



**Hindi Vidya Prachar Samiti's**  
**Ramniranjan Jhunjhunwala College**  
**of Arts, Science & Commerce**  
**(Autonomous College)**

**Affiliated to**  
**UNIVERSITY OF MUMBAI**

**Syllabus for the M.Sc. Part – II**

**Program: M.Sc. (Physical Chemistry)**

**Program Code: RJSPGCHEP**

**CBCS: 2020 -2021**

**M.Sc. (Physical Chemistry) Semester – III**

<b>Course</b>	<b>Nomenclature</b>	<b>Credits</b>	<b>Topics</b>
RJSPGCHEP301	Polymer, Surface & Photo Chemistry	4	Polymer Chemistry-I Modern Applications of Surface Chemistry. Photo Chemistry-I Applications of Fluorescence Phenomena.
RJSPGCHEP302	Nanochemistry, Statistical Mechanics & Nuclear Chemistry	4	Nanochemistry of gold, cadmium, selenide. Nano chemistry of silica and polydimethylsiloxane. Statistical Mechanics. Thermodynamic probability. Partition functions. Nuclear Chemistry
RJSPGCHEP303	Atomic & Molecular: Structure and Spectroscopy	4	Atomic structure. Atomic spectroscopy Molecular Structure. Molecular spectroscopy. Rotational Spectroscopy. Raman Spectroscopy. Electronic Spectra of molecules
RJSPGCHEP304	Advanced Instrumental Techniques	4	Spectral Methods Electro-analytical Methods – I Principles, instrumentation and applications. Radio-Analytical Methods Pulse Polarography
RJSPGCHEPRP301	Polymer, Surface & Photo Chemistry Practical	8	Polymer, Surface & Photo Chemistry Practical
RJSPGCHEPRP302	Nanochemistry, Statistical Mechanics &		Nanochemistry, Statistical Mechanics & Nuclear Chemistry Practical

RJSPGCHEPRP303	Nuclear Chemistry Practical  Atomic & And Molecular: Structure and Spectroscopy Practical		Atomic & And Molecular: Structure And Spectroscopy Practical
RJSPGCHEPRP304	Advanced Instrumental Techniques Practical		Advanced Instrumental Techniques Practical

**Detailed syllabus of M.Sc. (Physical Chemistry) Semester – III Paper – I**

Course Code	Topic	Credits
RJSPGCHEP301	<b>Polymer, Surface &amp; Photo Chemistry</b>	4
<b>UNIT- I: Polymer Chemistry</b> <b>1.1 Introduction:</b> Polymer Science, fundamental terms, historical outline, classification based on: the origin (natural, semi-synthetic, synthetic etc.), the structure (linear, branched, network, hyper branched, dendrimer, ladder, cross linked, IPN), the type of atom in the main chain (homo chain, hetero chain), the formation (condensation, addition), homopolymers, copolymers (random, alternate, block, graft), the behavior on application of heat (thermoplastic and thermosetting), the form and application (plastics, fibre, elastomer, sand, resins). <b>1.2 Molar Mass:</b> Molecular weight averages, fractionation, molecular weight determination by GPC/SEC, end group analysis, viscometry, vapour phase osmometry, gradient elution, and molecular weight distribution curve.  <b>1.3 Types of polymerization:</b> condensation, addition (cationic and anionic) and copolymerization (with kinetics), chain transfer reactions.		1
<b>UNIT-II Modern Applications of Surface Chemistry</b> <b>2.1 Surface active agents and micelle:</b>		1

<p><b>2.1.1 Surface active agents</b> and their classification, hydrophile-lipophile balance</p> <p><b>2.2 Micellization:</b> shape and structure of micelles, hydrophobic interaction, critical micelles concentration (CMC), factors affecting CMC of surfactants, counter ion binding to micelles, micelle catalysis, reverse micelles.</p> <p><b>2.1.3 Emulsions:</b> Solubilization, micro emulsions, characterization of micro emulsions,</p> <p><b>2.2. Hydrogen Storage by Adsorption:</b></p> <p><b>2.2.1 Hydrogen storage:</b> Fundamentals of physisorption, temperature and pressure influence, chemisorption, adsorption energy, electrochemical adsorption.</p> <p><b>2.2.2. Practical adsorption:</b> Storage of hydrogen with carbon materials, activated carbon, graphite graphene, carbon nanostructures, fullerene. Carbon nanofibers(CNF) and graphite nanofibers, electrochemical storage of hydrogen in carbon materials.</p>	
<p><b>UNIT-III Photo Chemistry-I</b></p> <p><b>3.1 Photochemical principles:</b> Environmental effect on absorption and emission spectra, properties of excited states, excited state acidity constants, dipole moments and redox properties, Importance of photochemistry, origin of life.</p> <p><b>3.2 Photo physical processes in electronically excited molecules:</b> Types of photo physical pathways, types of radiation less transitions, fluorescence emission, fluorescence and structure. Triplet state and phosphorescence emission, delayed fluorescence, E-type and P-type delayed fluorescence.</p> <p><b>3.3 Photochemical reactions:</b> ketones, olefins conjugated olefins and aromatic compounds, photosynthesis.</p>	1
<p><b>UNIT-IV Applications of Fluorescence Phenomena</b></p> <p><b>4.1 Fluorescence sensing:</b> Mechanism of sensing; sensing techniques based on coalitional quenching, energy transfer, electron transfer; examples of pH sensors, glucose sensors and protein sensors.</p> <p><b>4.2 Novel fluorophores:</b> Quantum dots, lanthanides and long-lifetime</p>	1

metal-ligand complexes.

**4.3 Radiative decay engineering:** metal enhanced fluorescence  
**DNA technology**–sequencing.

M.Sc.	Semester III Theory
<b>RJSPGCHEP301</b> <b>Paper I</b> <b>Polymer,</b> <b>Surface &amp;</b> <b>Photo</b> <b>Chemistry</b>	<p><b>Course Outcome</b></p> <ol style="list-style-type: none"> <li>1. To evaluate molar mass of polymers by different methods like end group analysis, viscometry, vapour phase osmometry and molecular weight distribution curve.</li> <li>2. To understand the properties and importance of surface-active agents, micelles and emulsion and to learn the applications of surface chemistry for the storage of graphene, fullerenes and nanomaterials.</li> <li>3. To learn the principles of photo physical processes in electronically excited molecules and mechanism of their relaxation by fluorescence and phosphorescence.</li> <li>4. To understand application of photochemical reactions in organic systems (conjugated olefins and aromatic compounds).</li> </ol> <p><b>Learning outcomes:</b></p> <p>After completing this course students will be able to:</p> <ol style="list-style-type: none"> <li>1. Understand types of polymers based on structure, origin, formation, behaviour and application.</li> <li>2. Evaluate different types of molar mass of polymers.</li> <li>3. understand mechanisms and kinetics of different types of polymerizations.</li> <li>4. learn about surface active agents, hydrophilic/hydrophobic balance micellization, emulsification and factors affecting these processes.</li> <li>5. learn about hydrogen storage and different absorbing carbon materials.</li> <li>6. understand principles and the importance of photochemistry.</li> <li>7. learn about photophysical processes in electronically excited molecules.</li> <li>8. understand the mechanism of photochemical reactions and photosynthesis.</li> <li>9. Learn different mechanisms of fluorescence sensing.</li> <li>10. Understand the new and effective fluorophores.</li> <li>11. Understand the utility of special metal enhanced fluorescence in Radioactive decay techniques.</li> <li>12. Learn the role of fluorophores in determining the nucleic acid sequence.</li> </ol>

### Reference Books: Unit I

1. P. Bahadur and N. V. Sastry, Principles of Polymer Science, second edition, Narosa Publishing House, 2005.
2. C. E. Carraher, Jr., Carraher's Polymer Chemistry, 8<sup>th</sup> edition, CRC Press, New York, 2010.
3. Joel R. Fried, Polymer Science and Technology, Prentice-Hall of India Pvt. Ltd., 2000.
4. V.R. Gowarikar, H.V. Viswanathan and J. Sreedhar, Polymer Science. New Age International Pvt. Ltd., New Delhi, 1990.
5. F. W. Billmeyer Jr., Text Book of Polymer Science, 3<sup>rd</sup> edition, John Wiley and Sons, 1984.
6. V.K. Ahluwalia & A. Mishra, Polymer Science, A text book, Ane-Books Pvt. Ltd, 2008.
7. R. Sinha, Outline of Polymer Technology manufacture of Polymers, Prentice hall of India Pvt. Ltd. 2000
8. F.J. Davis, Polymer Chemistry, Oxford University Press, 2000.
9. D. Walton & P. Lotimer, Polymer, Oxford University Press, 2000.
10. R. Ypung, Introduction to Polymers, Chapman & Hall, reprint, 1989. 11. V. Jain. Organic Polymer Chemistry, I V Y Publishing House, 2003.
11. A. Singh, Polymer Chemistry, Campus Book International, 2003.

### Reference Books: Unit II

1. M. J. Rosen. Surfactants and Interfacial Phenomena (3<sup>rd</sup> edn.), John Wiley (2004).
2. Y. Moroi, Micelles: Theoretical and Applied Aspects, (1992) Plenum Press, New York
3. Arun K. Chattopadhyay, Kashmiri Lal Mittal, Surfactants in Solution, Volume 64 of Surfactant Science Series, Volume 64 of Lecture Notes in Pure and Applied Mathematics, illustrated, Marcel Dekker, 1996
4. K.L. Mittal, American Chemical Society, Micellization, solubilization, and microemulsions, Volume 1
5. Micellization, Solubilization, and Microemulsions, American Chemical Society, illustrated, Plenum Press, 1977
6. Deepak Thassu, Michel Deleers, Yashwant Pathak, Nanoparticle Drug Delivery Systems Volume 166 of Drugs and the Pharmaceutical Sciences Series illustrated, CRC Press, 2007
7. Tushar K. Ghosh, Energy Resources and Systems: Volume 2: Renewable Resources, Volume 2 of Energy Resources and Systems, Energy Resources and Systems, Springer Link: Bücher, Springer, 2011
8. R. Ströbel a, J. Garche b, P.T. Moseley c, L. Jörissen b, G. Wolf d. "Review Hydrogen storage by carbon materials." Journal of Power Sources (WWW.Sciencedirect.com) 159 (June 2006): 781–801.
9. Agata Godula-Jopek, Walter Jehle, Joerg Wellnitz, Hydrogen Storage Technologies: New Materials, Transport, and Infrastructure, John Wiley & Sons, 2012
10. Yury Gogotsi, Carbon Nanomaterials, illustrated Volume 1 of Advanced Materials Series, Advanced Materials and Technologies Series, CRC Press, 2006
11. Robert A. Varin, Tomasz Czujko, Zbigniew S. Wronski, Nanomaterials for Solid State Hydrogen Storage Fuel Cells and Hydrogen Energy illustrated Springer, 2009

**Reference Books : Unit III**

- 1 C.H.DePuy,O.L.Chapman,Molecular reactions and photochemistry, Prentice hall Of India PVT. LTD.1988.
- K.K.Rohatgi-Mukherjee. Fundamentals of Photochemistry. Reprint 2002. NewAge International Publisher,1978.

**Reference Books : Unit IV**

1. B. Valeur, Molecular Fluorescence: Principles and Applications, Wiley-VCH (2001).
2. J.R.Lakowicz,Principles of Fluorescence Spectroscopy,Springer(2006). Reference Book.
3. D.L.Andrews & A.A.Demidov,Resonance Energy Transfer, John Wiley & Sons (1999).

