Shri Vile Parle Kelavani Mandal's

MITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE & AMRUTBEN JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS (AUTONOMOUS)

NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),

Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India

Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: MSc

Course: Physical Chemistry

Semester :I

Choice Based Credit System (CBCS) with effect from the Academic year

2018-2019

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the M.Sc. Analytical Chemistry, the learners should be enriched with knowledge and be able to-

PSO1: To have sound knowledge about the fundamentals and applications of various Analytical Instruments.

PSO2: To familiarize with the different branches of science like material Science, Nanoscience, Geology, Solid state Chemistry, Solid state Physics, etc which utilizes Analytical Chemistry to drive information.

PSO3: Deals with Qualitative and Quantitative Analysis.

PSO4: To develop better understanding of GMP and GLC.

PSO5: It also involves study of environmental pollution, Waste management, Green Chemistry, etc.

PSO6: To handle various Analytical Instruments, Interpretation of Spectra's, and trouble shooting.

PSO7: To study MSDS of various Chemicals.

PSO8: To study Stoichiometry and Chemometrics.

Preamble

The well-organized curriculum including basic as well as advanced concepts in the subject of Analytical Chemistry from first year to second year shall inspire the students for pursuing higher studies in chemistry, research and for becoming an entrepreneur. It also enable students to get employed in the various research Institutes, industries, educational Institutes, competitive exams and in the various departments of State and Central Government based on subject chemistry.

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	TEST	15 marks
Component 2 (CA-2)	ASSIGENMENT	10 marks

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
1	Any **Three** out of Five	5	15
2	Any **Three** out of Five	5	15
3	Any **Three** out of Five	5	15
4	Any **Three** out of Five	5	15
5	Any **Three** out of Four	5	15
		Total Marks	**75**

Signature Signature Signature

HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. Chemistry				**Semester : I**	
Course : Physical chemistry				**Course Code:PSMACH101**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment and Evaluation (CAE) (Marks –25)**	**Term End Examinations (TEE) (Marks- 75 in Question Paper)**
4	4	N/A	4 + 2	15 +10	75

Learning Objectives:

1. To orient learner about the importance of Physical chemistry.
2. To orient learner about the principle, theory and principles of Physical chemistry.
3. To teach learner about the various applications of Physical chemistry to understand the physical phenamenon.
4. To teach learner about the basic and fundamental concepts of Physical chemistry.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: Interpret the state functions and exact differentials, the student will be able to solve the problems.

CO2: Derive the Maxwell equation

CO3: Describe the Maxwell thermodynamic Relations; it's significance and applications to ideal gases .

CO4: Understand Classical Mechanics, failure of classical mechanics, Need for Quantum Mechanics

CO5: Describe Debye –Huckel equation , limiting and extended forms.

CO6: Explain . Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system

CO7: Discuss membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Thermodynamics-I**	15
2	**Quantum Chemistry**	15
3	**Quantum Chemistry-II**	15
4	**Electrochemistry**	15
	Total	**60**
Practical		**02**

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

Unit	Topic	No. of Hours/Credits
Module 1	**Thermodynamics-I** 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. 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.	15/01
Module 2	**Quantum Chemistry** 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.	15/01

	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.	
Module 3	**Quantum Chemistry-II** 3.1 Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates, separation of the variables, the phi equation, wave function, quantum number, the theta equation, wave function, quantization of rotational energy, spherical harmonics. 3.2 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 equation, 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 3.3 Application of the Schrödinger equation to two electron system, limitations of the equation, need for the approximate	15/01

PRACTICAL I
(If applicable)

Non – Instrumental:

	solutions, methods of obtaining the approximate solution of the Schrödinger wave equation. 3.4 Hückel Molecular Orbital (HMO) theory for ethylene, 1,3 butadiene, allyl, cyclopropene and benzene ** Derivation expected*	
Module 4	**Electrochemistry** **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) **Note:Wherever possible numerical are expected.**	15/01

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 $CaSO_4$ 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.

