DEPARTMENT OF CHEMISTRY

MASTER OF SCIENCE (M.Sc.): CHEMISTRY

SYLLABUS: 2020-2021

SEMESTER I & II

Department of Chemistry
Title of the course: M.Sc. Chemistry
Preamble of the syllabus

❖ Master of Science (M.Sc.) in Chemistry is a two year full time post graduate program offered by Department of Chemistry, K. J. Somaiya College of Science and Commerce (Autonomous) affiliated to the University of Mumbai.

❖ In our M.Sc. program, Sem I and II are common for all M.Sc students (i.e. students of physical, inorganic, organic, analytical chemistry branches). In semesters III & IV, students will have specialization in any of these four branches.

In sem I and sem II there are four courses:
Course I: Physical chemistry
Course II: Inorganic chemistry
Course III: Organic chemistry
Course IV: Analytical chemistry

❖ Each course is framed to meet the following programme outcomes:
PO1: Cutting-edge Knowledge, fundamental principles of Environmental Science
PO2: Scientific methods, Problem Analysis and critical thinking
PO3: Design/development of solutions
PO4: Conduct investigations of complex Problems,
PO5: Integrating technology tools
PO6: The Graduate and society
PO7: Environment, sustainability and Legitimacy
PO8: Moral values and responsibility
PO9: Individual and team work
PO10: Communication
PO11: competitive exams Entrepreneurship, Project management and finance
PO12: Life-long learning

Programme Specific Outcomes (PSO)

PSO1 (Physical):
PSO2 (Inorganic): The students will learn reaction mechanism, solid state chemistry, structure determination, study of different compounds such as coordination compounds, cage and cluster compounds and industrially important materials
PSO3 (Organic):
PSO4 (Analytical):

M.Sc. 2020-2021
Semester I, II

Structure of syllabus and evaluation pattern (For Physical/Inorganic/Organic/Analytical)

	Papers (Theory) Total Credits 16 Total Marks 400				Practicals Total Credits 08 Total Marks 200				Total
Paper	I	II	III	IV	I	II	III	IV	
No .of Credits	4	4	4	4	2	2	2	2	24
No of marks	60 + 40 (I) =100M	60 + 40 (I) =100M	60 + 40 (I) =100M	60 + 40 (I) =100M	50 M	50 M	50 M	50 M	600 M

- 60 M End semester theory examination
- 40 M (Internal)-By continuous assessment during semester
- 50 M (Practical)- No practical end sem exam; continuous assessment during practicals

M.Sc. – I
Semester I
Physical Chemistry
Course Code PSCH101

Module I

1 Thermodynamics – I **15L**

1.1 State function, Exact and inexact differentials, Cyclic rule, Coefficient of thermal expansion (α) and Compressibility Coefficient (β), and relationship between α and β, Integrating factor. Maxwell equations, Maxwell thermodynamic square. Enthalpy as a function of Temperature and pressure for ideal and real gases **5L**

1.2 Joule Thomson coefficient, Joule Thomson coefficient in terms of van der Waals constants, inversion temperature, Free Expansion of a gas. Relationship between Cp and Cv. Mathematical treatment of Entropy concept, Entropy as state function, Thermodynamic equation of state **5L**

1.3 Entropy changes for a system, surrounding and phase transition, Third law of thermodynamics, Evaluation of absolute entropies, determination of absolute entropies in terms of heat capacity data, standard molar entropies and their dependence on molecular mass and molecular structure. Residual entropy **5L**

Module II

2 Thermodynamics – II **15L**

2.1 Fugacity, relation between fugacity and pressure, determination of fugacity of a real gas, variation of fugacity with temperature and pressure. Equilibrium constant for real gases in terms of fugacity. Activity, dependence of activity on temperature and pressure **5L**

2.2 Thermodynamic functions of mixing: Gibbs energy, entropy and enthalpy of mixing **3L**

2.3 Excess functions of non-ideal solutions: excess thermodynamic functions of chemical potential, Gibb's free energy, entropy, enthalpy and volume **3L**

2.4 Partial molar quantities: calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation **4L**

Module III

3 Applied Thermodynamics **15L**

3.1 Phase Rule: Introduction. Graphical representation of three component system: Binodal curve, Plait point. Effect of temperature on plait point. Formation of two pairs of partially miscible liquids. Formation of three pairs of partially miscible liquids **2L**

3.2 Phase transition: Classification of phase transitions, Experimental determination of phase transition **2L**

3.3 Thermodynamics of Surfaces

3.3.1 Surface tension, Curved surfaces, Capillary action, Pressure difference across curved surface-Laplace equation.. Vapor pressure of droplets- Kelvin equation **4L**

3.3.2 Adsorption of gases by solids: Types of adsorption curve, BET adsorption isotherms (Derivation Expected).Numericals **3L**

3.3.3 Adsorption of Solids from solution, Gibbs adsorption isotherm derivation, experimental results and verification (microtome and Domain and Barker method) **4L**

Module IV

4 Electrochemistry **15L**

4.1 Debye- Huckel theory of activity coefficient, Debye – Huckel limiting law and its extension to higher concentration (Derivation expected) **4L**

4.2 Electrolytic conductance and ionic interactions, Relaxation effect, Debye – Huckel – Onsagar equation (derivation expected), validity of this equation for aqueous and non-aqueous soutions, deviations from Onsagar equation, Debye – Falkenhagen effect (dispersion of conductance at high frequencies), Wein effect **4L**

Applied Electrochemistry

4.3 Batteries: Working principle, cell reactions and cell performances of Lithium batteries (Primary and Secondary), Lithium based conducting polymer batteries, Silver- anode primary batteries, High temperature solid state batteries **4L**

4.4 Fuel cells: Classification, H2 – O2 fuel cell, Alkaline fuel cells, Phosphoric acid fuel cells, Solid polymer electrolyte fuel cells, Solid oxide fuel cells, Biochemical fuel cells **3L**

References

Module I and II

1. R. P. Rastogi & R. R.Misra, An Introduction to Chemical Thermodynamics, 6th Revised Edition., Vikas Publishing House PVT Ltd.

2. Donald A. McQuarrie & John D. Simon, Physical Chemistry-A Molecular Approach, Viva Books Pvt. Ltd.

3. Peter Atkins and Julio de Paula, Physical Chemistry, 10th Edition, Oxford University Press, Thomson Press (India) Ltd.

4. K. L. Kapoor, A Text Book of Physical Chemistry-Thermodynamics and Chemical equilibrium, 4th Ed., Vol. 2, Macmillan Publishers India Ltd.