**Detailed syllabus of M.Sc. (Physical Chemistry) Semester – III Paper – II**

Course Code	Topic	Credits
RJSPGCHEP302	<b>Nanochemistry, Statistical Mechanics &amp; Nuclear Chemistry</b>	4
<b>UNIT-I: Nanochemistry of gold and cadmium selenide (CdSe).</b> <b>1.1</b> Variation of optical and magnetic properties of nanomaterial with size, shape, surface characteristics and impurities. <b>1.2</b> Relationship between size and shape of nanomaterials. <b>1.3</b> Nano architecture: self-assembly and template methods. <b>1.4</b> Diagnosis and treatment of diseases using nanoparticles. <b>1.5</b> Safety and ethics of use of nanoparticles		1
<b>UNIT-II Nano chemistry of silica and polydimethylsiloxane:</b> <b>2.1</b> Variation of optical and magnetic properties of nanomaterials with size, shape, surface characteristics and impurities <b>2.2</b> Relationship between size and shape of nanomaterials. <b>2.3</b> Nano architecture: self-assembly and template methods. <b>2.4</b> Diagnosis and treatment of diseases using nanoparticles		1
<b>Unit- III Statistical Mechanics</b> <b>3.1 Thermodynamic probability:</b> Combinatorial problems, Stirling's approximation, Lagrange's method, macro and microstates, ensembles, Boltzmann distribution law.		1

<p><b>3.2 Partition functions:</b> Translational, rotational, vibrational, electronic and nuclear partition functions, Expressions for thermodynamic functions in terms of partition function. Internal energy, heat capacity, the Helmholtz and Gibbs functions, enthalpy, entropy and equilibrium constants. Sackur-Tetrode equation for the entropy of a mono atomic gas. Molecular partition function.</p> <p><b>3.3</b> Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.</p> <p><b>3.4</b> Debye and Einstein theory of specific heat of solids.</p>	
<p><b>UNIT—IV Nuclear Chemistry</b></p> <p><b>4.1 Charged particle accelerators:</b> linear accelerator, cyclotron, betatron, Synchro-cyclotron, synchrotron.</p> <p><b>4.2 Nuclear forces:</b> characteristics and Meson field theory of nuclear forces.</p> <p><b>4.3 Nuclear Models:</b> Liquid drop model, Fermi Gas Model, Shell Model, Collective Model, Optical Model.</p> <p><b>4.4 Applications of Nuclear radiations:</b> Geological applications of radioactivity, age of minerals and rocks, age of earth and solar system, medical, industrial and agricultural applications of radiochemistry, positron emission tomography (PET) and radioimmunoassay (RIA).</p>	1

M.Sc.	Semester III Theory
<p>RJSPGCHEP302 Paper II Nanochemistry, statistical mechanics &amp; Nuclear chemistry</p>	<p><b>Course Outcome</b></p> <ol style="list-style-type: none"> <li>1. To introduce the nanochemistry of gold and cadmium selenide and to understand optical and magnetic properties of nano material and how it varies with the shape, size and surface of nano particles.</li> <li>2. To aware the learners about the diagnosis and treatment of diseases using nano particles.</li> <li>3. To learn the concept of distribution and thermodynamic probability and to evaluate most probable distribution state for all type of statics i.e. for Maxwell- Boltzmann, Fermi-Dirac and Bose-Einstein statistics.</li> <li>4. To understand the concept of partition function, its physical significance and calculation of molar and atomic partition function</li> </ol>

	<p>5. To determine the age of minerals, rocks, earth and solar system employing the nuclear chemistry and to discuss the application of radiochemistry in medical, industrial and agricultural field.</p> <p><b>Learning outcomes:</b></p> <p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1) learn nanochemistry of gold, cadmium selenide and to understand optical and magnetic properties of nano material and how it varies with the shape, size and surface of nanoparticles.</li> <li>2) learn about the diagnosis and treatment of diseases using nanoparticles of gold, cadmium and selenide.</li> <li>3) learn about Safety and ethics of use of nanoparticles of gold, cadmium and selenide.</li> <li>4) learn nanochemistry of silica and polydimethylsiloxane nanoparticles.</li> <li>5) learn about the diagnosis and treatment of diseases using nanoparticles of silica and polydimethylsiloxane nanoparticles.</li> <li>6) learn about Safety and ethics of use of nanoparticles of silica and polydimethylsiloxane nanoparticles.</li> <li>7) To learn the concept of distribution and thermodynamic probability and to evaluate most probable distribution state for all type of statics i.e. for Maxwell- Boltzmann, Fermi-Dirac and Bose –Einstein statistics.</li> <li>8) To understand the concept of partition function, its physical significance and calculation of molar and atomic partition function</li> <li>9) understand different types of forces and models responsible for nuclear stability.</li> <li>10) To determine the age of minerals, rocks, earth and solar system employing the nuclear chemistry and to discuss the application of radiochemistry in medical, industrial and agricultural field.</li> </ol>
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### Reference Books: Unit II

1. Ludovico Cademartiri and Geoffrey A.Ozin, Concepts of Nanochemistry, Wiley–VCH Verlag GmbH & co, 2009
2. C.Br  chignac, P.Houdy, Marcel Lahmani, Nanomaterials and Nanochemistry, Springer, 2007
3. C.N.R.Rao, Achim M  ller, Anthony K.Cheetham, Nanomaterials Chemistry, John Wiley & Sons, 2007
4. Geoffrey A. Ozin, Andr   C. Arsenault, Ludovico Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry (Great Britain) 2, illustrated, Royal Society of Chemistry, 2009g

**Reference Books: Unit III**

1. Atkins P.W, Physical Chemistry, Oxford University Press, 6th edition, 1998
2. John M. Seddon & Julian D. Gale, Thermodynamics and statistical mechanics, Tutorial Chemistry Text series, Vol. 10, Royal Society of Chemistry, 2001.
3. Silbey R.J. & Alberty R.A., Physical Chemistry, 3<sup>rd</sup> edition, John Wiley and sons, Inc. 2002.
4. Laidler K.J. and Meiser J.H., Physical Chemistry, 2<sup>nd</sup> edition, CBS publishers & distributors, 1999.
5. B.K. Agarwal and M. Eisner, Statistical Mechanics, (1988) Wiley Eastern, New Delhi.
6. D.A. McQuarrie, Statistical mechanics, (1976) Harper and Row Publishers, New York.

**Reference Books: Unit IV**

1. G. Friedlander, J.W. Kennedy, Nuclear and Radiochemistry. Third. John Wiley and sons, 1981.
2. H.J. Arnikaar, Essentials of Nuclear Chemistry. second. Wiley Eastern Ltd., 1989.

**Detailed syllabus of M.Sc. (Physical Chemistry) Semester – III Paper – III**

Course Code	Topic	Credits
RJSPGCHEP303	<b>Atomic and Molecular: Structure and Spectroscopy</b>	4
<b>UNIT I: Atomic structure</b> <b>1.1</b> Introduction to approximate methods in Quantum Mechanics- <b>1.1.1</b> Variation Theorem, linear and nonlinear variation functions. <b>1.1.2</b> Perturbation Theory, non-degenerate perturbation theory, first order wave function correction, first order and second order energy correction. <b>1.1.3</b> Application of variation and perturbation theory to ground state of Helium Atom. <b>1.2 Multi-electron atoms:</b> Antisymmetry and Pauli's exclusion principle, Slater determinants, Hartree-Fock and configuration interaction wave functions, Slater type orbitals, Gaussian orbitals, orbitals plots, Basis sets. Density functional theory.		1
<b>UNIT-II Atomic spectroscopy</b> <b>2.1</b> Angular momentum, orbital and spin, total angular momentum, total angular momentum(J) of many electron atoms, Russell-Saunders (L-S) coupling and J-J coupling. <b>2.2</b> Term symbols, term symbols for multi electron atoms like He, Li, Be, B etc.		1

<p><b>2.3</b> Exchange of interactions and multiplicity of states.</p> <p><b>2.4</b> Anomalous Zeeman Effect and Paschen-Back effect.</p> <p><b>2.5</b> Atomic spectra and selection rules, energy level diagram of atomic sodium.</p>	
<p><b>UNIT-III: Molecular Structure</b></p> <p><b>3.1</b> The Born–Oppenheimer approximation.</p> <p><b>3.2</b> LCAO method-molecular orbital formation.</p> <p><b>3.3</b> Calculation of energy of hydrogen molecule ion using:</p> <p>    <b>3.3.1</b> Valence bond method</p> <p>    <b>3.3.2</b> Heitler-London treatment</p> <p>    <b>3.3.3</b> Improvements in Heitler-London treatment</p> <p><b>3.4</b> Electronic structure of polyatomic molecules</p> <p>    <b>3.4.1</b> Valence bond method for BeH<sub>2</sub>, H<sub>2</sub>O, NH<sub>3</sub>, BH<sub>3</sub>, CH<sub>4</sub></p> <p>    <b>3.4.2</b> Huckel's molecular orbital theory for ethylene, allyl system, cyclopropenyl system and cyclobutadiene.</p>	1
<p><b>UNIT-IV: Molecular spectroscopy</b></p> <p><b>4.1 Rotational Spectroscopy:</b> Einstein coefficients, classification of polyatomic molecules, spherical top, symmetric top and asymmetric top molecules, rotational spectra of polyatomic molecules, Stark modulated microwave spectrometer.</p> <p><b>Raman Spectroscopy</b>-Classical theory of molecular polarizability, pure rotational, vibrational and vibration-rotation spectra of diatomic and polyatomic molecules, polarization and depolarization of Raman lines, correlation between IR and Raman spectroscopy instrumentation.</p> <p><b>Electronic Spectra of molecules:</b> Term symbols for line and molecules, selection rules, characteristics of electronic transitions, Franck-Condon principle, types of electronic transitions, d-d, vibronic, charge transfer, <math>\pi-\pi^*</math>, <math>n-\pi^*</math> transitions, fate of electronically excited states, fluorescence, phosphorescence, dissociation and pre-dissociation</p>	1

M.Sc.	Semester III Theory
RJSPGCHEP303 Paper III Atomic and Molecular: Structure and Spectroscopy	<p><b>Course Outcome</b></p> <ol style="list-style-type: none"> <li>1) To discuss the variation and perturbation theory and its application to Helium atom. To introduce term symbol for multi electron atoms, exchange of interactions and multiplicity of states.</li> <li>2) To evaluate hydrogen molecule using valence bond method.</li> <li>3) To apply molecular spectroscopy on spherical top, symmetrical top and asymmetrical top molecules.</li> </ol> <p><b>Learning outcomes:</b></p> <p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1) learn variation and perturbation theory and its application to Helium atom.</li> <li>2) learn term symbol for multi electron atoms, exchange of interactions and multiplicity of states.</li> <li>3) understand angular momentum, Russell Saunders(L-S) coupling and J-J coupling</li> <li>4) evaluate term symbols of multi electron atoms like He, Li, Be, B etc.</li> <li>5) understand approximations and methods for molecular orbital formation.</li> <li>6) evaluate hydrogen molecules energy using valence bond method and Heitler-London treatment.</li> <li>7) determine electronic structure of polyatomic molecules using valence bond method and Hückel molecular orbital theory.</li> <li>8) learn classification of polyatomic molecules of different symmetric molecules.</li> <li>9) understand selection rules characteristics of electronic transitions- Franck-Condon principle, types of electronic transitions-d-d, vibronic, charge transfer, <math>\pi-\pi^*</math>, <math>n-\pi^*</math> transitions.</li> </ol>

**Reference Books:**

1. C.N.Banwell and E.M.Mc Cash, Fundamentals of Molecular Spectroscopy, 4<sup>th</sup> Ed., Tata-McGraw-Hill, 1994.
2. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, 2001.
3. H.S.Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd., 2003

4. G.Aruldas, Molecular Structure and Spectroscopy, Prentice-Hall of India, 2001.
5. J. Michael Hollas, Modern Spectroscopy, 4th Ed., John Wiley and Sons, 2004.
6. Laidler and Miser, Physical Chemistry, 2<sup>nd</sup> edition, CBS publishers, New Delhi. (chapters 11-14)
7. Silbey and Alberty, Physical Chemistry, 3<sup>rd</sup> edition, John Wiley and sons, 2000. (Part two quantum chemistry)
8. Atkins P.W, Physical Chemistry, Oxford University Press, 6<sup>th</sup> edition, 1998.
9. William Kemp, Organic spectroscopy, 3<sup>rd</sup> Edition, ELBS, 1996.
10. R. K. Prasad, Quantum Chemistry, 3<sup>rd</sup> Ed., New Age International Publishers, 2006.
11. James E. House, Fundamentals of Quantum Chemistry, Second Ed., Academic Press, 2005.
12. T.A. Little field and N. Thorley, Atomic and Nuclear Physics- In Introduction, Van Nostrand, 1979.