Suggested Readings

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 18. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2nd Ed

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Best College (2016-17), University of Mumbai

Affiliated to the

UNIVERSITY OF MUMBAI

Program: M.Sc. Analytical Chemistry

Semester: II

Choice Based Credit System (CBCS) with effect from the Academic year 2018 – 19

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the M.Sc I , the learners should be enriched with knowledge and be able to-

PSO 1: To have sound knowledge about the fundamentals and applications of various Analytical Instruments.
PSO 2: To familiarize with the different branches of science like material Science, Nanoscience, Geology, Solid state Chemistry, Solid state Physics, etc which utilizes Analytical Chemistry to drive information.
PSO 3: Deals with Qualitative and Quantitative Analysis.
PSO 4: To develop better understanding of GMP and GLC.
PSO 5: It also involves study of environmental pollution, Waste management, Green Chemistry, etc.
PSO 6: To handle various Analytical Instruments, Interpretation of Spectra's, and trouble shooting.
PSO 7: To study MSDS of various Chemicals.
PSO 8: To study Stoichiometry and Chemometrics.

Preamble

The purpose of post-graduate education in Science is to create highly skilled manpower in specific areas, which will lead to generation of new knowledge and creation of wealth for the country. Chemistry is a fundamental science and has contributed immensely to the improvement of the life of human beings by providing many of human requirements and essentialities. The credit system has been adopted for all these courses, which would allow students to develop a strong foundation in the fundamentals and specialize in the disciplines of his/her liking and abilities. The courses are designed so that the students pursuing these courses will obtain fundamental knowledge about the subject in the respective specialization. The students are also expected to get corresponding experimental training during the practical courses.

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	**Written Test**	15 marks
Component 2 (CA-2)	**Assignment**	10 marks

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
1	Any Three out of Five (From Module 1)	3 x 5	15
2	Any Three out of Five (From Module 2)	3 x 5	15
3	Any Three out of Five (From Module 3)	3 x 5	15
4	Any Three out of Five (From Module 4)	3 x 5	15
5	Any Three out of Four (One question from each module)	3 x 5	15
		Total Marks	**75**

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HOD Approved by Vice –Principal Approved by Principal

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. Analytical Chemistry				**Semester: II**	
Course: Physical Chemistry				**Course Code: PSMACH201**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	NIL	4 + 2	15 + 10	75

Learning Objectives:

To introduce concepts thermodynamics of real gases and real solutions. Further, it helps the students to know Chemical Dynamics .The students will be allowed to explore Solid State Chemistry and Phase Equilibria.

Course Outcomes:

After completion of the course, learners would be able to:

CO1: To understand the thermodynamics of real gases and real solutions

CO2: To analyse the free energy of surfaces and biochemical reactions.

CO3: To derive the quantum mechanical solution for energy, probability density, radial and angular plots for hydrogen atom and Huckel Molecular Orbital theory

CO4: To apply Schrodinger equation for multi electron systems and study approximation methods

CO5: To interpret the factors affecting reaction rates and to devise equations for enzyme catalysed reactions

CO6: To introduce the concept of kinetics for reactions in solid state

CO7: To outline the different types of defects in solids

CO8: To construct the phase diagrams for two- and three-component systems.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Chemical Thermodynamics II**	**15**
2	**Chemical Dynamics-I**	**15**
3	**Chemical Dynamics- II**	**15**
4	**Solid State Chemistry and Phase Equilibria**	**15**
	Total	**60**
PRACTICALS		

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL I

Unit	Topic	No. of Hours/Credits
Module 1	**Chemical Thermodynamics II** 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. 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.	**15/01**
Module 2	**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. 3.3Reaction in Gas Phase Unimolecular Reactions: Lindeman-Hinshelwood theory, collision theory for bimolecular reaction (NET SET exam), Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory.	**15/01**

Module 3	**Chemical Dynamics- II** 3.1 Elementary Reactions in Solution Solvent Effects on reaction rates, Reactions between ions-influence of solventDielectric constant, influence of ionic strength, Linear free energy relationships. Enzyme action. 3.2 Enzyme action, 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.	**15/01**
Module 4	**Solid State Chemistry and Phase Equilibria** **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 d) Thermodynamics of formation of defects (Mathematical derivation to find concentration of defects and numerical problems based on it) **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	**15/01**

Note:Wherever possible numerical are expected.

(If applicable)

Non – instrumental:

1 Polar plots of atomic orbitals such as 1s, 2sand 3Pz 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

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Suggested Readings

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.

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. Analytical Chemistry				**Semester: II**	
Course: Inorganic Chemistry				**Course Code: PSMACH202**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	NIL	4 + 2 = 6	15 + 10	75

Learning Objectives:

The objective of the course is to introduce students to Rate of reactions, factors affecting the rate of reactions Octahedral and square planer complexes, Redox reactions, EAN rule and organometallic chemistry of Transition metals, Conception of Heavy Metals and environmental chemistry and metalloenzymes and their role in biology

Course Outcomes:

After completion of the course, learners would be able to:

CO 1: Understand the rate of reaction and factors affecting the rate of reaction particular octahedral and square planer complexes.