5. J. Gareth Morris, A Biologist's Physical Chemistry, 2nd edition, ELBS & Edward Arnold Pub. Ltd.

Module III

1. K. L. Kapoor, A Text Book of Physical Chemistry Vol. 3, 2nd Ed., Macmilan India Ltd.

2. J. N. Gurtu & A. Gurtu, Advanced Physical Chemistry, 12th Ed., A Pragati Edition.

3. Puri, Sharma, Pathania, Principles of Physical Chemistry, 41st Ed. Vishal Publishing Co.

Module IV

1. R. Narayan and B. Vishwanathan, Chemical and Electrochemical Energy Systems, Universities Press (India) Ltd. 1998.
2. John O'M. Bockris, Amulya K. N. Reddy, Modern Electrochemistry 1: Ionics, Modern Electrochemistry 2A: Fundamentals of Electrodics, 2nd Edition.

M.Sc. – I
Semester I
Physical Chemistry Practical
Course Code PSCHP101

Instrumental Experiments

1. To determine the formula of silver ammonia complex or copper-ethylene diamine complex by potentiometric method.
2. Determination of Hamett constant of m and p amino / nitro benzoic acid by pH measurement.
3. To determine the CMC of Sodium Lauryl Sulphate from measurement of conductivities at different concentrations.
4. Verification of Ostwald's dilution law and determination of the dissociation constant of a weak monobasic acid conductometrically.

Non instrumental Experiments

5. To study the three component system : Water - Acetic acid - Chloroform
6. 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.
7. To determine the chain linkage in polyvinyl alcohol from viscosity measurement.

Reference books for Practicals

1. B. Vishwanathan and P. S. Raghavan, Practical Physical Chemistry, Viva Book Private Limited, 2005.
2. A. M. James and F. E. Prichard, Practical Physical Chemistry, 3rd Ed., Longman, 1974.
3. B. P. Lewit (ed.) Findlay's Practical Physical Chemistry, 9th Ed., 1973.
4. V. D. Athwale, P. Mathur, Experimental Physical Chemistry, New Age International Publishers, 2001.

M.Sc. – I
Inorganic Chemistry
Semester I
Course Code PSCH102

Learning objectives:

- Organometallic compounds find wide use in commercial reactions, both as homogeneous catalysis and as stoichiometric reagents, synthesis of many organic molecules. Natural and contaminant organometallic compounds are found in the environment. Some that are remnants of human use, such as organolead and organomercury compounds, are toxicity hazards. Hence the study of organometallic compound is included in both sem I and sem II. The composition, properties and indeed very existence of non stoichiometric compounds can be well understood only in terms of their structures. Also knowledge of molecular symmetry and group theory is important to understand the structures of these inorganic solids hence solid state chemistry and molecular symmetry theory and group theory are included in sem I and sem II. The knowledge of inorganic cluster and polymeric compounds is also essential hence both are studied at sem I or sem II level. Apart from structure, reaction mechanism (inorganic) and bonding involved is also important hence inorganic reaction mechanism and chemical bonding are included in sem I and sem II level

Course Objectives:

CO1: The students will learn inorganic reaction mechanism
CO2: The students will learnsynthesis, structure and bonding of organometallic compounds
CO3: The students will learndifferent structures of solids
CO4: The students will learninorganic cage and cluster compounds
CO5: The students will learnpreparation of inorganic complexes and their characterization.

	Module – I	
1	**Inorganic Reaction Mechanisms**	**15L**
1.1	(a) Rate of reactions.	**03L**
	(b) Influence of acid and base on reaction rate. (c) Mixed valence complexes.	
1.2	Mechanism, derivation of the rate equations and factors affecting ligand substitution reactions of (a) Octahedral complexes without breaking of metal-ligand bond (b) Square planar complexes – trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions. (c) Tetrahedral complexes.	**07L**
1.3	Redox reactions	**03L**
	(a) Electron and atom transfer reactions (b) Inner and outer sphere mechanisms	

	(c) Marcus theory (d) Complimentary and non-complimentary reactions	
`	Isomerization and racemization reactions.	**02L**
	Module – II	
2.	**Organometallic Chemistry I**	**15L**
2.1	Organometallic compounds of transition metals: Synthesis, properties, Structure and bonding of the following organometallic compounds:	**14L**
	(a) Alkyl and Aryl derivatives (b) Carbenes and Carbynes (Fischer and Tropsch) (c) Alkene complexes (Zeise's salt) (d) Alkyne complexes (diphenylacetylene platinum (0)) (e) Allyl complexes (diallyl nickel) (f) Cyclopentadiene complexes (ferrocene) (g) Arene complexes [sandwich (dibenzene chromium (0)) and half sandwich (CpMn (CO)3, CpNi(NO), triple deckers complexes (Cp3Ni2)].	
2.2	Sixteen electron rule and electron counting with examples.	**01L**

	Module– III	
3.	**Solid state chemistry**	**15L**
3.1	Structures of Compounds of the type:	**08L**
	(a) AB [Nickel arsenide (NiAs), PbO and CuO]	
	(b) AB2 type [β-cristobalite, CaC2 and Cs2O, fluorite (CaF2) and antifluorite structures, rutile (TiO2) structure and layer structure [cadmium chloride and iodide (CdCl2, CdI2)].	**07L**
	(c) AB3 (ReO3, Li3N), A2B3 type (Cr2O3 and Bi2O3), ABO3 relation between ReO3 and pervoskite BaTiO3 and its polymorphic forms, oxide bronzes, ilmenite structure, AB2O4 type, normal, inverse, and random spinel structures.	
	Module– IV	
4	**Inorganic cage and cluster compounds**	**15L**
4.1	Introduction of cage and cluster	
	(a) Bonding in boranes (b) Wade's rule (c) STYX numbers (d) Heteroboranes (e)Carboranes (f) Cluster compounds with ligands and without ligands (Zintl ions)	**07L**

	(g) Electron precise compounds and their relation to clusters. (h) Metal-Metal bonding and Metal Clusters (i) Electron Count and Structures of Clusters		
4.2	Isolobal Analogy and Structures		**08L**
	Reference books		
	Module I		
	1	D. Banerjea, Coordination Chemistry, Tata McGraw Hill, Delhi, 1993.	
	2	F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions 2nd ed., Wiley, New York, 1967.	
	3	D. Benson, Mechanisms of Inorganic Reactions in solution, McGraw – Hill, New York, 1968.	
	4	J. O. Edwards, Inorganic Reaction Mechanisms, Benjamin, New York, 1974.	
	Module II		
	1	R. C. Mehrotra and A. Singh, Organometallic Chemistry-A Unified Approach, 2nd ed., New Age International Pvt. Ltd., 2000.	
	2	Gary O. Spessard and Gary L.Miessler, Organometallic Chemistry, Prentice-Hall,1977.	
	3	R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 5th ed., Wiley Interscience, 2009.	
	4	K. F. Purcell and J. C. Klotz, Inorganic Chemistry, Saunders, Hongkong, 1977.	
	5	B. Douglas, D. H. McDaniel and J. J. Alexander. Concepts and Models of Inorganic Chemistry, 2nd Ed., John Wiley & Sons, 1983.	
	6	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 2006	
	7	Gopalan and Ramalingam, Concise coordination chemistry 2012.	
	8	Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004	
	Module III		
	1	A. R. West, Solid State Chemistry and Its Applications, John Wiley & Sons, New York, 1987.	
	2	L. V. Azaroff, Introduction to solids, Tata McGraw Hill Book Co., New Delhi, 1977.	
	3	H. V. Keer, Principles of Solid State, Wiley Eastern Ltd., 1993.	
	4	C. N. R. Rao and G. Gopalkrishnan, New Directions in solid state chemistry, 2nd Ed., Cambridge University Press, (1997).	
	5	L. E. Smart and E.A. Moore, Solid State Chemistry An Introduction, Taylor & Francis, 3rd Ed. (2010)	
	Module IV		

