1.3. Application of FMO concepts in (a) SN 2 reaction, (b) Lewis acid base adducts (BF3- NH3 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. 3.2. Applications of UV and IR spectroscopy: (8 L) 3.2.1. 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	15 Lectures

	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). 3.2.2. 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.	
4	NMR spectroscopy and Mass spectrometry (15 L) 4.1. 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. 4.2. 13C 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. 4.3. 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. 4.4. Structure determination involving individual or combined use of the above spectral techniques. [Reference Books: 13-18]	15 Lectures

REFERENCES

Sem II

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
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

Detailed Syllabus: Unit wise / ~~Module wise~~ with number of lectures

Course title: Chemistry Paper 04 Analytical Chemistry

Course code: VESPSCH 204

Objective: To understand and develop competence in use of Basic of Analytical chemistry and Spectroscopic techniques.

LO1 To study thermal method such as Differential Scanning Calorimetry and Automation in chemical analysis

LO2 To learn principle working of gas chromatography, HPLC, X-ray spectroscopy and mass spectrometry

LO3 To study Surface Analytical Techniques such as Scanning Electron Microscopy (SEM), Scanning Tunneling Microscopy (STM), Transmission Electron Microscopy (TEM), electroanalytical Methods.

Unit no.	**Details of topics**	**No of lectures**
1	Chromatography [15 L] 1.1 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.[2 L] **1.2** 1.2 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.[5 L] **1.3** 1.3 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. [3 L] **1.4** 1.4 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. [5 L]	15 Lectures
2	2.1 X-ray spectroscopy: principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. [4 L] 2.2 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.[6 L] 2.3 Radioanalytical Methods – recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. [5 L]	15 Lectures
3	Surface Analytical Techniques – [9 L] Introduction, Principle, Instrumentation and Applications of: 3.1.1 Scanning Electron Microscopy (SEM) 3.1.2 Scanning Tunneling Microscopy (STM) 3.1.3 Transmission Electron Microscopy (TEM) 3.1.4 Electron Spectroscopy (ESCA and Auger) 3.2 Atomic Spectroscopy [6 L] 3.2.1 Advantages and Limitations of AAS 3.2.2 Atomic Spectroscopy based on plasma sources – Introduction, Principle,	15 Lectures

	Instrumentation and Applications	
4	Electroanalytical Methods (Numericals are Expected) 4.1 Ion selective potentiometry and Polarography: [10 L] 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. 4.2 Electrogravimetry: Introduction, principle, instrumentation, factors affecting the nature of the deposit, applications.[3 L] 4.3 Coulometry: Introduction, principle, instrumentation, coulometry at controlled potential and controlled current [2 L]	15 Lectures

REFERENCES

Unit I

1. Instrumental Analysis, Skoog, Holler & Crouch

2 HPLC Practical and Industrial Applications, 2 nd Ed., Joel K. Swadesh, CRC Press

Unit II

1. Essentials of Nuclear Chemistry, H J Arnikar, New Age Publishers (2005)
2. Fundamentals of Radiochemistry D. D. Sood , A. V. R. Reddy and N. Ramamoorthy
3. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 12
4. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 20

Unit III

1. Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition, (2003), ISBN-10: 8131505421, ISBN-13: 978-8131505427
2. Physical Principles of Electron Microscopy, An Introduction to TEM, SEM, and AEM
3. Authors: Ray F. Egerton, ISBN: 978-0- 387-25800- 3 (Print) 978-0- 387-26016- 7 (Online)
4. Modern techniques of surface science by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994.
5. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, NewYork, 1993.
6. 5. Transmission Electron Microscopy: A text book for Material Science, David B Williams and C., Barry Carter, Springer
7. Modern Spectroscopy, by J.M. Hollas, 3rd Edition (1996), John Wiley, New York
8. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.
9. Instrumental Analysis by Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition (2003), ISBN10: 8131505421, ISBN-13: 978-8131505427

Unit IV

1. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th Edition, Harcourt College Publishers, 1998. Chapters - 23, 24, 25.
2. Analytical Chemistry Principles – John H Kennnedy, 2nd edition, Saunders College Publishing (1990).
3. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000).
4. Vogel's Text book of quantitative chemical analysis, 6th edition, Pearson Education Limited, (2007).
5. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980).

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M.Sc. (CHEMISTRY)
(SEMESTER II) PRACTICAL

CHEMISTRY PHYSICAL PRACTICALS **Semester II**

LO1 Students will be able to plot atomic orbitals,rate constant by Dilatometric method.

LO2 student will study influence of ionic strength on the base catalysed hydrolysis of ethyl acetate

LO3 Learner will learn determination of formula of silver ammonia complex by potentiometric method.

LO4 Students will learn determination of Hammette constant pHmetrically.