### **Detailed syllabus of M.Sc. (Physical Chemistry) Semester – III Paper – IV**

Course Code	Topic	Credits
RJSPGCHEP304	<b>Advanced Instrumental Techniques</b>	4
<b>UNIT-I Spectral Methods</b> Principle, instrumentation and applications of the following: <b>1.1</b> Reflectance spectroscopy. <b>1.2</b> Photo-acoustic spectroscopy <b>1.3</b> Polarimetry: Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD) spectroscopy. <b>1.4</b> Chemiluminescence method. <b>1.5</b> Nuclear Quadrupole Resonance (NQR) spectroscopy, Electron Nuclear Double Resonance (ENDOR), Electron-Electron Double Resonance (ELDOR) spectroscopy.		1
<b>UNIT-II Electroanalytical Methods – I</b> <b>Principles, instrumentation and applications</b> <b>2.1</b> Ion selective field effect transistors, bio-catalytic membrane electrodes, disposable multi-Layer ion selective systems, screen-printed electrodes. <b>2.2</b> Chronopotentiometry and chronoamperometry. <b>2.3</b> Fused salt electrolysis.		1

<b>UNIT-III Radio-Analytical Methods</b> <b>3.1 Activation analysis-</b> basic principles, fast neutron activation analysis, radio-chemical method, inactivation analysis. <b>3.2</b> Isotopic dilution method-principle and applications. <b>3.3</b> Auto, x-ray and gamma radiography. <b>3.4</b> Radiometric titrations. <b>3.5</b> Applications of radio-analytical techniques.	1
<b>UNIT-IV Pulse Polarography:</b> <b>4.1</b> Normal pulse polarography(NPP), Differential pulse polarography(DPP), Double differential pulse polarography (DDPP). <b>4.2</b> Sinusoidal AC polarography, square wave polarography. <b>4.3</b> Applications of electrochemical methods in Organic synthesis.	1

M.Sc.	Semester III Theory
RJSPGCHEP304 Paper IV Advanced Instrumental Techniques	<b>Course Outcome</b> <ol style="list-style-type: none"> <li>To understand the principles, instrumentation and applications of different types of spectroscopies and polarography.</li> <li>To expose the learner to the basic concepts of electroanalytical methods, radioanalytical and pulse polarography methods.</li> <li>To study the application, methods and techniques of the electroanalytical methods, radioanalytical and pulse polarography methods.</li> </ol> <b>Learning outcomes:</b> <i>After completing this course students will be able to:</i> <ol style="list-style-type: none"> <li>Apply principles of spectroscopy, and polarography on different polar and nonpolar molecules.</li> <li>Understand the terms involved in electroanalytical methods.</li> <li>Understand the principles of Chronopotentiometry and chronoamperometry.</li> <li>Learn radiometric titrations, Isotopic dilution method and x-ray and gamma radiography.</li> <li>Understand applications of electrochemical methods in Organic synthesis.</li> </ol>

### **Reference Books: Unit II**

1. A.J.Bard and L.R.Faulkner, Electrochemical Methods, 2<sup>nd</sup> Ed, John Wiley and sons, Asia Pvt. Ltd, (2004).
2. J.J.Lingane, Electro-analytical Chemistry, 2<sup>nd</sup> Ed, Inter science Publishers, Inc., New York (1958)
3. A.M.Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., New York, (1980)
4. A.J.Bard (Ed), Electro-analytical Chemistry, Marcel Dekker Inc., New York ( A series of volumes).
5. Donald T.Sawyer, A.Sobkowiak and, J.L.Roberts, Jr., Electrochemistry for Chemists, 2<sup>nd</sup> Ed., John Wiley and Sons, Inc., New York., (1995).
6. D.A.Skoog, F.J.Holler, J.A.Nieman, Principles of Instrumental analysis, 6<sup>th</sup> Ed.
7. R.D.Braun, introduction to Instrumental Analysis, MacGraw hill, 1987.
8. H.A. Willard, L.L.Merritt, J.A.Dean & F.A.Settle, Instrumental methods of analysis, 5<sup>th</sup> Ed. CBS, 1986.
9. M.noel, K.J.Vasu, Cyclic Voltammetry and Frontiers of electrochemistry, IBH, New Delhi, 1990.
10. P.T.Kissinger, W.R.heinman, Laboratory Techniques in electroanalytical Chemistry, Dekkar, NY. 1984.

### **References Books: Unit III**

1. J.Ruticka and J.Stary, Substoichiometry in Radiochemical Analysis, Pergamon Press, (1968)
2. R.A.Faires and G.G.J.Boswell, Radioisotope Laboratory Technique, 4<sup>th</sup> Ed, Rutterworths; London, (1981)
3. D.Brune, B.Forkman, B.Person, Nuclear Analytical Chemistry, Chartwell- Bratt Ltd., (1984)
4. Maheshwar Sharon and Madhuri Sharon, Nuclear Chemistry, Ane Books Pvt. Ltd. (2009)
5. Nuclear Chemistry By Arnikaar

### **References Books: Unit IV**

1. M.Noel and K.I.Vasu, Cyclic Voltammetry and the frontiers of Electrochemistry, IBH, New Delhi, (1990)
2. A.M.Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., New York, 1980.
3. A. J. Bard and Faulkner, Electrochemical Methods, 2<sup>nd</sup> Ed, John Wiley and Sons (Asia) Pvt. Ltd., 2004.

**M.Sc. (Physical Chemistry) Semester – III Practicals**

RJSPGCHEPRP301	<b>Polymer, Surface &amp; Photo Chemistry Practical</b>
<ol style="list-style-type: none"> <li>1. To determine of the formula of the copper (II) ammonia complex by partition method.</li> <li>2. To determine the transport no. of copper (II) ions by Hittorf's method.</li> <li>3. To determine the isoelectric point of gelatin by viscosity measurement.</li> </ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRP301 Practical I Polymer, Surface & Photo Chemistry	<p>Course Outcome:</p> <ol style="list-style-type: none"> <li>1. To understand the standard operating procedure of various instruments.</li> <li>2. To learn complex formation by instrumental and non-instrumental methods.</li> <li>3. To determine transport number by Hittorf's method.</li> <li>4. To learn various physical parameters by instrumental and non-instrumental methods.</li> </ol> <p>Learning outcome:</p> <p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1. determine of the formula of the copper (II) ammonia complex by partition method.</li> <li>2. determine the transport no. of copper (II) ions by Hittorf's method.</li> <li>3. determine the isoelectric point of gelatin by viscosity measurement.</li> </ol>

RJSPGCHEPRP302	<b>Nanochemistry, Statistical Mechanics &amp; Nuclear Chemistry Practical</b>
<ol style="list-style-type: none"> <li>1. To determine the mean ionic activity coefficient of zinc chloride by emf method.</li> <li>2. To construct the phase diagram for a two component system forming a simple eutectic.</li> </ol> <p style="text-align: center;"><b>Non instrumental</b></p> <ol style="list-style-type: none"> <li>1. To determine the equilibrium constant for the reaction <math display="block">\text{CaSO}_4(s) + 2\text{Ag}^+(aq) = \text{Ag}_2\text{SO}_4(s) + \text{Ca}^{+2}(aq)</math> </li> <li>2. To determine the partial molar volume of ethanol.</li> </ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRP302 Practical II Nanochemistry, statistical mechanics & Nuclear chemistry	<p>Course Outcome:</p> <ol style="list-style-type: none"> <li>1. To understand the standard operating procedure of various instruments.</li> <li>2. To understand concept of mean activity and mean activity coefficient using emf method.</li> <li>3. To learn phase rule of two component system by drawing phase diagram.</li> </ol> <p>Learning outcome:</p> <p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1. determine the mean ionic activity coefficient of zinc chloride by emf method.</li> <li>2. construct the phase diagram for a two component system forming a simple eutectic.</li> <li>3. determine the equilibrium constant for the reaction</li> <li>4. determine the partial molar volume of ethanol.</li> </ol>

RJSPGCHEPRP303	<b>Atomic and Molecular: Structure and Spectroscopy Practical</b>
<ol style="list-style-type: none"> <li>1. Determination of the energy of activation and other thermodynamic parameters of activation for the acid catalyzed hydrolysis of methyl acetate.</li> <li>2. To determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement.</li> </ol> <p style="text-align: center;"><b>Conductometry</b></p> <ol style="list-style-type: none"> <li>1. To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant.</li> <li>2. To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of the complex.</li> </ol> <p style="text-align: center;"><b>Potentiometry</b></p> <ol style="list-style-type: none"> <li>1. To determine the <math>E^0</math> of the quinhydrone electrode.</li> <li>2. To determine the formula of the zinc(II)ferrocyanide complex by titration of Zn(II) sulphate with potassium ferrocyanide.</li> </ol> <p style="text-align: center;"><b>pH metry</b></p> <ol style="list-style-type: none"> <li>1. To estimate the amount of hydrochloric acid and acetic acid in a mixture by titration with an alkali using a pH meter.</li> <li>2. To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base.</li> </ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRP303 Practical III Atomic and Molecular: Structure and Spectroscopy	<p>Course Outcome:</p> <ol style="list-style-type: none"> <li>1. To understand the standard operating procedure of various instruments.</li> <li>2. To evaluate the thermodynamic parameters of chemical reaction, stability constant and formula of complex.</li> </ol> <p>Learning outcome: <i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1. Determine of the energy of activation and other thermodynamic parameters of the acid catalyzed hydrolysis of methyl acetate.</li> <li>2. determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement.</li> <li>3. determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant.</li> <li>4. determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base.</li> </ol>

RJSPGCHEPRP304	<b>Advanced Instrumental Techniques Practical</b>
<p>1. To determine the molar mass of a non-volatile solute by cryoscopic method.</p> <p style="text-align: center;"><b>Colorimetry &amp; spectrophotometry</b></p> <p>2. To determine the ionization constant of bromophenol blue</p> <p>3. To study complex formation between nickel(II) with o-phenanthroline.</p> <p>4. To determine the rate constant and the order of the reaction between persulphate and iodide ions.</p>	

M.Sc.	Semester III Practical
RJSPGCHEPRP304 Practical IV Advanced Instrumental Techniques	<p>Course Outcome: To understand the use of absorption of spectroscopy of different dyes, complexes using colorimetric and spectrophotometric methods.</p> <p>Learning outcome:</p> <p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1. study complex formation between metal and ligand.</li> <li>2. determine the rate constant and the order of the reaction between persulphate and iodide ions.</li> <li>3. determine the molar mass of a nonvolatile solute by cryoscopic method.</li> </ol>