	1	Gurudeep Raj, Advanced Inorganic Chemistry, Vol- II, Krishna Prakashan Media Pvt.Ltd.	
	2	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 2006	
	3	Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.	
	4	S. Pimpalpure, Rashmi Jain,UshaSoni and S.D. Dwivedi, Advanced Inorganic Chemistry, Vol- II, Pragatiprakashan.	
	5	Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd Edition.	
	6	Atkin and Shriver, Advanced Inorganic Chemistry, 6th Edition.	
	7	Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004	
	Inorganic Chemistry Practical PSCHP102 **Instrumental Methods of Analysis: Colorimetry:**		
1	Estimation of Ti using hydrogen peroxide		
2	Spectrophotometer titration of Cu(II) against EDTA		
3	Determination of formation constant by Job's variation method for Fe3+ SCN system.		
	Synthesis and characterization of the following inorganic preparations		
1	Potassium trioxalato chromate		
2	Bis (ethyelene diammine) copper(II) sulphate		
3	Hexamine nickel (II) chloride/sulphate		
4	Tris(thiourea) copper (I) sulphate		
5	O- hydroxybenzylidine copper (II) [only synthesis]		
6	$K[Cr(C_2O_4)_2(H_2O)_2]_3H_2O$		
	Reference books for practicals		
	1	A. I. Vogel, Quantitative Inorganic Analysis	
	2	J. D. Woolins, Inorganic Experiments	
	3	Palmer, Inorganic Preparations	
	4	G. Raj, Advanced Practical Inorganic Chemistry	
	5	P. C. Kamboj, University Practical Chemistry	

M.Sc. – I
Organic Chemistry
Semester I
Course Code PSCH103

	Module I	
1	**Physical Organic Chemistry and Reaction Mechanism**	**15L**
1.1	Thermodynamic and kinetic requirements of a reaction: Transition state theory, Hammond's postulate, Principle of microscopic reversibility, Kinetics vs Thermodynamic control.	**02L**
1.2	Acids and bases: Factors affecting acidity & basicity. Acid & base	**03L**

	catalysis specific & general catalysis	
1.3	Determining mechanism of a reaction: Product analysis, Kinetic studies, Stereo chemical outcome, Kinetic isotope effect –primary kinetic & secondary kinetic isotope effect.	**03L**
1.4	Organic reactive intermediates, methods of generation, structure, stability and important reactions involving carbocations, carbanions, nitrenes, carbenes, arynes and ketenes.	**03L**
1.5	Elimination Reactions (a) Types of elimination reactions. E1, E2 and E1cB mechanisms. (b) Pyrolytic elimination: Chugaev reaction, Cope reaction and Pyrolysis of acetates.	**04L**
	Module – II	
2	**Carbonyl group chemistry**	**15L**
2.1	Enolates: Structure and stability of enolates. Generation of enolates using nucleophilic and non-nucleophilic bases. Kinetic and thermodynamic control in regiochemistry of enolates, Reactions of enolates ions.	**05L**
2.2	Name reaction: Aldol, Claisen, Claisen-Schmidt condensation, Stobbe condensation, Diekmann reaction, Perkin reaction, Knoevenagel reaction, Benzoin condensation, Mannich reaction, Shapiro reaction, Michael Reaction, Robinson ring annulation, Haloform reaction, Reformatsky reaction.	**10L**
	Module– III	
3	**Stereochemistry-I**	**15L**
3.1	Symmetry operations: Rotation, reflection, inversion, rotation-reflection. Identification of the different axes and planes of symmetry.	**02L**
3.2	Molecules with tri and tetra coordinate chiral centres: Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centres and their relative configurational stabilities.	**02L**
3.3	Molecules with two or more chiral centres: Configurational nomenclature. Constitutionally unsymmetrical molecules: Erythro-threo and syn-anti systems. Constitutionally symmetrical molecules with odd and even number of chiral centres: enantiomeric and meso forms, concept of stereogenic, chirotopic and pseudo asymmetric centres.	**03L**
3.4	Axial and planar chirality: Principles of axial and planar chirality. Stereo chemical features and configurational descriptors (R, S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spiranes, biaryls (including BINOLs and BINAPs), ansa compounds and cyclophanes.	**04L**
3.5	Prochirality: Homotopic, heterotopic and diastereotopic ligands and faces. Identification using substitution and symmetry criteria.	**04L**

	Nomenclature of stereo heterotopic ligands and faces. Symbols for stereo heterotopic ligands in molecules with one or more prochiral centres, pro-pseudo asymmetric centre, chiral and prochiral centre; prochiral axis and prochiral plane. Symbols for enantiotopic and diastereotopic faces.	
	Module– IV	
4	**Oxidation – Reduction**	**15L**
4.1	Oxidation General mechanism, selectivity, stereochemistry and important applications of the following: (a) Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ). (b) Dehydrogenation/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, hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation) and Oppenauer oxidation. (c) 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 $NaIO_4$. (d) Oxidation involving replacement of hydrogen by oxygen: Oxidation of allylic CH_2 to CO by SeO_2, Oxidation of aryl methane by CrO_2Cl_2 (Etard oxidation).	**01L** **04L** **02L** **01L**
4.2	Reduction General mechanism, selectivity, stereochemistry and important applications of the following reducing: (a) Reduction of CO to CH_2 in aldehydes and ketones –Clemmensen reduction, Wolff-Kishner reduction and Huang-Minlon modification. Ra-Ni desulfurization of Thioketal (Mozingo reduction) (b) Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, $Na(OAc)_3BH$, Aluminium reagents ($LiAlH_4$, DIBALH, Red Al, L and K selectrides), MPV reduction, NH_2NH_2 (diimide reduction (c) 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.	**02L** **03L** **02L**
	References:	
	Module I	
	1 John McMurry, Organic chemistry, 8th edition.	
	2 Carruthers and Iain Coldham, Modern methods of Organic Synthesis, 4th edition W. Cambridge University Press, 2004.	