Unit no.	Details of topics	No of lectures
	Non – instrumental: 1. Polar plots of atomic orbitals such as 1*s*, $2P_x$ and 3_{Z^2} 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
4. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005. 5. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974. **6.** Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

CHEMISTRY INORGANIC PRACTICALS **Semester II**

LO1 Learner will gain knowledge of complex preparation and their characterization
LO2 Learner will able to handle instruments like potentiometer as well as conductometer

Unit no.	Details of topics	No of lectures
	Inorganic Chemistry. 1) Bis-(tetraethylammonium) tetrachloro Cuprate (II) (Et4 N) 2[CuCl4] 2) Bis-(tetraethylammonium) tetrachloro Nickelate (II) (Et4 N) 2 [NiCl4] 3) Bis-(tetraethylammonium) tetrachloro Cobaltate (II) (Et4 N) 2 [CoCl4] (Any two from above preparations) 4) Tetrammine monocarbanato Cobalt (III) Nitrate [Co(NH3)4CO3]NO3 5) Bis (ethylenediammine) Copper (II) Sulphate [Cu(en)2]SO4 6) Hydronium dichloro bis(dimethylglyoximato) Cobaltate(III) H[Co(dmgH)2Cl2]	
	1) Determination of equilibrium constant by Slope intercept method for Fe+3/ SCNsystem 2) Determination of Electrolytic nature of inorganic compounds by Conductance measurement.	

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

CHEMISTRY ORGANIC PRACTICALS **Semester II**

LO1 Planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS should be learnt.
LO2 Purify the product by crystallization. Formation and purity of the product should be checked by TLC
LO3 Report mass and melting point of the purified product
.

Unit no.	Details of topics	No of lectures
	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	

REFERENCES

1. Systematic Qualitative organic analysis, H. Middleton (Orient Longman)
2. A Handbook of Organic Analysis, H.T. Clark (Orient Longman)
3. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York) 4. Practical Organic Chemistry by Mann and Saunders.
5. Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication

CHEMISTRY ANALYTICAL PRACTICALS **Semester II**

LO1 To understand the use of non-aqueous titration in the determination of persantage purity of drug

LO2 Student will learn simultaneous determination of individual metals from mixture of metals using spectrophotometry and potentiometric

LO3 Students will learn percentage purity of sodium carbonate by pH metrically

LO4 student will learn application of flame photometry in the determination of potassium content from fertilizer

Unit no.	Details of topics	No of lectures
	2. 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 the given solution containing a mixture of Cu(II) and Fe(II). 7. To determine number of nitro groups in the given compound using TiCl3.	

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REFERENCES PRACTICAL
1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964) 1. 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",PartII, 4th Ed.,A Wiley Interscience Publication,New York,1978

Modality of assessment

The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by Internal Assessment with 40% marks in the first part & by conducting the Semester End Examinations with 60% marks in the second part. Practical Examination will consist of End Sem examination.

Student will have to score 40% of marks in Internal assessment as well as End Sem examination to pass the course.

The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below:-

Internal Assessment: It is defined as the assessment of the learners on the basis of internal evaluation as envisaged in the Credit & Choice based system by way of participation of learners in various academic and correlated activities in the given semester of the programme.

Semester End Assessment : It is defined as the assessment of the learners on the basis of Performance in the semester end Theory/ written/ Practical examination.

A. Theory - Internal assessment 40% **40 marks**

Sr No	Evaluation type	Marks
1.	Seminar presentation	40

B. Theory - External examination - 60% **60 marks**

Semester End Theory Assessment **Semester End Theory Assessment**

Duration - Each paper shall be of 2.5 hours' duration.

1. Theory question paper pattern as per the university pattern : -
    a. There shall be FIVE compulsory questions.
    b. Question No 1, 2, 3 and 4 will be based upon Unit 01, Unit 02, Unit 03 and Unit 04 respectively.

c. Question No 05 will be based on Unit 01, 02 ,03 and 04

Question no.	Details	Marks
Q1.	**(Unit 01)**	12M
	Attempt **any three of the six** A) /B) / C) /D) /E) /F)	
Q2.	**(Unit 02)**	12M
	Attempt **any three of the six** **A)**/ B)/C)/D)/E)/F)	
Q3.	**(Unit 03)**	12M
	Attempt **any three of the six** A)/B)/C)/D)/E)/F)	
Q4	**(Unit 04)**	12M
	Attempt **any three of the six** **A)**/B)/C)/D)/E)/F)	
Q5	**(Unit 01, 02 ,03 and 04)**	**12M**
	Attempt any four out of eight A)/B)/C)/D)/E)/F)/G)/H)	

C. For Each Semester Practical Assessment

	Section 1 Based on Paper 02	**Marks**
A	Experimental work	40
B	Viva	05
C	Journal	05
		50 Marks

PRACTICAL BOOK/JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Coordinator / In-charge of the department ; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

SEMESTER I

Course	VESPSCH101	VESPSCH102	VESPSCH103	VESPSCH104	Grand Total
Theory	100	100	100	100	400
Practical	50	50	50	50	200

SEMESTER II

Course	VESPSCH201	VESPSCH102	VESPSCH103	VESPSCH104	Grand Total
Theory	100	100	100	100	400
Practical	50	50	50	50	200

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