CO 2: To apply EAN rule and study organometallic compounds of polynuclear ligands

CO 3: To interpret effect of Heavy elements and case studies of environmental chemistry particular toxicity of elements

CO 4: To develop knowledge roll of metalloenzymes biology in carrying oxygen transport and nitrogen fixation

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Inorganic Reaction Mechanism:**	**15**
2	**Organometallic Chemistry of Transition metals:**	**15**
3	**Environmental Chemistry:**	**15**
4	**Bioinorganic Chemistry:**	**15**
	Total	**60**
PRACTICALS		

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL II

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
3	Estimation of Cl^- ion using silver nitrate conductometrically.

Suggested Readings

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	Topic	No. of Hours/Credits
Module 1	**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 non-complimentary reactions. **1.4** Stereochemistry of substitution reactions of octahedral complexes. (Isomerization and racemization reactions and applications.)	**15/01**
Module 2	**Organometallic Chemistry of Transition metals:** **2.1** Eighteen and sixteen electron rule and electron counting with examples. **2.2** Preparation, properties and applications of the following compounds (of transition metals in general): (a) Alkyl and aryl derivatives (b) Carbenes and carbynes (c) Alkene derivatives (d) Alkyne derivatives (e) Allyl derivatives (f) Sandwich compounds and Half Sandwich compounds **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) $[Pt(PPh_3)_2(HC{\equiv}CPh)_2]$, diallylnickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl (η^4-butadiene) iron(0).	**15/01**
Module 3	**Environmental Chemistry:** **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.	**15/01**

	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.	
Module 4	**Bioinorganic Chemistry:** **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 its 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	**15/01**

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, 2nd ed, 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.

5. G.N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri & Sons, Calcutta, 1988.

6. J.Chem. Educ. (Special issue), Nov, 1985.

7. E.Frienden, J.Chem. Educ., 1985, 62.

8. Robert R.Crechton, Biological Inorganic Chemistry – An Introduction, Elsevier

9. J. R. Frausto da Silva and R. J. P. Williams *The Biological Chemistry of the Elements*, Clarendon Press, Oxford, 1991.

10. JM. D. Yudkin and R. E. Offord *A Guidebook to Biochemistry*, Cambridge University Press, 1980.

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. Analytical Chemistry				**Semester: II**	
Course: Organic Chemistry				**Course Code: PSMACH 203**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	Nil	4+2	15+10	75

Learning Objectives:
To provide the basic knowledge of organic reaction mechanism, physical organic chemistry and synthetic organic chemistry.

Course Outcomes:
After completion of the course, learners would be able to:

CO1: Comprehend the reactivity of different organic molecules with nucleophilic carbons.

CO2: Identify various name reactions and their outcomes.

CO3: Explain method to determine mechanism of any organic reaction.

CO4: Understand various equations related to physical organic chemistry and acid-base theories.

CO5: Understand reactivity and selectivity of various reagents used in organic chemistry.

CO6: Select appropriate reagent for oxidation and reduction

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Alkylation of Nucleophilic Carbon Intermediates**	15
2	**Reactions and Rearrangements**	15
3	**Physical Organic Chemistry**	15
4	**Oxidation and reduction**	15
	Total	**60**
PRACTICALS		

Unit	**Topic**	**No. of Hours/Credits**

Module 1	**Alkylation of Nucleophilic Carbon Intermediates**	**15/01**
	1.1. Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. 1.2. Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation. 1.3. Alkylation of aldehydes, ketones, esters, amides and nitriles. 1.4. Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines. 1.5**.** Alkylation of carbon nucleophiles by conjugate addition (Michael reaction). **Reaction of carbon nucleophiles with carbonyl groups** 1.6 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. 1.7 Addition reactions with amines and iminium ions; Mannich reaction. 1.8 Amine catalyzed condensation reaction: Knoevenagel reaction. 1.9 Acylation of carbanions.	
Module 2	**Reactions and Rearrangements**	**15/01**
	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.	
Module 3	**Physical Organic Chemistry**	**15/01**
	3.1. 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. **3.2. 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. **3.3. 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.	
Module 4	**Oxidation and Reduction**	**15/01**
	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 $K_2Cr_2O_7/H_2SO_4$ (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. **4.1.3. 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 $NaIO_4$. **4.1.4. 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). **4.1.5. Oxidation of aldehydes and ketones:** with H_2O_2 (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 CH_2 in aldehydes and ketones**-Clemmensen reduction, WolffKishner reduction and Huang-Minlon modification. **4.2.2. 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). **4.2.3.**NH_2NH_2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzschdihydropyridine). **4.2.4. 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.	