	3	Eric V Anslyn, Dennis A. Dougherty, Modern physical chemistry, University science books, 2006.	
	4	N. S. Isaacs, Physical Organic Chemistry, ELBS/Longman.	
		Module II	
	1	W. Carruthers and Iain Coldham, Modern methods of Organic Synthesis, 4thEdition Cambridge University Press 2004.	
	2	Jerry March, March's Advanced Organic Chemistry, 6th edition, 2007, John Wiley and sons.	
	3	V. K. Ahluwalia, R. K. Parashar, Organic Reaction Mechanism, 4th edition, Narosa Publication.	
	4	J. Clayden, S. Warren, N. Greeves, P. Wothers, Organic Chemistry, 1st Edition, Oxford University Press (2001).	
	5	Gautam Brahmachari, Organic Name reaction: a unified approach, Narosa publication.	
	6	Name Reactions: A Collection of detailed mechanisms and synthetic applications, Jie Jack Li, Springer-Verlag Berlin Heidelberg.	
		Module III	
	1	D, Nasipuri, Stereochemistry of Carbon Compounds: Principles and Applications, 3rd Edition, New Age International Ltd.	
	2	Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley- India.	
	3	P. S. Kalsi, Stereochemistry, 4thedition, New Age International Ltd.	
	4	M. J. T. Robinson, Organic Stereochemistry, Oxford University Press, New Delhi, India edition, 2005.	
		Module IV	
	1	Jonathan Clayden, Nick Greeves and Stuart Warren Organic Chemistry (2nd Edition).	
	2	Seyan Ege, Organic Chemistry: Structure and Reactivity , 5th Edition.	
	3	Ratan Kumar Kar, Redox and Reagents in Organic Chemistry by (Volume 1) NCBA Publication.	
	4	S.N Sanyal, Reactions, Rearrangements and Reagents.	
	5	Michael H Nantz, W. W. Freeman and Company, Modern Organic Synthesis ,1st Edition.	

M.Sc. – I
Paper III - Organic Chemistry Practical
Semester I

PSCHP103

	Chemical separation of binary mixtures:		
1	Solid /Solid mixture (including water soluble component)		
2	Solid liquid mixtures		
3	Liquid liquid mixture		
	References:		
	1	A. I. Vogel, Practical Organic Chemistry, 5th edition.	
	2	H. Middleton, Systematic Qualitative Organic Analysis.	

M.Sc. – I
Paper IV - Analytical Chemistry
Semester I
Course Code PSCH104

Summary of syllabus

Module	Topic	Common with
I	**Introduction to Analytical Chemistry**	-
II	**Chromatographic Separation Techniques**	-
III	**Introduction to spectroscopic methods**	-
IV	**Spectroscopic Technique I**	-

Learning objectives

Analytical Chemistry concerns with analysis of real samples, both qualitative and quantitative. As analytical chemist, the students must be aware of basic terminology and methodology of Analytical chemistry.

Module 1 is framed to emphasize basis of qualitative and quantitative analysis. Quality is at the core of Analytical chemistry. It is important that students must be aware of the Quality aspect and different quality systems used worldwide to establish quality standards.

Module II speaks about chromatography. It is an essential technique in chemical analysis. Different types of chromatographic techniques with instrumental details are essential for students to understand the importance of these techniques in industry.

Spectroscopy is most important branch of chemical analysis. The basic theory, general instrumental design of different types of spectroscopies is covered in module III.

UV-Visible spectroscopy is most important technique amongst different spectroscopies for quantitative analysis. It is covered in great detail in module IV. This will equip the students to use this versatile technique.

Course Objective:

CO1: To understand the basic terminology of Analytical chemistry.
CO2: Quality concept in analytical chemistry
CO3: Complete in depth understanding of different chromatographic techniques and their applications.
CO4: To understand basic general instrumentation of spectroscopic techniques.
CO5: Complete theory, instrumentation and applications of UV-Visible spectroscopic techniques for qualitative and quantitative analysis.

Module I: Introduction to Analytical Chemistry		**15 L**
1.1	**Recapitulation**: Classification of Analytical methods, An overview of analytical methods, Types of instrumental methods	2
1.2	Instruments for analysis, data domains, electric and non-electric domains, detectors, transducers, sensors, sensitivity, detection limit and dynamic range.	3
1.3	Classification of techniques: calibration curve, standard addition and internal standard methods. selection of analytical method, performance characteristics of instruments, figures of merit	3
1.4	**Quality in analytical chemistry**: quality systems in chemical laboratories, cost and benefits of a quality system, types of quality standards for laboratories	4
1.5	Total quality management, quality audits and quality reviews, responsibility	3

of laboratory staff for quality

Module II: Chromatographic Separation Techniques **15 L**

2.1	**Introduction to chromatography**, Classification of chromatographic methods, elution on column chromatography, column efficiency, Methods for describing column efficiency, analytical dilution, Plate height, effect of migration rate and zone broadening on resolution. kinetic variables affecting zone broadening, column resolution, qualitative and quantitative analysis	4
2.2	**GC Chromatography:** columns, stationary phase, detectors (coulometric, thermionic, NP detectors), temperature programming, applications	2
2.3	**HPLC:** scope of HPLC, instruments for HPLC: Mobile phase reservoirs and solvent treatment system, pumping systems, sample injection systems, LC Columns, Types of column packing, detectors: Absorbance detector, Refractive Index detector, column efficiency in LC, applications.	3
2.4	**Partition Chromatography:** Column for bonded phase chromatography, reversed and normal phase packing, column selection in partition chromatography, applications. Ion chromatography, Affinity chromatography, Super critical chromatography, application	6

Module III: Introduction to spectroscopic methods **15 L**

3.1	**Introduction to electromagnetic radiations:** general properties, wave properties, wave parameters, electromagnetic spectrum	1
3.2	**Component of optical instruments**: Source (Continuum, Line and Laser), Wavelength selectors (Filters and Monochromators), Sample containers, Radiation transducers (Photonic and Thermal), Signal processors and readouts	10
3.3	Fiber optics and fiber optics sensors	2
3.4	Fourier Transform optical instruments	2

Module IV: Spectroscopic Technique I **15 L**

4.1	**IR Spectroscopy:** Introduction, basic principle, dipole changes during vibrations and rotations, rotational transitions, vibrational transitions, types of molecular vibrations, vibrational modes, vibrational coupling and applications of IR regions.	3
4.2	**Dispersive and non-dispersive IR**: Instrumentation, working and its application FT-IR: Principle instrumentation and working, Qualitative and quantitative application	4
4.3	**UV-Visible Absorption Spectroscopy**: Introduction, basic principle, Absorbing species, absorbing species containing sigma, pi and non-bonding electrons, types of absorbing electrons, organic chromophore, effect of conjugation of chromophore, absorption by aromatic systems, solvent selection	5
4.4	**Application of UV-VIS spectroscopy**: Derivative, Simultaneous and dual wavelength spectrometry: principle, instrumentation and working, application.	3