**Hindi Vidya Prachar Samiti's**  
**Ramniranjan Jhunjhunwala College**  
**of Arts, Science & Commerce**  
**(Autonomous College)**

**Affiliated to**  
**UNIVERSITY OF MUMBAI**

**Syllabus for the M.Sc. Part – II**  
**Program: M.Sc. (Inorganic Chemistry)**

**Program Code: RJSPGCHEI**

**CBCS: 2020 -2021**  
**M.Sc. (Inorganic Chemistry) Semester – III**

Course	Nomenclature	Credits	Topics
RJSPGCHEI301	Chemistry of Inorganic Solids	4	1. Descriptive Crystal Chemistry Simple structures Linked Polyhedra 2. Imperfection in crystals and Non-Stoichiometry. Point defects. Line defects. Surface Defects. 3. Methods of Preparations 4. Behaviour of Inorganic Solids Diffusion in Solids. Solid state reactions. Liquid Crystals.
RJSPGCHEI302	Bioinorganic and Coordination Chemistry	4	1. Bioinorganic Chemistry 2. Reactivity of Chemical Species –I 3. Reactivity of Chemical Species –II Pourbaix Diagrams. 4. Structure, Bonding, and Stereochemistry of Coordination Compounds
RJSPGCHEI303	Spectral Methods in Inorganic Chemistry	4	1. Diffraction Methods –I 2. Diffraction Methods –II Electron Diffraction Neutron Diffraction 3. Electron Spin Resonance Spectroscopy. 4. Mossbauer Spectroscopy
RJSPGCHEI304	Applied Chemistry	4	1. Inorganic Materials Classification, manufacture and applications. Preparation, properties and uses of industrially important chemicals. 2. Nuclear Chemistry and Inorganic Pharmaceuticals. 3. Advances in Nanomaterials 4. Some Selected Topics 5. i) Isopoly and Hetropoly acids, ii) Supramolecular chemistry

			iii) Inorganic pesticides, and iv) Intercalation compounds
RJSPGCHEPRI301	Chemistry of Inorganic Solids Practical	8	Chemistry Of Inorganic Solids Practical
RJSPGCHEPRI302	Bioinorganic and Coordination Chemistry Practical		Bioinorganic And Coordination Chemistry Practical
RJSPGCHEPRI303	Spectral Methods in Inorganic Chemistry Practical		Spectral Methods In Inorganic Chemistry Practical
RJSPGCHEPRI304	Applied Chemistry Practical		Applied Chemistry Practical

**Detailed syllabus of M.Sc. (Inorganic Chemistry) Semester – III Paper – I**

Course Code	Topic	Credits
RJSPGCHEI301	Chemistry of Inorganic Solids	4
<b>Unit I Descriptive Crystal Chemistry</b> <b>(a) Simple structures</b> Structures of <b>AB</b> type compounds (PbO and CuO), <b>AB<sub>2</sub></b> type ( $\beta$ cristobalite, CaC <sub>2</sub> and Cs <sub>2</sub> O), <b>A<sub>2</sub>B<sub>3</sub></b> type (Cr <sub>2</sub> O <sub>3</sub> and Bi <sub>2</sub> O <sub>3</sub> ), <b>AB<sub>3</sub></b> (ReO <sub>3</sub> , Li <sub>3</sub> N), <b>ABO<sub>3</sub></b> type, relation between ReO <sub>3</sub> and perovskite BaTiO <sub>3</sub> and its polymorphic forms, Oxide bronzes, ilmenite structure, <b>AB<sub>2</sub>O<sub>4</sub></b> type, normal, inverse, and random spinel structures. <b>(b) Linked Polyhedra</b> (i) Corner sharing: tetrahedral structure (Silicates) and octahedral structure (ReO <sub>3</sub> ) and rotation of ReO <sub>3</sub> resulting in VF <sub>3</sub> , RhF <sub>3</sub> and calcite type structures. (ii) Edge sharing: tetrahedral structures (SiS <sub>2</sub> ) and octahedral structures (BiI <sub>3</sub> and AlCl <sub>3</sub> ). pyrochlores, octahedral tunnel structures and lamellar structures		1
<b>Unit II Imperfection in crystals and Non- Stoichiometry</b> <b>(a) Point defects:</b> Point defects in metals and ionic Crystal – Frenkel defect and Schottky defect. Thermodynamics formation of these defects (mathematical derivation to find defect concentration); Defects in non- Stoichiometric compounds, colour centres. <b>(b) Line defects:</b> Edge and Screw Dislocations. Mechanical Properties and Reactivity of Solids. <b>(c) Surface Defects:</b> Grain Boundary and Stacking Fault. Dislocation and Grain Boundaries, Vacancies and Interstitial Space in Non-Stoichiometric Crystals, Defect Clusters, Interchangeable Atoms and Extended Atom Defects.		1
<b>Unit III Methods of Preparations</b> <b>(a) Methods of Synthesis:</b> Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples). <b>(b) Different methods for single crystal growth:</b> (i) Crystal Growth from Melt–: Bridgman and Stockbarger, Czochralski and Verneuil methods. (ii) Crystal growth from liquid solution: Flux growth and temperature gradient methods (iii) Crystal growth from vapor phase: – Epitaxial growth methods. <b>(c) Thin film preparation:</b> Physical and Chemical methods. <b>(d) Solid Solutions:</b> Formation of Substitutional, Interstitial and Complex Solid Solutions; Mechanistic Approach; Study of Solid solutions by X-ray Powder Diffraction and Density Measurement. <b>IV</b>		1
<b>Unit IV Behaviour of Inorganic Solids</b> <b>(a) Diffusion in Solids:</b> Fick's Laws of Diffusion; Kirkendall Effect; Wagner mechanism, Diffusion and Ionic Conductivity; Applications of Diffusion in Carburizing and non-Carburizing Processes in Steel Making.		1

<b>(b) Solid state reactions:</b> General principles and factors influencing reactions of solids, Reactivity of solids.	
<b>(c) Liquid Crystals:</b> Introduction and classification of thermotropic liquid crystals, Polymorphism in liquid crystal, Properties and applications of liquid crystals.	

M.Sc.	Semester III Theory
<b>RJSPGCHEI301</b> <b>Paper I</b> <b>Chemistry of Inorganic Solids</b>	<p><b>Course outcome:</b> Students learn about the simple crystal structures, linked polyhedrons and the properties of various crystal types, defects in the crystals both stoichiometric and non-stoichiometric defects, details of Frenkel and Schottky defects, its mathematical derivations and numericals based on these defects, preparation of solid crystals using various techniques, properties of solids and solid state reactions.</p> <p><b>Learning outcome:</b> <i>On successful completion of this course students will be able to</i></p> <ul style="list-style-type: none"> <li>Understand the terminologies involved in solid state chemistry, Gain knowledge about the structures of simple compounds and linked polyhedral units., Understand the structure and properties of Ilmenites, Perovskites and Spinel</li> <li>Understand the imperfections in crystals, gain knowledge on different types of defects in crystal structures, Solve numerical related to Frenkel and Schottky defects, Learn about non-stoichiometric crystal structure.</li> <li>Gain knowledge about the different methods of synthesis of solid crystals, understand the different chemical processes available for the synthesis of crystal structure, Learn the advantages and disadvantages associated with each method, Synthesise solids crystals by employing suitable preparatory methods.</li> </ul> <p>Understand the behaviour of inorganic solid substances, learn different properties of solids, Understand solid state reactions, Gain knowledge about the reactivity of various solid crystals.</p>

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### Detailed syllabus of M.Sc. (Inorganic Chemistry) Semester – III Paper – II

Course Code	Topic	Credits
RJSPGCHEI302	Bioinorganic and Coordination Chemistry	4
<b>Unit I Bioinorganic Chemistry</b> (i) Coordination geometry of the metal ion and functions. (ii) Zn in biological systems: Carbonic anhydrase, proteolytic enzymes, e.g. carboxypeptidase, Zinc finger. (iii) Role of metal ions in biological electron transfer processes: iron sulphur proteins. (iv) Less common ions in biology e.g. Mn (arginase; structure and reactivity), Ni (urease ; structure and reactivity) (v) Biomineralization.		1
<b>Unit II Reactivity of Chemical Species –I</b>  <b>Unit II Reactivity of Chemical Species –I</b> 2.1 Recapitulation of the definition of Lewis acids and bases, Classification of Lewis acids and bases based on frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases. 2.2 Group Characteristic of Lewis acids (Gp-1,13-17). 2.3 Pauling rules to determine the strength of oxoacids; classification and Structural anomalies.		1

<b>Unit III Reactivity of Chemical Species –II</b>  <b>3.1 Pourbaix Diagrams.</b> 3.2 Amphoteric behavior, Periodic trends in amphoteric properties of p-block and d-block elements 3.3 Oxoanions and Oxocations. 3.4 Measures of hardness and Softness of Acids and Bases, Drago Wayland Equation 3.5 Applications of acid-base Chemistry: Super acids and Superbases, heterogeneous acid-base reactions.	1
<b>Unit IV Structure, Bonding, and Stereochemistry of Coordination Compounds</b> <b>4.1 Structure and Bonding.</b> i) Molecular Orbital Theory for Complexes with Coordination Number 4 and 5 for the central ion (sigma as well as Pi bonding) (ii) Angular Overlap Model for octahedral and tetrahedral complexes for sigma and pi bonds. <b>4.2 Stereochemistry of Coordination Compounds.</b> (i) Chirality and Fluxionality of Coordination compounds with Higher Coordination Numbers. (ii) Geometries of coordination compounds from Coordination number 6 to 9.	1

M.Sc.	Semester III Theory
<b>RJSPGCHEI302</b> <b>Paper II</b> Bioinorganic and Coordination Chemistry	<b>Course Outcome</b> <ul style="list-style-type: none"> <li>Students will learn the role of metal ions in biological systems. Role of different metal ions in the form of metalloenzymes such as Zn in biological systems in the form of carboxypeptidase, carbonic anhydrase, and zinc fingers. The role of Mn and Ni in the form of their respective metalloenzymes.</li> <li>Students will learn the Chemical reactivity of species based on Recapitulation of Lewis acid-base theory, the advanced approach of frontier molecular orbital theory (FMOT), and Pauling's rules to determine the strength of acid and bases.</li> <li>Students will learn Pourbaix Diagrams, Drago Weyland equations, and the concept of superacids and bases.</li> <li>Students will also learn the stereochemistry and MOT of complexes with higher coordination numbers such as 6,7,8 &amp; 9. Different stereochemical aspects of chirality, fluxionality will be learned by the students</li> </ul> <b>Learning outcomes:</b> On successful completion of this course students will be able to: <ul style="list-style-type: none"> <li>understand chemical reactions mainly as acid base interaction, learn to classify Lewis acids and bases, map the region of organometallic compounds.</li> <li>understand the amphoteric nature of elements and oxides, hydroxides.</li> <li>Application of Pourbaix diagram to Fe, Cu metals in contact with water,</li> <li>Drago Weyland equation to understand covalent and ionic contribution in given reaction and learn to predict the stability of the product.</li> <li>Extension of pH scale to accommodate superacids and bases, their</li> </ul>

	<p>applications</p> <ul style="list-style-type: none"> <li>• After successful completion of bioinorganic chemistry, students will be able to understand and work with the metalloenzymes in the human body.</li> <li>• The role of trace minerals such as Zn, Mn, Ni, Fe in the biological system will provide awareness to students regarding its deficiency and excess.</li> <li>• Designing, synthesis, and characterization of new organometallic compounds will be easy for students after having the knowledge of stereochemistry of coordination compounds.</li> </ul>
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**Detailed syllabus of M.Sc. (Inorganic Chemistry) Semester – III Paper – III**