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL III

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. The Component which has to be characterized has to be bi-functional.
3. Determination of mass 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.

Suggested Readings

Reference Books:

1. Modern Organic Synthesis: An Introduction, G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, (2007).
2. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Academic Press (2002).
3. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon, 3rd Edn., Nelson Thornes
4. Organic Chemistry, 7th Edn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
5. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti& B. Czako (2005), Elsevier Academic Press
6. Advanced Organic Chemistry: Reactions & Mechanisms, 2nd Edn., B. Miller & R. Prasad, Pearson
7. Organic reactions and their mechanisms, 3rd revisededition, P.S. Kalsi, New Age International Publishers
8. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004
9. Name Reactions and Reagents in Organic Synthesis, 2nd Edn.,
10. Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
11. March's Advanced Organic Chemistry, Jerry March, sixth edition, 2007, John Wiley and sons.
12. Organic Reaction Mechanism, 4th edition, V. K. Ahluvalia, R. K. Parashar, Narosa Publication.
13. Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh, Macmillan Publishers, India.
14. Organic Chemistry, Part A and B, Fifth edition,2007, Francis A. Carey and Richard J. Sundberg, Springer.
15. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press (2001).
16. Organic Chemistry, W. G. Solomons, C. B. Fryhle, ,9th Edition, Wiley India Pvt. Ltd.,2009.
17. Modern methods of Organic Synthesis, 4th Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004.
18. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books,2006.
19. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman.
20. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd.
21. Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley-India.
22. Stereochemistry, P. S. Kalsi, 4th edition, New Age International Ltd.
23. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005.
24. Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A john Wiley and Sons, Ltd., Publication).
25. Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5th Edition, Springer Verlag
26. Modern Methods of Organic Synthesis, 4th Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004.

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. Analytical Chemistry				**Semester: II**	
Course: Analytical Chemistry				**Course Code: PSMACH204**	
Teaching Scheme				**Evaluation Scheme**	
Lecture (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks - 25)**	**Semester End Examinations (SEE) (Marks- 75 in Question Paper)**
4	4	NIL	4 + 2	15 + 10	75

Learning Objectives:

To orient the learner about the basic separation techniques like chromatography.
To orient the learner about the important analytical techniques and their importance and applications.
To teach learner about various techniques which are very useful with respect to analysis of various types of samples .

Course Outcomes:

After completion of the course, learners would be able to:

CO1: know various analytical techniques and methods for analysis.

CO2: Understand where a particular technique can be employed.

CO3: Use sophisticated instruments in less time and can interpret the obtained results with efficiency.

Outline of Syllabus: (per session plan)

Module	**Description**	**No of Hours**
1	**Chromatography**	**15**
2	**X – Ray Spectroscopy**	**15**
3	**Surface Analytical Techniques**	**15**
4	**Electroanalytical Methods (Numerical are Expected)**	**15**
	Total	**60**
PRACTICALS		

Unit	Topic	No. of Hours/Credits
Module 1	**Chromatography** **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**.** **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**.** **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. **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	**15/01**
Module 2	**2.1 X-ray spectroscopy**: principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. **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 **2.3 Radioanalytical Methods –** recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications.	**15/01**
Module 3	**3.1 Surface Analytical Techniques** 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** **3.2.1** Advantages and Limitations of AAS **3.2.2** Atomic Spectroscopy based on plasma sources – Introduction, Principle, Instrumentation and Applications.	**15/01**

Module 4	**Electroanalytical Methods (Numericals are Expected)** **4.1 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. **4.2 Electrogravimetry**: Introduction, principle, instrumentation, factors affecting the nature of the deposit, applications**.** **4.3 Coulometry:** Introduction, principle, instrumentation, coulometry at controlled potential and controlled current	**15/01**
Note: Wherever possible numerical are expected.		

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL IV

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 H_2SO_4on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$.
8. To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.

Suggested Readings

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, 5Harcourt College Publishers, 1998. Chapters - 23, 24, 25. th Edition,

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).

6. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7th edition, CBS publishers.