References:

Module I, II, III and IV

1. Introduction to instrumental analysis, R. D. Braun, McGraw Hill (1987)

2. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)

3. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt-Saunders 6th Edition (1992)

4. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Edition (1998)

5. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N. Y 1997

6. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)

M.Sc. – I
Analytical Chemistry Practical
Semester I
PSCHP104

1. Determination of amount of Cr (III) and Fe (III) individually in a mixture of two by Complexometric titration
2. Solvent Extraction: (1) Fe (III) & Mg (II) and (2) Fe (III) & Ni (II)
3. Water analysis: Hardness, alkalinity, salinity, acidity
4. Anion exchanger chromatography: (1) Ni (II) & Zn (II) and (2) Co(II) & Ni(II)
5. Determination of Iodine value and Acid value of given oil sample
6. TLC and Column chromatography: separation of a mixture of ortho and para nitro-anilines.
7. Assay of Chlorambutol using precipitation titration

References:

1. Inorganic quantitative analysis by Vogel sixth edition.

2. Pharmacopeia of India

3. Biochemical methods, Sadashivam and Manichem, New age international publication

4. General Chemistry experiments by Elias, Universities Press

M.Sc. – I
Semester II
Physical Chemistry
Course Code PSCH201

Module I

1 Quantum Chemistry – I **15L**

1.1 Recapitulation: Black body radiation, photoelectric effect, wave particle duality, Heisenberg's uncertainty principle **2L**

1.2 Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions **2L**

1.3 Operators and their algebra, linear and Hermitian operators, operators for dynamic variables 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 Hamiltonian operator, average value and expectation value of a dynamic variable of system, Postulates of Quantum Mechanics, Time independent Schrödinger wave equation **4L**

1.4 Application of quantum mechanics to the following systems:

a) Free particle, wave function and energy of a free particle **1L**

b) Particle in a one, two and three-dimensional box, separation of variables, Expression for wave function of the system, expression for energy of the system, concept of quantization, introduction of quantum number, degeneracy of energy levels **3L**

c) Harmonic oscillator, approximate solution of equation, Hermite polynomials, expression for wave function, expression for energy, use of recursion formula **3L**

Module II

2 Quantum Chemistry – II **15L**

2.1 Rigid rotor, spherical coordinates, Schrodinger wave equation in spherical coordinates, separation of variables, the phi equation, the theta equation, wave function, quantization of rotational energy, spherical harmonics. Space quantization of angular momentum **6L**

2.2 Hydrogen atom, the two particle problem, separation of energy as translational and potential, separation of variables, the R, the theta and the phi equations, solution of the equations, introduction of the four quantum numbers and their interdependence on the basis of solutions of three equations, total wave function, expression for the energy, probability density function, distances and energies and atomic units, radial and angular plots., points of maximum probability, expressions for the total wavefunction for 1s, 2s, 2p and 3d orbitals of hydrogen **9L**

Module III

3 Chemical Kinetics – I **15L**

3.1 Methods of determining rate laws, Steady state approximation and its applications, Mechanism of photochemical (hydrogen-bromine and hydrogen-chlorine), chain reaction (hydrogen-bromine reaction) consecutive reactions. Inorganic mechanisms: Formation and decomposition of phosgene, decomposition of ozone. **5L**

3.2 Organic Decompositions: pyrolysis of acetaldehyde, Decomposition of ethane, Decomposition of acetaldehyde. **3L**

3.3 Gas phase reactions: Reaction between H2 and O2 , Semenov-Hinshelwood-Thompson Mechanism. Explosion Limits and factors affecting explosion limits. **2L**

3.4 Collision theory of reaction rates, collision cross-sections, rate coefficient, steric factor, Straight chain reactions. Theory of absolute reaction rates, activated complex theory, potential energy surface, thermodynamic interpretation, comparison of results with Eyring and Arrhenius equations. **2L**

3.5 Fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis, nuclear magnetic resonance method. Kinetic isotopic effect. 3L

Module IV

4 Chemical Kinetics – II **15L**

4.1 Elementary Reactions in Solution

Solvent Effects on reaction rates, Reaction between ions- influence of solvent dielectric constant, influence of ionic strength, linear free energy relationships(LEFR). Effect of substituent on reaction rates (Hammet relationship) **5L**

4.2 Enzyme Catalysis

Enzyme action, Kinetics of reactions catalysed by enzymes- Michaelis- Menten analysis, Lime weaver –Burk and Eadie analyses

Inhibition of Enzyme action: Competitive, non-competitive and uncompetitive inhibition, effect of pH, Enzyme activation by metal ions, regulatory enzymes. **5L**

4.3 Kinetics of reactions in solids

Rate laws for reactions in solid: parabolic rate law, first order rate law, contracting sphere rate law, contracting area rate law, some examples of kinetic studies. 5L

References

Module I and II

1. P. Atkins and J. de Paula, Atkins' Physical Chemistry, Oxford University Press, 8th edition, 2006.
2. I. N. Levine, Physical Chemistry, 5th edition, Tata McGraw-Hill, New Delhi, 2002.
3. D. A. McQuarrie and J.D. Simon, Physical Chemistry - a molecular approach, Viva Books Pvt. Ltd. (1998).
4. R. K. Prasad, Quantum Chemistry, 4th Revised edition, New Age Science Ltd..
5. David J. Griffiths, Introduction to Quantum Mechanics, Addison Wesley, 2nd edition (31 March 2004).

Module III and IV

1. Keith J. Leidler, Chemical Kinetics, Pearson, 2003.
2. Kenneth A Corners, The study of reaction rates in solution, VCH, 1990.
3. K. L. Kapoor, Physical Chemistry (Vol.1 & 2), Macmillan, 2001.
4. Paul Houston, Chemical Kinetics and reaction Dynamics, Dover Books on Chemistry.
5. James E. House, Principles of Chemical Kinetics, Second Edition.

M.Sc. – I
Semester II
Physical Chemistry Practical
Course Code PSCHP201

Non-instrumental Experiments

1. Determination of heat of solution of benzoic acid / Salicylic acid by solubility measurements.
2. Investigation of the reaction between acetone and iodine.

Instrumental Experiments

3. Titration of a mixture of Trichloroacetic acid, Monochloroacetic acid and Acetic acid with sodium hydroxide conductometrically.
4. Study the effect of substituents on the dissociation constant of acetic acid by conductometrically.
5. Determination of pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
6. Determination of mean ionic activity coefficient of an electrolyte by emf measurements.
7. Kinetic study of ethyl acetate by conductometric method.