Course Code	Topic	Credits
RJSPGCHEI303	Spectral Methods in Inorganic Chemistry	4
<b>Unit I Diffraction Methods –I</b> X-Ray Diffraction: Bragg Condition; Miller Indices; Laue Method; Bragg Method; Debye Scherrer Method of X-Ray Structural Analysis of Crystals.		1
<b>Unit II Diffraction Methods –II</b> <b>(a) Electron Diffraction:</b> Scattering of electrons, Scattering Intensity Vs Scattering Angle, Weir Measurement Technique, Elucidation of Structures of simple gas phase molecules. <b>(b) Neutron Diffraction:</b> Scattering of Neutrons: Scattering of neutrons by Solids and Liquids, Magnetic Scattering, Measurement Technique.		1
<b>Unit III Electron Spin Resonance Spectroscopy</b> <b>(a)</b> Electron behaviour, interaction between electron spin and magnetic field. <b>(b)</b> Instrumentation : Source, Sample cavity. Magnet and Modulation coils, Microwave Bridge, Sensitivity. <b>(c)</b> Relaxation processes and Line width in ESR transitions: <b>(i) ESR relaxation and chemical bonding.</b> <b>(ii)</b> Interaction between nuclear spin and electron spin (hyperfine coupling) <b>(iii)</b> Spin polarization for atoms and transition metal ions. <b>(iv)</b> Spin-orbit coupling and significance of g tensors. <b>(v)</b> Application to transition metal complexes (having one unpaired electron).		1
<b>Unit IV Mossbauer Spectroscopy</b> <b>Mössbauer Spectroscopy:</b> 4.1 Basic principle, recoil energy and Doppler shift. 4.2 Instrumentation: sources and absorber; motion devices, detection, reference substances and calibration, 4.3 Isomer shift, quadrupole interaction, magnetic interaction, electronegativity and chemical shift. 4.4 Applications: <b>Iron compounds</b> - low spin and high spin Fe(II) and Fe(III) compounds and complexes, effect of pi-bonding, mono and polynuclear iron complexes, spinel oxides and iron-sulphur proteins; <b>Tin Compounds</b> - tin halides and tin oxides, organotin compounds; <b>Iodine Compounds</b> - I <sub>2</sub> and alkali metal iodide compounds.		1

M.Sc.	Semester III Theory
<b>RJSPGCHEI303</b> <b>Paper III</b> <b>Spectral</b> <b>Methods in</b> <b>Inorganic</b> <b>Chemistry</b>	<p><b>Course Outcome</b></p> <p>Students learn different spectroscopic techniques based on diffraction (x-ray electron,neutron), resonance absorption of microwaves, Electron paramagnetic resonance,( EPR) and of gamma rays,(Mosbauer spectroscopy). Application of above techniques for structure elucidation of inorganic compounds is taught specifically.</p> <p><b>Learning outcomes:</b></p> <p>After completing this course students will be able to understand:</p> <ul style="list-style-type: none"> <li>● indexing planes in crystalline compounds, calculate various parameters of crystalline compounds,deduce the structure based on diffraction patterns.</li> <li>● how to generate electron and neutron waves of appropriate wavelength required for structure determination,advantages and limitations of these techniques over X-ray diffraction,</li> <li>● which systems can be studied by EPR, instrumentation, its application in coordinate compounds and biological systems.</li> <li>● recoilless emission and resonant absorption of gamma rays by samples containing elements with resultant nuclear spin.such as Fe,Sn,I</li> <li>● instrumentation of MB spectrometer, important application of Doppler effect in MB spectroscopy.</li> </ul>

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**M.Sc. (Inorganic Chemistry Semester – III Paper – IV)**  
**(Applied Chemistry)**

**Paper Code: RJSPGCHEI304**

Course Code	Topic	Credits
RJSPGCHEI304	Applied Chemistry	4
<b>Unit I Inorganic Materials</b> <b>(a) Classification, manufacture and applications of:</b> (i) Inorganic fibers. (ii) Inorganic fillers. <b>Study of</b> (i) Condensed phosphates. (ii) Coordination polymers. <b>(b) Preparation, properties and uses of industrially important chemicals:</b> bleaching powder, hydrogen peroxide, potassium dichromate, potassium permanganate and sodium thiosulphate.		1
<b>Unit II Nuclear Chemistry and Inorganic Pharmaceuticals</b> <b>(a) Nuclear Chemistry :</b> Introduction of nuclear fuels and separation of fission products from spent fuel rods by <b>PUREX (Plutonium Uranium Recovery by Extraction)</b> process. Super heavy elements (From Rutherfordium (Rf-104) - Oganesson (Og-118), discovery, preparation and their position in the periodic table. <b>(b) Inorganic Pharmaceuticals:</b> <b>Radiopharmaceuticals</b> containing Tc and Bi, contrast agents for X-ray and NMR imaging. <b>Gastrointestinal agents</b> viz. (i) antacids (aluminium hydroxide, milk of magnesia, sodium bicarbonate and (ii) <b>Cathartics</b> (magnesium sulphate and sodium phosphate). <b>Topical agents</b> viz. (i) protectives and		1

adsorbents (talc,calamine), (ii)antimicrobial agents(potassium permanganate, tincture iodine, boric acid)and astringents( potash alum).	
<b>Unit III Advances in Nanomaterials:</b> <b>(a) Types of nanomaterials</b> , e.g. nanotubes, nanorods, solid spheres, core-shell nanoparticles, mesoporous materials; isolation of nanomaterials <b>(b) Some important properties of nanomaterials:</b> optical properties of metal and semiconductor nanoparticles, magnetic properties. <b>(c) Some special nanomaterials: Carbon nanotubes:</b> Types, synthesis using various methods, growth mechanism, electronic structure; <b>Porous silicon:</b> Preparation and mechanism of porous silicon formation, Factors affecting porous structure, properties of porous silicon; <b>Aerogels:</b> Types of aerogels, Properties and applications of aerogels. <b>(d) Applications of nanomaterials in</b> electronics, energy, automobiles, sports and toys, textiles, cosmetics, medicine, space and defense. <b>(e) Environmental effects of nanotechnology.</b>	1
<b>Unit IV Some Selected Topics</b> i) Isopoly and Heteropoly Acids. ii) Supramolecular Chemistry. iii) Inorganic pesticides. iv) Intercalation compounds.	1

M.Sc.	Semester III Theory
<b>RJSPGCHEI304</b> <b>Paper IV</b> <b>Applied</b> <b>Chemistry</b>	<ul style="list-style-type: none"> <li>After successful completion of the module, students will be able to understand:</li> <li>The real use of inorganic fibers and fillers in real life, their manufacturing process, and applications.</li> <li>Nuclear fuels are extremely important for the overall growth of the nation in terms of nuclear power energy. This requirement can be met with the recovery of U and Pu by the PUREX process.</li> <li>Medical use of inorganic compounds such as potassium permanganate etc. is extremely important at the bulk level.</li> <li>The use of nanomaterials and nanotechnology for the welfare of society. Its preparation, properties, and applications in different fields will provide an impetus to work in the field of nanomaterials.</li> </ul> <p>The importance of supramolecular chemistry in the use of materials, everyday use of materials such as water and different biomolecules in our body. Inorganic pesticides and intercalation compounds play a pivotal role in solving usual problems.</p>

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1. G.M.Masters, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt. Ltd. New Delhi, 1995.
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5. B.Douglas, D.H. McDaniel and J.J.Alexander, Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley & Sons,1983.

### M.Sc. (Inorganic Chemistry) Semester – III Practicals

RJSPGCHEPRI301	Chemistry of Inorganic Solids Practical
<ol style="list-style-type: none"> <li>1. Analysis of Brass alloy: <ol style="list-style-type: none"> <li>(i) Cu content by iodometric method.</li> <li>(ii) Zn content by complexometric method.</li> </ol> </li> <li>2. Analysis of Bronze alloy: <ol style="list-style-type: none"> <li>(i) Cu content by complexometric method,</li> <li>(ii) Sn content by gravimetric method.</li> </ol> </li> <li>3. Analysis of galena ore: <ol style="list-style-type: none"> <li>(i) Pb content as <math>\text{PbCrO}_4</math> by gravimetric method using 5% potassium chromate.</li> <li>(ii) Fe content by colorimetrically using 1,10- phenanthroline.</li> </ol> </li> <li>4. Analysis of Zinc blende ore: <ol style="list-style-type: none"> <li>(i) Zn content by complexometric method.</li> <li>(ii) Fe content by colorimetric method(Azide method).</li> </ol> </li> </ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRI301 Practical I Analysis of alloys/ores Chemistry of Inorganic Solids Practical	<b>Course outcome:</b> Students learn to analyze commercial samples viz. Diet supplements, cosmetics, etc. <b>Learning outcome:</b> Students learn to estimate calcium content from the table, zinc content from powder complexometrically. Estimate Iron content calorimetrically.

RJSPGCHEPRI302	Bioinorganic and Coordination Chemistry Practical
1. Separation of Co and Ni using n-butyl alcohol and estimation of Co. 2. Separation of U and Fe using 8-hydroxyquinoline in chloroform and estimation of U. 3. Separation of Fe and Mo using isoamyl alcohol and estimation of Mo. 4. Separation of Cu and Fe using n-butyl acetate and estimation of Cu.	

M.Sc.	Semester III Practical
RJSPGCHEPRI302 Practical II Solvent Extraction Bioinorganic and Coordination Chemistry Practical	<b>Course outcome:</b> Students will learn to extract two components of metals in a sample by solvent extraction method. <b>Learning Outcome:</b> Students will understand the concept of solvent extraction which can help them in the separation of different components in real samples in industries.

RJSPGCHEPRI303	Spectral Methods in Inorganic Chemistry Practical
1. Preparation of $\text{Co}(\alpha\text{-nitroso-}\beta\text{-naphthol})_3$ 2. Preparation of $\text{Ni}(\text{salicylaldoxime})_2$ 3. Hexamine cobalt (III) chloride 4. Preparation of Trans-bis (glycinato) $\text{Cu(II)}$	

M.Sc.	Semester III Practical
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RJSPGCHEPRI303 Practical III  Inorganic Preparations  Spectral Methods in Inorganic Chemistry Practical	<b>Course Outcome:</b> Students learn to prepare various coordination complexes <b>Learning outcome:</b> Students could successfully prepare the coordination complexes of various metals like Ni, Cu, and Cobalt.
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RJSPGCHEPRI304	Applied Chemistry Practical
1. Calcium tablet for its calcium content by complexometric titration. 2. Bleaching powder for its available chlorine content by iodometric method. 3. Iron tablet for its iron content colorimetrically by using 1,10-phenanthroline. 4. Nycil powder for its Zn content complexometrically.	