Reference books for Practicals

1. B. Vishwanathan and P. S. Raghavan, Practical Physical Chemistry, Viva Book Private Limited, 2005.
2. A. M. James and F. E. Prichard, Practical Physical Chemistry, 3rd Ed., Longman, 1974.
3. B. P. Lewit (ed.), Findlay's Practical Physical Chemistry, 9th Ed. 1973.
4. V. D.Athwale, P. Mathur, Experimental Physical Chemistry, New Age International Publishers, 2001.

M.Sc. – I
Semester II
Inorganic Chemistry
Course Code – PSCH202

Learning objectives:

- Organometallic compounds find wide use in commercial reactions, both as homogeneous catalysis and as stoichiometric reagents, synthesis of many organic molecules. Natural and contaminant organometallic compounds are found in the environment. Some that are remnants of human use, such as organolead and organomercury compounds, are toxicity hazards. Hence the study of organometallic compound is included in both sem I and sem II. The composition, properties and indeed very existence of non stoichiometric compounds can be well understood only in terms of their structures. Also knowledge of molecular symmetry and group theory is important to understand the structures of these inorganic solids hence solid state chemistry and molecular symmetry theory and group theory are included in sem I and sem II. The knowledge of inorganic cluster and polymeric compounds is also essential hence both are studied at sem I or sem II level. Apart from structure, reaction mechanism (inorganic) and bonding involved is also important hence inorganic reaction mechanism and chemical bonding are included in sem I and sem II level

Course Objective:

CO1: The students will learn the nature of bonding
CO2: The students will Synthesis, structure and bonding of organometallic compounds
CO3: The students will learn and understand the concept of molecular symmetry and group theory
CO4: The students will learn about inorganic ring and chain compounds
CO5: The students will learn to analyze the compounds by different methods.

	Module – I	
1	**Chemical Bonding**	**15L**
1.1	Molecular orbital theory for cyclic molecules: generators orbitals, orbital symmetry rules for concerted reactions, molecular orbitals for Dnh complexes (BF3, BH3 and PF5).	**06L**
1.2	Molecular Orbital Theory (LCAO-MO approach) for (a) Electron deficient species (B2H6), and (b) Electron rich species (triodide ion, I3-).	**02L**
1.3	Hydrogen bonding – concept, types, properties, methods of detection and	**04L**

	importance. Van der Waal's forces, ion-dipole, dipole-dipole, London forces.	
1.4	Bent's Rule. Reactivity of molecules: e.g. chlorofluorides of phosphorous, fluoromethanes, etc.	**03L**
	Module – II	
2	Organometallic Chemistry II	**15L**
2.1	Organometallic Chemistry of f- block Elements.	**03L**
2.2	Introduction, basic concepts, oxidative addition, reductive elimination, migratory insertion, organometallic compounds as stochiometric and catalytic reagents.	**02L**
2.3	Catalysis-Homogenous and Heterogenous Catalysis: Comparison, Fundamental reactions steps, turn-over number, turn over frequency catalytic cycle.	**04L**
2.4	Organometallics as Catalysts in Organic Reaction: (a) Hydrogenation (b) Asymmetric hydrogenation (c) hydroamination (d) Monsanto process (e) hydroformylation.	**05L**
2.5	Organometallics in medicine, agriculture, and their biological and environmental aspects.	**01L**
	Module – III	
3	Molecular Symmetry and Group theory	**15L**
3.1	Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups.	**03L**
3.2	Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules.	**03L**
3.3	Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem. Construction of character tables for point groups C2v, C3v and D2h, structure of character tables, determination of symmetry species for translations and rotations; Mulliken's notations for irreducible representations, group-subgroup relationships, descent and ascent in symmetry, correlation diagrams showing relationship between different groups.	**07L**
3.4	Reduction formula, application of reduction formula to vibrational modes of water and ammonia molecule.	**02L**
	Module – IV	
4	Inorganic ring and chain compounds	**15L**
4.1	Silicates, polysilicates and aluminosilicates	**04L**
4.2	Phosphazenes, phosphazene polymers	**04L**
4.3	Polymeric sulfur nitride (SN)x, sulfur phosphide (PS)x	**02L**
4.4	Zeolites: Synthesis, characterization, determination of surface acidity, shape selectivity and applications.	**05L**
	Reference Books	
	Module I	

	1	Durrant and Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967	
	2	R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin / Cummings Publishing Company, 1989.	
	3	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993	
	4	Gary wulfsberg, Inorganic chemistry, viva books, 2010.	
	5	Gary Miessler and Donald Tarr, Inorganic Chemistry, 3rd Ed. Pearson Education, 2004	
	6	R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., Calcutta, 2001.	
	7	C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.	
	8	J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, New York, 1978.	
	9	George A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., New York, 1997.	
	Module II		
	1	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993.	
	2	Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.	
	3	R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., Calcutta, 2001.	
	4	R. C. Mehrotra, A. Singh, Organometallic Chemistry: A unified approach- 2nd Edition, New Age International Publication, 2006.	
	Module III		
	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, 1966.	
	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 Ed., New Age International Publishers, New Delhi, 2009.	
	Module IV		
	1	James Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry – Principles of Structure and Reactivity, 4th Edition, Harper Collins, 1993	
	2	Puri, Sharma and Kalia, Principles of Inorganic Chemistry – 31st Edition, Milestone Publishers, 2010.	

	3	B. E. Douglas and H. McDaniel, Concepts and models ins inorganic chemistry, 3rd Ed., John Wiley& Sons, Inc., New York, (1994).	
	4	H. J. Emeleus and A. G. Sharpe, Modern aspects of inorganic chemistry, 4th Ed., ELBS &Routledge&Kegan Paul, (1973).	
	5	A. R. West, Solid state chemistry and its chemical applications, John Wiley & Sons, (1984). Chapter- 10	
	6	Lesley E. Smart and Elaine A. Moore, Solid state chemistry – An introduction, 3rd Ed., Taylor and Francis, (2005).	
	Inorganic Chemistry Practical PS2CHP202		
	Analysis of complex Materials		
1	Devarda's Alloy: Cu by EDTA method, Al by Gravimetry using oxine.		
2	Cu-Ni Alloy: Cu by iodometric method, Ni gravimetrically by DMG method.		
3	Solder Alloy: Sn content by gravimetrically as oxide, Pb content by complexometric method.		
4	Lime stone Ore: Loss on ignition, Ca by EDTA method		
5	Haematite Ore: acid insoluble residue, Fe by Redox titration.		
	Instrumental methods of analysis:		
1	**Conductometry :** i) Estimation of chloride in NaCl/KCl using silver nitrate. ii) Estimation of boric acid using NH4OH		
2	**Potentiometry:** i) Estimation of Cu2+ using sodium thiosulphate. ii) Estimation of Fe2+ using ceric ammonium sulphate.		
	Reference books for practicals		
	1	A. I. Vogel, Quantitative Inorganic Analysis	
	2	J. D. Woolins, Inorganic Experiments	
	3	Palmer, Inorganic Preparations	
	4	G. Raj, Advanced Practical Inorganic Chemistry	

M.Sc. – I
Organic Chemistry
Semester II
Course Code PSCH203

	Module I	
1	**Reaction pathways**	**15L**
1.1	Aliphatic nucleophilic substitution: S_N1,S_N2, S_Ni, SET mechanism. Ion pair in reactions. Stereochemistry of all the above reactions. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group, ambident nucleophiles.	**04L**
1.2	Aliphatic nucleophilic substitution reactions at sp^2 (vinylic), allylic	**02L**

	carbon.	
1.3	Aromatic Electrophilic Substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagram, The ortho/para ratio, *ipso* attack, orientation in other ring system, Naphthalene, Anthracene, Diazonium coupling, Vilsmeier reaction, Gattermann – Koch reaction, etc.	**03L**
1.4	Aromatic nucleophilic substitution reaction: S_NAr, S_N1, Benzyne mechanisms. Mechanisms, Reactivity effect of substrate structure, leaving group and attacking nucleophile: *ipso*, *cine* and *tele* substitutions, vicarious nucleophilic substitution (VNS).	**03L**
	Module – II	
2	**Pericyclic Reactions**	**15L**
2.1	LCAO and MOs: π-MOs of ethylene, higher polyenes, allylic systems, their energies and symmetry properties.	**02L**
2.2	Pericyclic reactions: Classification of Pericyclic reactions; thermal and photochemical reactions. Three approaches: Frontier molecular orbital approach [FMO], Conservation of orbital symmetry - Correlation diagram and Aromatic transition state approach [Huckel and Mobius]. (a) Electrocyclic reactions: Conrotatory and disrotatary motions, 4nπ and (4n+2)π electron systems. (b) Cycloaddition reactions: (2+2) π and (4+2)π electron systems. 1, 3-Dipolar Cycloaddition and cheletropic reactions, regioselectivity, periselectivity, site selectivity and effect of substituents in Diels-Alder reactions. (c) Sigmatropic rearrangements: Supra and antarafacial migrations, H-shifts and C-shifts, retention and inversion of configurations. Ene reaction, Cope (including oxy-Cope and aza-Cope), Claisen rearrangements and fluxional tautomerism. (d) Formation of Vitamin D from 7-dehydrocholestrol, synthesis of citral using pericyclic reactions.	**02L** **03L** **04L** **03L** **01L**

	Module – III	
3	**Metals / Non-metals in organic synthesis-I**	**15L**
3.1	Organoboron compounds: Preparation and applications of organoborane reagents e.g. 9-BBN, catechol borane, Thexylborane, ICPBH2, IPC2BH in organic synthesis. Hydroboration-mechanism, stereo and regeoselectivity. Synthesis of EE, EZ, ZZ dienes and alkynes. Allylboranes synthesis, mechanism and uses. Functional group reduction by diborane.	**05L**
3.2	Organosilicons compounds: Important features of silicon governing the reactivity of C-Si compounds: preparation and important bond forming reactions of alkyl silanes, alkenylsilanes, aryl silanes and allylsilanes. β-silylcations as intermediate, Peterson olefination.	**04L**

3.3	Silylenol ethers as enolate precursors, iodotrimethylsilane in organic synthesis.	**02L**
3.4	Organomagnesium, Organolithium and Organo-copper compounds: Preparation and application.	**04L**
	Module – IV	
4	**Spectroscopy-I**	**15L**
4.1	Ultraviolet spectroscopy: Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, solvent polarity. Calculation of absorption maxima by Woodward-Fieser Rules (using Woodward-Fieser tables for values for substituents) for the following classes of organic compounds: conjugated polyenes (cyclic and acyclic), enones and substituted benzene derivatives.	**05L**
4.2	Infrared spectroscopy: Fundamental, overtone and combination bands, vibrational coupling, important group frequencies for the common functional groups, factors affecting vibrational frequencies. Principle and applications of FT-IR.	**03L**
4.3	NMR spectroscopy (a) Proton magnetic resonance spectroscopy: Chemical shift, Factors affecting chemical shift, Chemical and magnetic equivalence, Spin-spin coupling, Coupling constant J, Factors affecting J, First order spectra, Geminal and vicinal coupling (allylic and aromatic) (b) ^{13}C-NMR spectroscopy introduction: ^{13}C chemical shifts, calculation of ^{13}C-chemical shift and examples.	**04L** **01L**
4.4	Structure determination involving individual or combined use of the above spectral techniques.	**02L**

	References:		
	Module I		
	1	Carey and Sundberg, Adv. Organic Chemistry Part B 3rd edition.	
	2	H.O. House, Synthetic Organic Chemistry.	
	3	Gould E.S., Mechanism and Structure in Organic Chemistry,	
	4	Norman R.O.C. , Organic Chemistry,	
	5	J. March Advanced Organic Chemistry, 4th Edition.	
	6	J. Clayden, N.Greeveset. al , Organic Chemistry,	
		Module II	
	1	S. Sankararaman, Pericyclic Reactions Wiley VCH, 2005.	
	2	Jagdamba Singh, L. D. S. Yadav, Advanced organic chemistry, Pragati Prakashan, 2011.	
	3	Ian Fleming, Pericyclic reactions, Oxford University Press, 1999.	
	4	S. M. Mukherji, Pericyclic reactions-A mechanistic approach, Macmillan Co. of India	

		Module III	
	1	Carruthers and lain Coldham, Modern method of organic synthesis. (Cambridge)William, 4th edition.	
	2	F. A. Caray and R. J. Sundberg, Advance Organic Chemistry Part-B- Plenum Press.	
	3	R.O.C Norman and J.M. Coxon, Principles of organic synthesis. (Nelsons Thoran), 3rd edition.	
	4	V.K.Ahluwalia, Rakesh Kumar Parashar, Organic reaction mechanism. 4th edition.	
	5	P. S. Kalsi, Organic reaction structure and mechanism, 4th edition.	
	6	Clayden, Greeves, Warren and Wothers, Organic Chemistry, (Oxford).	
	7	C. Eabon, Organosilicon Compound.	
	8	H. C. Brown, Organic Synthesis via Boranes.	
	9	T. P. Onak, Organoborane Chemistry.	
	10	W. Gerrard, Organic Chemistry of Boron.	
		Module IV	
	1	Donald L. Pavia and Gary M. Lampman, Introduction to Spectroscopy: A Guide for Students of Organic Chemistry.	
	2	Silversteine and Basser, Spectrometric Identification of Organic Compounds.	
	3	P. S. Kalsi, Spectroscopy of Organic compounds.	
	4	J. Bellamy, Infrared spectra of Complex molecules.	
	5	I Fleming, Organic Spectroscopy.	