M.Sc.	Semester III Practical
RJSPGCHEPRI304 Practical IV Analysis of the following samples Applied Chemistry Practical	<b>Course Outcome:</b> Students will learn the analysis of commercial samples for their active components such as Ca in calcium tablets and Zn in Nycil powder. <b>Learning outcome:</b> <b>Learning Outcomes:</b> <i>On successful completion of this course students will be able to:</i> <ul style="list-style-type: none"> <li>● Dissolve the given alloy by suitable acid treatment followed by estimating the metal content present in it quantitatively by gravimetric or volumetric method.</li> <li>● understand the process of solvent extraction by making them separate the metals from their mixtures by using a suitable solvent and to estimate the separated metal quantitatively.</li> <li>● study preparation of some coordination complexes.</li> <li>● analyze metal contents in some commercial samples.</li> </ul>

**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*.
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**Hindi Vidya Prachar Samiti's**  
**Ramniranjan Jhunjhunwala College**  
**of Arts, Science & Commerce**  
**(Autonomous College)**

**Affiliated to**  
**UNIVERSITY OF MUMBAI**

**Syllabus for the M.Sc. Part – II**

**Program: M.Sc. (Organic Chemistry)**

**Program Code: RJSPGCHEO**

**CBCS: 2020 -2021**

**M.Sc. (Organic Chemistry) Semester – III**

Course	Nomenclature	Credits	Topics
RJSPGCHEO301	Theoretical Organic Chemistry - I	4	1. Organic reaction mechanisms 2. Pericyclic reactions 3. Stereochemistry-I 4. Photochemistry
RJSPGCHEO302	Synthetic Organic Chemistry - I	4	1. Name reactions with mechanism and application. 2. Radicals in organic synthesis 3. Enamines, Ylides and $\alpha$ -C-H functionalization. 4. Metals / Non-metals in organic synthesis
RJSPGCHEO303	Natural Products and Spectroscopy	4	1. Natural products-I Carbohydrates, Natural pigments Insect pheromones, Alkaloids 2. Natural products-II Multi-step synthesis of natural products. Prostaglandins. Lipids. Insect growth regulators. Plant growth regulators. 3. Advanced spectroscopic techniques-I Proton NMR spectroscopy $^{13}\text{C}$ –NMR spectroscopy 4. Advanced spectroscopic techniques-II
RJSPGCHEO304	Medicinal, Biogenesis and Green Chemistry	4	1. Drug discovery, design and development.

			2. Drug design, development and synthesis. 3. Biogenesis and biosynthesis of natural products. 4. Green chemistry
RJSPGCHEPRO301	Theoretical Organic Chemistry - I Practical	8	1. Theoretical Organic Chemistry - I Practical
RJSPGCHEPRO302	Synthetic Organic Chemistry - I Practical		2. Synthetic Organic Chemistry - I Practical
RJSPGCHEPRO303	Natural Products and Spectroscopy Practical		3. Natural Products and Spectroscopy Practical
RJSPGCHEPRO304	Medicinal, Biogenesis and Green Chemistry Practical		4. Medicinal, Biogenesis and Green Chemistry Practical

### Detailed syllabus of M.Sc. (Organic Chemistry) Semester – III Paper – I

Course Code	Topic	Credits
RJSPGCHEO301	<b>Theoretical Organic Chemistry-I</b>	4
<b>Unit 1 Organic reaction mechanisms</b> <b>1.1 Organic reactive intermediates:</b> methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes. <b>1.2 Neighbouring group participation:</b> Mechanism and effects of anchimeric assistance, NGP by unshared/ lone pair electrons, $\pi$ -electrons, aromatic rings, $\sigma$ -bonds with special reference to norbornyl and <b>bicyclo[2.2.2]octyl cation</b> systems (formation of non-classical carbocation) <b>1.3 Role of FMOs in organic reactivity:</b> Reactions involving hard and soft electrophiles and nucleophiles, ambident nucleophiles, ambident electrophiles, the $\alpha$ -effect. <b>1.4 Pericyclic reactions:</b> Classification of pericyclic reactions; thermal and photochemical reactions. Three approaches: Evidence for the concertedness of		1

<p>bond making and breaking Symmetry-Allowed and symmetry-Forbidden Reactions:</p> <ul style="list-style-type: none"> <li>• The Woodward-Hoffmann Rules-Class by Class</li> <li>• The generalized Woodward-Hoffmann Rule Explanations for Woodward-Hoffmann Rules</li> <li>• The Aromatic Transition structures [Hückel and Mobius]</li> <li>• Frontier Orbitals</li> <li>• Correlation Diagrams, FMO and PMO approach Molecular orbital symmetry, Frontier orbital of ethylene, 1,3 butadiene, 1,3,5 hexatriene and allyl system.</li> </ul>	
<p><b>Unit 2 Pericyclic reactions</b></p> <p><b>2.1 Cycloaddition reactions:</b> Supra and antarafacial additions, <math>4n</math> and <math>4n+2</math> systems, <math>2+2</math> additions of ketenes. Diels-Alder reactions, 1,3-Dipolar cycloaddition and cheletropic reactions, ene reaction, retro-Diels-Alder reaction, regioselectivity, periselectivity, torquoselectivity, site selectivity and effect of substituents in Diels-Alder reactions. <b>Other Cycloaddition Reactions-</b> <math>[4+6]</math> Cycloadditions, Ketene Cycloaddition, Allene Cycloadditions, Carbene Cycloaddition, Epoxidation and Related Cycloadditions. Other Pericyclic reactions: Sigmatropic Rearrangements, Electrocyclic Reactions, Alder 'Ene' Reactions.</p> <p><b>2.2 Electrocyclic reactions:</b> Conrotatory and disrotatory motions, <math>4n\pi</math> and <math>(4n+2)\pi</math> electron and allyl systems.</p> <p><b>2.3 Sigmatropic rearrangements:</b> H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations. Cope (including oxy-Cope and aza-Cope) and Claisen rearrangements. Formation of Vitamin D from 7-dehydrocholesterol, synthesis of citral using pericyclic reaction, conversion of Endiandric acid E to Endiandric acid A.</p>	1
<p><b>Unit 3: Stereochemistry-I</b></p> <p><b>3.1</b> Classification of point groups based on symmetry elements with examples (nonmathematical treatment).</p> <p><b>3.2</b> Conformational analysis of medium rings: Eight to ten membered rings and their unusual properties, I-strain, transannular reactions.</p> <p><b>3.3</b> Stereochemistry of fused ring and bridged ring compounds: decalins, hydrindanes, <b>perhydro anthracenes</b>, steroids, and Bredt's rule.</p>	1

<b>3.4 Anancomeric systems</b> , Effect of conformation on reactivity of cyclohexane derivatives in the following reactions (including mechanism): electrophilic addition, elimination, molecular rearrangements, reduction of cyclohexanones ( <b>with LiAlH<sub>4</sub>, selectride and MPV reduction</b> ) and oxidation of cyclohexanols.	
<p><b>Unit 4 Photochemistry</b></p> <p><b>4.1 Principles of photochemistry:</b> quantum yield, electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process.</p> <p><b>4.2 Photochemistry of carbonyl compounds:</b> <math>\pi \rightarrow \pi^*</math>, <math>n \rightarrow \pi^*</math> transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of <math>\alpha</math>, <math>\beta</math>-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction.</p> <p><b>4.3 Photochemistry of olefins:</b> cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di- <math>\pi</math>- methane rearrangement including aza-di- <math>\pi</math>-methane. Photochemical Cross-Coupling of Alkenes, Photodimerization of alkenes.</p> <p><b>4.4 Photochemistry of arenes:</b> 1, 2- , 1, 3- and 1, 4- additions. Photocycloadditions of aromatic Rings.</p> <p><b>4.5</b> Singlet oxygen and photo-oxygenation reactions. Photochemically induced Radical Reactions. Chemiluminescence.</p>	1

M.Sc.	Semester III Theory
<b>RJSPGCHEO301</b> <b>Paper I</b> Theoretical organic chemistry-I	<p><b>Course Outcome</b></p> <ol style="list-style-type: none"> <li>1. To predict the major and minor products of a variety of organic reactions with appropriate stereochemistry and Regio chemistry.</li> <li>2. Understanding of concerted reactions (Pericyclic Reaction): Principle, reactions, and applications.</li> <li>3. To understand the conformational analysis of medium ring and fused ring compounds.</li> <li>4. To understand the principle, reactions, and applications of photochemistry.</li> </ol> <p><b>Learning outcomes:</b></p> <p><i>After completing this course students will be able to:</i></p>

	<ol style="list-style-type: none"> <li>1. To understand the mechanisms with stereo chemistry and regio chemistry of some selected reactions.</li> <li>2. To learn applications and principle involved in a pericyclic reactions.</li> <li>3. To understand the stereochemistry of fused ring compounds.</li> <li>4. To get familiar with the principles of photochemistry.</li> </ol>
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- 2 A guide to mechanism in Organic Chemistry, 6<sup>th</sup> edition, 2009, Peter Sykes, Pearson education, New Delhi.
- 2 Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002).
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- 21 Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books, 2006
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- 23 Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3<sup>rd</sup> edition, New Age International Ltd.

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- 29 Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992.
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- 31 Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wiley-Eastern
- 32 Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
- 33 Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
- 34 Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill
- 35 Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
- 36 Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
- 37 Molecular Orbitals and Organic Chemical Reactions by Ian Fleming  
(Wiley – A John Wiley and Sons, Ltd., Publication)

### Detailed syllabus of M.Sc. (Organic Chemistry) Semester – III Paper – II

Course Code	Topic	Credits
RJSPGCHEO302	<b>Synthetic Organic Chemistry-I</b>	4
<b>Unit 1: Name reactions with mechanism and application</b> <b>1.1</b> Mukaiyama esterification, Mitsunobu reaction, Darzen's Glycidic Ester synthesis, Ritter reaction, Yamaguchi esterification, Peterson olefination.  <b>1.2 Domino reactions:</b> Characteristics; Nazarov cyclization. <b>1.3 Multicomponent reactions:</b> Strecker Synthesis, Ugi 4CC, Biginelli synthesis, Hantzsch synthesis, Pictet-Spengler synthesis.  <b>1.4 Click Reactions:</b> Characteristics; Huisgen 1,3-Dipolar Cycloaddition.		1
<b>Unit 2: Radicals in Organic Synthesis</b> <b>2.1 Introduction:</b> Generation, stability, reactivity and structural and stereochemical properties of free radicals, Persistent and charged radicals, Electrophilic and nucleophilic radicals.		1

<p>2.2 <b>Radical Initiators:</b> azobisisobutyronitrile (AIBN) and dibenzoyl peroxide.</p> <p>2.3 <b>Characteristic reactions</b> - Free radical substitution, addition to multiple bonds. Radical chain reactions, Radical halogenation of hydrocarbons (Regioselectivity), radical cyclizations, auto-oxidations: synthesis of cumene hydroperoxide from cumene.</p> <p>2.4 <b>Radicals in synthesis:</b> Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors. Cleavage of C-X, C-Sn, C-Co, C-S, O-O bonds. Oxidative coupling, C-C bond formation in aromatics: <math>S_{RN}Ar</math> reactions.</p> <p>2.5 Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation.</p>	
<p><b>Unit 3: Enamines, Ylides and <math>\alpha</math>-C-H functionalization</b></p> <p>3.1 <b>Enamines:</b> Generation &amp; application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison between enamines and enolates. Synthetic reactions of enamines including asymmetric reactions of chiral enamines derived from chiral secondary amines.</p> <p>3.2 <b>Phosphorus, Sulfur and Nitrogen Ylides:</b> Preparation and their synthetic applications along with their stereochemical aspects. Wittig reaction, Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination.</p> <p>3.3 <b><math>\alpha</math>-C-H functionalization:</b> By nitro, sulfoxide, sulfone and phosphonate groups: generation of carbanions by strong bases (LDA/n-butyl lithium) and applications in C-C bond formation. Bamford-Steven's reaction, Julia olefination and its modification, Seyferth-Gilbert homologation, Steven's rearrangement.</p>	1
<p><b>Unit 4: Metals / Non-metals in organic synthesis</b></p> <p>4.1 <b>Mercury in organic synthesis:</b> Mechanism and Regio chemistry of oxymercuration and demercuration of alkenes, mercuration of aromatics, transformation of aryl mercurials to aryl halides. Organomercurials as carbene transfer reagents.</p> <p>4.2 <b>Organoboron compounds:</b> Mechanism and regiochemistry of hydroboration of alkenes and alkynes, asymmetric hydroboration using chiral boron reagents, 9-BBN hydroboration, oxazaborolidine (CBS catalyst) and functional group reduction by diborane.</p> <p>4.3 <b>Organosilicons:</b> Salient features of silicon governing the reactivity of organosilicons, preparation and important bond-forming reactions of alkyl silanes,</p>	1