M.Sc. – I
Organic Chemistry Practical
Semester II
PSCHP203

	Organic Preparations		
1	Anthracene to Anthraquinone		
2	Benzoin to Benzil		
3	Bromobenzene to p-nitrobromobenzene		
4	Anthracene to Anthracene-Maleic anhydride adduct		
5	5,5-Diphenylhydantion from urea and benzyl		
6	4-Benzyllidene -2-Phenyl oxazol-5-one from hippuric acid and acetic anhydride		
7	Resorcinol to 7-hydroxy-4-methyl coumarin		
8	2-naphthol to 1,1′-Bis-2-naphthol		
	References,		
	1	A. I. Vogel, Quantitative Organic Analysis	

	2	H. Middleton, Systematic qualitative Organic Analysis	

M.Sc. – I
Analytical Chemistry
Semester II
PSCH204

Summary of syllabus

Module	Topic	Common with
I	**Electroanalytical technique**	-
II	**Capillary electrophoresis Techniques**	-
III	**Separation Techniques II**	-
IV	**Spectroscopic technique II**	-

Learning objectives:

In semester II, module I covers applied electro analytical techniques. These techniques are widely used for specific estimations in industry, environmental sciences and research.

Module II covers electrophoresis techniques. These are widely used for analysis of biological and clinical samples. Students must be aware of different types of electrophoretic methods with specific applications in bio analysis. Separation is an essential step in analysis.

Module III discusses basic and applied separation techniques which are routinely used for the separation of desired analyte from complex matrix.

Module IV deals with two most important techniques used by analytical and organic chemist for structural elucidation i.e. NMR and mass spectroscopy. It is utmost important for students to know basic principles, detail instrumentation, working methodology and applications of these spectroscopic techniques.

Course Objectives:

CO1: Applied Electroanalytical techniques like ion selective electrodes, electro gravimetry and chronopotentiometry.

CO2: To understand the theory and operating principles of different electrophoresis techniques.

CO3: Complete in depth understanding of solvent extraction and its applications.

CO4: To understand use of other latest separation techniques like super critical extraction and allied techniques

CO5: Complete theory, instrumentation and applications of NMR and mass spectroscopic techniques for qualitative and quantitative analysis.

Module I: Electroanalytical technique **15 L**

1.1	**Ion Selective Electrodes**: Classification, properties, types: solid state/precipitation electrodes, glass electrode, fluoride electrode, liquid membrane electrodes, gas sensing probes and Bio-catalytic membrane / enzyme electrodes.	6
1.2	**Electrogravimetry**: Principle, instrumentation, factors affecting deposit, applications.	2
1.3	Chronopotentiometry and chronoamperometry	3
1.4	**Coulometry**: Principle, instrumentation, coulometry: at controlled potential and controlled current, applications.	4

Module II: Capillary electrophoresis Techniques **15 L**

2.1	Introduction to capillary electrophoresis (CE), basic theory, instrumentation, working, detection system, factor affecting separation and resolution, application	4
2.2	Theory, instrumentation and applications of- Capillary electrochromatography electrophoresis (CECE), Miceller electro kinetic capillary chromatography (MECKE).	4
2.3	Capillary gel electrophoresis (CGE) and sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE): principle, instrumentation, working, application.	4

2.4	Introduction to Capillary Isotachophoresis electrophoresis (CITPE), Capillary isoelectric focusing electrophoresis (CIEFE), applications	3

Module III: Separation Techniques II **15 L**

3.1	**Solvent extraction:** Recapitulation, factors affecting the solvent extraction of inorganic species, separation of metal ions as chelates, concept of $[pH]_{1/2}$ and its significance, ion association, solvation with suitable examples	7
3.2	**Super critical fluid extraction:** Basic principles, working and application	2
3.3	**Supramolecules in extraction:** Crown ethers, cryptands, dextrin	2
3.4	**HPTLC:** Basic recapitulation of TLC, Advancement in TLC, Instrumentation, working principle and applications. Comparison between HPTLC and HPLC	4

Module IV: Spectroscopic technique II **15 L**

4.1	**Nuclear Magnetic Resonance (NMR)**: Quantum description of NMR, precession of nuclei in a field relaxation process, spin lattice relaxation, spin-spin relaxation, origin of chemical shift, spin-spin splitting, proton decoupling, theory of chemical shift, Abscissa scales for NMR spectra, effect of magnetic anisotropy, correlation of chemical shift with structure, interpretation of first order and second order spectra, effect of chemical exchange on spectra.	4
4.2	**NMR spectrometers:** Instrumentation, working, applications of ^{1}H NMR, ^{13}C NMR, ^{31}P NMR, ^{19}F NMR.	3
4.3	**Mass Spectrometry**: Introduction, ion source, electron impact source, electron impact spectra, isotope peaks, collision product peaks, advantage and disadvantage of electron impact source, chemical ionisation source and spectra, field ionisation source and spectra, field desorption sources, MALDI, electrospray ionisation.	5
4.4	**Mass spectrometer:** sample inlet system, mass analysers, magnetic sector analyser, time of flight, quadruple, ion trap, double focussing spectrometer, application in organic and inorganic chemistry	3

References:

Module I, II, III and IV

1. Introduction to instrumental analysis, R. D. Braun, McGraw Hill (1987)

2. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)

3. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt-Saunders 6th Edition (1992)

4. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Edition (1998)

5. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N. Y 1997.

6. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)

M.Sc. – I
Analytical Chemistry Practical
Semester II
PSCHP204

1. Determination of glucose by Folin-Wu method

2. Determination of Fe (III) in the given solution by colorimetric method.

3. To determine the amount of Cr (VI) and Mn (VII) in a sample by simultaneous Spectrophotometry/determination of Cu(II) and Bi(II) simultaneously by photometric titration.

4. To determine the amount of sodium benzoate using perchloric acid (HClO4) in glacial acetic acid by Potentiometry using glass-calomel system

5. To determine weight percentage of HCl and H2SO4 in a mixture of the two conductometrically

6. Estimation of soil sample by flame photometer for (1) Na+ and (2) K+ ion

7. To determine the amount of iodide, bromide and chloride in the given mixture by potentiometric titration using silver nitrate.

References:

1. Inorganic quantitative analysis by Vogel sixth edition.

2. Pharmacopeia of India

3. Biochemical methods, Sadashivam and Manichem, New age international publication