alkenyl silanes, aryl silanes and allyl silanes. $\beta$ -silyl cations as intermediates. Iodotrimethylsilane in organic synthesis. 4.4 <b>Silyl enol ethers</b> : Application: As nucleophiles (Michael reaction, Mukaiyama aldol reaction), in ring contraction reactions. 4.5 <b>Organotin compounds</b> : Preparation of alkenyl and allyl tin compounds; application in C-C bond formation, in replacement of halogen by H at the same C atom. 4.6 <b>Selenium in organic synthesis</b> : Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and selenoacetals as $\alpha$ -C-H activating groups	
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M.Sc.	Semester III Theory
<b>RJSPGCHEO302</b> <b>Paper II</b> Synthetic Organic Chemistry-I	<b>Course Outcome</b> <ol style="list-style-type: none"> <li>1. To discuss mechanistic aspects of some multicomponent reactions.</li> <li>2. To explore the importance of radicals in organic synthesis with relevant application.</li> <li>3. To understand the reactions and applications of enamines and ylides in organic synthesis.</li> <li>4. To discuss the importance of reaction, mechanism, and regiochemistry of metals and non-metals in synthetic organic chemistry with illustration.</li> </ol> <b>Learning outcomes:</b> <i>After completing this course students will be able to:</i> <ol style="list-style-type: none"> <li>1. To understand the multicomponent system.</li> <li>2. To know various radicals involved in organic synthesis.</li> <li>3. To understand the structure and methods of preparation of enamines and ylides.</li> <li>4. To follow the reactions involved with Metals and Non-Metals with respect to their regiochemistry.</li> </ol>

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- **Name Reactions**, Jie Jack Lie, 3<sup>rd</sup> Edn., Springer
- **Organic Electrochemistry**, H. Lund, and M. Baizer, 3<sup>rd</sup> Edn., Marcel Dekker.

### Detailed syllabus of M.Sc. (Organic Chemistry) Semester – III Paper – III

Course Code	Topic	Credits
RJSPGCHEO303	<b>Natural Products and Spectroscopy</b>	4
<b>Unit 1: Natural products-I</b>  1.1 <b>Carbohydrates:</b> Introduction to naturally occurring sugars: Deoxy sugars, amino sugars, branched sugars. Structure elucidation of lactose and D-glucosamine (synthesis not expected). Structural features and applications of inositol, starch, cellulose, chitin and heparin. 1.2 <b>Natural pigments:</b> General structural features, occurrence, biological importance and applications of: carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll). Structure elucidation of $\beta$ -carotene and Cyanin (with synthesis). Synthesis of ubiquinone from 3, 4, 5-trimethoxyacetophenone. 1.3 <b>Insect pheromones:</b> General structural features and importance. Types of pheromones (aggregation, alarm, releaser, primer, territorial, trail, sex pheromones etc.), advantage of pheromones over conventional pesticides. Synthesis of bombykol from acetylene, disparlure from 6-methylhept-1-ene, grandisol from 2-methyl-1, 3-butadiene. 1.4 <b>Alkaloids:</b> Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of coniine.		1

<p><b>Unit 2: Natural products-II</b></p> <p><b>2.1 Multi-step synthesis of natural products:</b> Synthesis of the following natural products with special reference to reagents used, stereochemistry and functional group transformations:</p> <p>a) Woodward synthesis of Reserpine from benzoquinone.</p> <p>b) Corey synthesis of Longifolene from resorcinol.</p> <p>c) Gilbert-Stork synthesis of Griseofulvin from phloroglucinol.</p> <p>d) Corey's Synthesis of Caryophyllene from 2-Cyclohexenone and Isobutylene</p> <p>e) Synthesis of Juvabione from Limonene</p> <p>f) Synthesis of Taxol.</p> <p><b>2.2 Prostaglandins:</b> Classification, general structure and biological importance. Structural elucidation of <b>PGE<sub>1</sub></b>.</p> <p><b>2.3 Lipids:</b> Classification, role of lipids, Fatty acids and glycerol derived from oils and fats.</p> <p><b>2.4 Insect growth regulators:</b> General idea, structures of JH<sub>2</sub> and JH<sub>3</sub>.</p> <p><b>2.5 Plant growth regulators:</b> Structural features and applications of aryl acetic acids, gibberellic acids and triacontanol. Synthesis of triacontanol (synthesis of stearyl magnesium bromide and 12-bromo-1-tetrahydropyranyloxydodecane expected).</p>	1
<p><b>Unit 3: Advanced spectroscopic techniques-I</b></p> <p><b>3.1 Proton NMR spectroscopy:</b> Recapitulation, chemical and magnetic equivalence of protons, First order, second order, Spin system notations (A<sub>2</sub>, AB, AX, AB<sub>2</sub>, AX<sub>2</sub>, AMX and A<sub>2</sub>B<sub>2</sub>-A<sub>2</sub>X<sub>2</sub> spin systems with suitable examples). Long range coupling (Allylic coupling, 'W' coupling and coupling in aromatic and heteroaromatic systems), Temperature effects. Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents.</p> <p><b>3.2 <sup>13</sup>C –NMR spectroscopy:</b> Recapitulation, equivalent and nonequivalent carbons (examples of aliphatic and aromatic compounds), <sup>13</sup>C- chemical shifts, calculation of <sup>13</sup>C- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to <sup>19</sup>F and <sup>31</sup>P.</p> <p><b>3.3 Spectral problems based on UV, IR, <sup>1</sup>H NMR and <sup>13</sup>C NMR and Mass spectroscopy.</b></p>	1
<p><b>Unit 4: Advanced spectroscopic techniques-II</b></p>	

<p>4.1 <b>Advanced NMR techniques:</b> DEPT experiment, determining number of attached hydrogens (Methyl/methylene/methine and quaternary carbons), two dimensional spectroscopic techniques, COSY and HETCOR spectra, NOE and NOESY techniques.</p> <p>4.2 Spectral problems based on UV, IR, <sup>1</sup>H NMR, <sup>13</sup>C NMR (Including 2D technique) and Mass spectroscopy .</p>	1
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M.Sc.	Semester III Theory
<b>RJSPGCHEO303</b> <b>Paper III</b> Natural products and Spectroscopy	<p><b>Course Outcome</b></p> <ol style="list-style-type: none"> <li>1. To give the students an overview of biomolecules.</li> <li>2. Recognize the structures and functions of biomolecules that form the basis of what we understand to be living organisms.</li> <li>3. Learn basic principles of structure and applications of carbohydrates, natural pigments, insect pheromones, and alkaloids.</li> <li>4. Understanding the use of nuclear magnetic resonance spectroscopy and advance nuclear magnetic resonance spectroscopy in diverse area of organic chemistry.</li> <li>5. Understanding multi-step synthesis of natural products with respect to reagents used, stereochemistry and functional group transformations.</li> <li>6. Understand general idea, structure, biological importance and application of prostaglandins, lipids, insect and plant growth regulators</li> </ol> <p><b>Learning outcomes:</b></p> <p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1. To understand various biomolecules.</li> <li>2. To understand the structures and functions of various biomolecules.</li> <li>3. To learn the principle and application of NMR spectroscopy.</li> <li>4. To learn multicomponent synthesis.</li> <li>5. To understand the structure, applications of some biomolecules like carbohydrates, Proteins, prostaglandins, lipids, insect and plant growth regulators.</li> </ol>

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### **Detailed syllabus of M.Sc. (Organic Chemistry) Semester – III Paper – IV**

Course Code	Topic	Credits
RJSPGCHEO304	<b>Medicinal, Biogenesis and Green Chemistry</b>	4
<b>Unit 1: Drug discovery, design and development</b> 1.1 Introduction, important terms used in medicinal chemistry: receptor, therapeutic index, bioavailability, drug assay and drug potency. General idea of factors affecting bioactivity: Resonance, inductive effect, bioisosterism, spatial considerations. Basic pharmacokinetics: drug absorption, distribution, metabolism (biotransformation) and elimination. Physical and chemical parameters like solubility, lipophilicity, ionization, pH, redox potential, H-bonding, partition coefficient and isomerism in drug distribution and drug-receptor binding. 1.2 Procedures in drug design: Drug discovery without a lead: Penicillin, Librium. Lead discovery: random screening, non-random (or targeted) screening. Lead modification: Identification of the pharmacophore, Functional group modification. Structure-activity relationship, Structure Modification to increase potency and therapeutic index: Homologation, chain branching, ring-chain transformation, bioisosterism, combinatorial synthesis (basic idea).		1
<b>Unit 2: Drug design, development and synthesis</b>		1

<p>2.1 Introduction to quantitative structure activity relationship studies. QSAR parameters: - steric effects: The Taft and other equations; Methods used to correlate regression parameters with biological activity: Hansch analysis- A linear multiple regression analysis.</p> <p>2.2 Introduction to modern methods of drug design and synthesis- computer aided molecular graphics-based drug design, drug design via enzyme inhibition (reversible and irreversible), bioinformatics and drug design.</p> <p>2.3 Concept of prodrugs and soft drugs. (a) Prodrugs: Prodrug design, types of prodrugs, functional groups in prodrugs, advantages of prodrug use. (b) Soft drugs: concept and properties.</p> <p>2.4 Synthesis and application of the following drugs: Fluoxetine, cetirizine, esomeprazole, fluconazole, zidovudine, methotrexate, diclofenac, labetalol, fenofibrate.</p>	
<p><b>Unit 3: Biogenesis and biosynthesis of natural products</b></p> <p>3.1 Primary and secondary metabolites and the building blocks, general pathway of amino acid biosynthesis.</p> <p><b>3.2 Acetate pathway:</b> Biosynthesis of malonyl CoA, saturated fatty acids, prostaglandins from arachidonic acid, aromatic polyketides.</p> <p><b>3.3 Shikimic Acid pathway:</b> Biosynthesis of shikimic acid, aromatic amino acids, cinnamic acid and its derivatives, lignin and lignans, benzoic acid and its derivatives, flavonoids and isoflavonoids.</p> <p><b>3.4 Mevalonate pathway:</b> Biosynthesis of mevalonic acid, monoterpenes –geranyl cation and its derivatives, sesquiterpenes – farnesyl cation and its derivatives and diterpenes.</p>	1
<p><b>Unit 4: Green chemistry</b></p> <p>4.1 Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and reaction conditions, green catalysts.</p> <p>4.2 Use of the following in green synthesis with suitable examples:</p> <p>a) <b>Green reagents:</b> dimethyl carbonate, polymer supported reagents.</p> <p>b) <b>Green catalysts:</b> Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts [Aliquat 336, benzyltrimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers], biocatalysts.</p>	1

<p>c) <b>Green solvents:</b> water, ionic liquids, deep eutectic solvents, supercritical carbon dioxide.</p> <p>d) <b>Solid state reactions:</b> solid phase synthesis, solid supported synthesis</p> <p>e) <b>Microwave assisted synthesis:</b> reactions in water, reactions in organic solvents, solvent free reactions.</p> <p>f) <b>Ultrasound assisted reactions.</b></p> <p>4.3 Comparison of traditional processes versus green processes in the syntheses of ibuprofen, adipic acid, 4-aminodiphenylamine, p-bromotoluene and benzimidazole.</p> <p>4.4 Green Catalysts: Nano catalyst, Types of nanocatalysts, Advantages and disadvantages of Nanocatalysts, Idea of Magnetically separable nanocatalysts.</p>	
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M.Sc.	Semester III Theory
<b>RJSPGCHEO304</b> <b>Paper IV</b> Medicinal, Biogenesis and green chemistry	<p><b>Course Outcome:</b></p> <ol style="list-style-type: none"> <li>1. To familiarize students with drug discovery, design, and development.</li> <li>2. To understand the uses of QSAR, computer in design, development, and synthesis of drugs.</li> <li>3. To study the synthesis and application of different drugs</li> <li>4. Students will learn about biogenesis, the nature of a variety of metabolic pathways, the regulation of these pathways and the mechanisms by which regulation is accomplished.</li> <li>5. To familiarize the student with basic principle and application of green chemistry with suitable examples of reagents, catalyst, solvent and modern reaction methods.</li> </ol> <p><b>Learning outcomes:</b></p> <p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1. To understand concept of drug discovery and development.</li> <li>2. To learn meaning and application of QSAR.</li> <li>3. To learn various metabolic pathways.</li> <li>4. To understand the importance of Green Chemistry.</li> <li>5. To learn various green reactions.</li> </ol>

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### **M.Sc. (Organic Chemistry) Semester – III Practicals**

RJSPGCHEPRO301	<b>Theoretical Organic Chemistry - I Practical</b>
<b>Separation of a solid ternary mixture using micro-scale technique</b> 1. Separation of solid components of a ternary mixture (water insoluble/soluble including carbohydrates) based upon differences in the physical and the chemical properties of the components. 2. Purification of the three components, measurement of their mass and determination of their physical constants. 3. Calculation of percentage yields of the individual components. (Identification of the components is not expected). <b>(Minimum 6 mixtures)</b>	

M.Sc.	Semester III Practical
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<p>RJSPGCHEPRO301</p> <p>Practical I</p> <p>Separation of a ternary mixture of organic compounds and identification including derivative preparations using micro-scale technique</p> <p><b>Theoretical Organic Chemistry - I Practical</b></p>	<p>Course Outcome:</p> <p>To be able to resolve the given solid ternary mixture into its components. 2. To be able to do the recrystallization into pure components. 3. To be able to record the correct melting point of it.</p> <p>Learning outcome:</p> <ol style="list-style-type: none"> <li>1. To understand and employ concept of type determination and separation of organic tertiary solid mixture.</li> <li>2. Purify (recrystallize/distill) the separated compounds.</li> <li>3. Meticulously record physical constants.</li> </ol>
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RJSPGCHEPRO302	<b>Synthetic Organic Chemistry - I Practical</b>
<ol style="list-style-type: none"> <li>1. Estimation of penicillin by iodometric titrations.</li> <li>2. Estimation of streptomycin using uv-visible spectrophotometer.</li> <li>3. Estimation of paracetamol by hydrolysis.</li> <li>4. Estimation of aspirin in the given tablet using uv-visible spectrophotometer.</li> <li>5. Estimation of diazepam by non-aqueous titrations.</li> <li>6. Estimation of vitamin C by iodometric titrations.</li> </ol>	

M.Sc.	Semester III Practical
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RJSPGCHEPRO302  Practical II  <b>Synthetic Organic Chemistry - I Practical</b>	Course Outcome:  1. To be able to prepare standard solutions needed for drug estimation. 2. To know the complete working and application of UV visible spectrometer. 3. Using it quantitative determination of certain drugs.  Learning outcome:  1. Preparation of standard solutions and reagents. 2. To understand the working principle and handling of uv-visible spectrophotometer. 3. To perform quantitative estimation of a drug in terms of functional group/s it possesses.
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RJSPGCHEPRO303	<b>Natural Products and Spectroscopy Practical</b>
<b>Organic preparations (1.0 g scale)</b>  1. Benzilic acid rearrangement: Benzilic acid from benzil 2. Sandmeyer reaction: p-Nitroiodobenzene from p-nitroaniline 3. Heterocyclic compound: 7-Hydroxy-4-methylcoumarin from resorcinol 4. Acetylation: Mannitol hexaacetate from mannitol 5. Claisen-Schmidt reaction: Dibenzalacetone from benzaldehyde 6. Oxidation: Fluorenone from fluorene 7. Acetylation: Acetylferrocene from ferrocene	

M.Sc.	Semester III Practical
RJSPGCHEPRO303 Practical III <b>Natural Products and Spectroscopy Practical</b>	<p>Course Outcome:</p> <ol style="list-style-type: none"> <li>1. Students are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS (ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.</li> <li>2. Students are expected to purify the final product by recrystallization, measure its mass, check the purity by TLC, determine physical constant, characterize using any spectroscopic method/s and calculate percentage yield.</li> </ol> <p>Learning outcome:</p> <ol style="list-style-type: none"> <li>1. To know the complete MSDS and the exact planning of synthesis.</li> <li>2. To characterize the product obtained by various spectroscopy techniques.</li> <li>3. To be able to purify the final product and determine the physical constant.</li> </ol>

RJSPGCHEPRO304	<b>Medicinal, Biogenesis and Green Chemistry Practical</b>
<p>A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard text-book/reference material etc .</p> <p><b>(Minimum 8 spectral analysis)</b></p>	

M.Sc.	Semester III Practical
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<p>RJSPGCHEPRO304</p> <p>Practical IV</p> <p><b>Medicinal, Biogenesis and Green Chemistry Practical</b></p>	<p>Course Outcome:</p> <ol style="list-style-type: none"> <li>1. To know the technique of reading different types of spectra of an organic compound.</li> <li>2. To develop the skill of spectral interpretation and compilation of the data to identify the probable structure of an organic compound.</li> </ol> <p>Learning outcome:</p> <ol style="list-style-type: none"> <li>1. To know the spectral interpretation of various organic compounds.</li> <li>2. To identify the compound from the given spectral data.</li> </ol>
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#### References for Practicals

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**Affiliated to**  
**UNIVERSITY OF MUMBAI**

**Proposed syllabus for the M.Sc. Part – II**  
**Sem III**

**Program: M.Sc. (Analytical Chemistry)**

**Program Code: RJSPGCHEA**

**CBCS: 2020 -2021**

**M.Sc. (Analytical Chemistry) Semester – III**

Course	Nomenclature	Credits	Topics
RJSPGCHEA301	Quality In Analytical Chemistry	4	1) Quality In Analytical Chemistry – I 2) Quality In Analytical Chemistry – II 3) Chromatographic Techniques –I 4) Chromatographic Techniques -II
RJSPGCHEA302	Advance Instrumental Techniques	4	1) Spectral Methods I 2) Spectral Methods – II 3) Electroanalytical Methods 4) Miscellaneous Techniques
RJSPGCHEA303	Bioanalytical Chemistry & Food Analysis	4	1) Bioanalytical chemistry 2) Immunological Methods 3) Food Analysis – I 4) Food Analysis - II
RJSPGCHEA304	Pharmaceutical & Organic Analysis	4	1) Air Pollution 2) Water Quality Standards 3) Other Types Of Pollution 4) Industrial Materials 5) Pharmaceutical Analysis 6) Drugs 7) Forensic Science 8) Cosmetic Analysis

RJSPGCHEPRA301	Quality In Analytical Chemistry Practical	8	Quality In Analytical Chemistry Practical
RJSPGCHEPRA302	Advance Instrumental Techniques Practical		Advance Instrumental Techniques Practical
RJSPGCHEPRA303	Bioanalytical Chemistry & Food Analysis Practical		Bioanalytical Chemistry & Food Analysis Practical
RJSPGCHEPRA304	Pharmaceutical & Organic Analysis Practical		Pharmaceutical & Organic Analysis Practical

**Detailed syllabus of M.Sc. (Analytical Chemistry) Semester – III Paper – I**

Course Code	Topic	Credits
RJSPGCHEA301	QUALITY IN ANALYTICAL CHEMISTRY	4
<b>UNIT I Quality in Analytical Chemistry - I</b> 1.1 Sampling: Definition, types of samples, sampling plan, quality of sample, subsampling, Sampling of raw materials, intermediates and finished products. Sample preparations – dissolution technology and decomposition, storage of samples. Pre-treatment of samples: soil, food and cosmetics. 1.2 Selection of the Method: sources of methods, factors to consider when selecting a method, performance criteria for methods used, reasons for incorrect analytical results, method validation, and quality by design (PAT).		1
<b>UNIT II Quality in Analytical Chemistry - II</b> 2.1 Measurement of uncertainty: Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results.		1

2.2 Signal to noise: Signal to noise ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction, software methods for noise reduction.	
2.3 Pharmaceutical Legislation: introduction to drug acts, drug rules (schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration.	
<b>UNIT III Chromatographic Techniques -I</b> 3.1 Ion exchange chromatography: Ion exchange equilibria, breakthrough capacity, inorganic ion exchangers, synthetic ion exchangers, chelating resins and their applications for separation of inorganic and organic compounds.  3.2 Ion chromatography: Principle, instrumentation with special reference to separation and suppressor columns, applications.  3.3 Exclusion chromatography : Theory, instrumentation and applications of gel permeation chromatography, retention behavior, inorganic molecular sieves, determination of molecular weight of polymers,	1
<b>UNIT IV Chromatographic Techniques -II</b> 4.1 Supercritical fluid Chromatography: Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis.  4.2 Affinity Chromatography: principle, instrumentation and applications 4.3 Optimum pressure liquid chromatography (OPLC)	1

M.Sc.	Semester III Theory
<b>RJSPGCHEA301</b> <b>Paper I</b> QUALITY IN ANALYTICAL CHEMISTRY	<b>Course Outcome</b> <ol style="list-style-type: none"> <li>1) understand the basic concepts of sampling in laboratories.</li> <li>2) understand the concept of method validation.</li> <li>3) implement good laboratory practices while working in the laboratory.</li> <li>4) understand the concept of sources of noise in instrumental analysis.</li> <li>5) understand the basic concepts of ion chromatography and various other techniques of chromatography.</li> </ol> <b>Learning outcomes:</b>

	<p><i>After completing this course students will be able to:</i></p> <ol style="list-style-type: none"> <li>1) Interpret the way analytical chemistry is used. Also, understand the concept of quality.</li> <li>2) implement good laboratory practices while working in the laboratory.</li> <li>3) understand the basic concepts of measurement of uncertainty.</li> <li>4) understand the basic concepts of ion exchange chromatography.</li> <li>5) understand the basic concepts of exclusion chromatography.</li> <li>6) understand the basic concept of Supercritical fluid Chromatography, affinity Chromatography and Optimum pressure liquid chromatography (OPLC), exclusion chromatography.</li> </ol>
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**List of books and references:**

1. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997.
2. Quality assurance in analytical Chemistry, W Funk, V Dammann, G. Donnevert VCH Weinheim 1995.
3. Amit S. Patil *et. al.*, Quality by Design (QbD) : A new concept for development of Quality pharmaceuticals, International Journal of Pharmaceutical Quality Assurance; 4(2); 13-19.
4. Lalit Singh and Vijay Sharma, Quality by Design (QbD) Approach in Pharmaceuticals: Status, Challenges and Next Steps, Drug Delivery Letters, 2015, 5, 2-8. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997
5. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West, Saunders, College publication.
6. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
7. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
8. Analytical Chemistry, G. D. Christain, Wiley
9. Extraction Chromatography T. Braun, G. Gherse, Elsevier Publications 1978.
- 10 Supercritical Fluid Extraction, Larry Taylor Wiley publishers N.Y. 1996
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- 12 Ion exchange chromatography Ed H.F Walton Howden, Hutchenson and Rossing 1976
13. Chromatographic and electrophoresis techniques I Smith Menemann Interscience 1960

**Detailed syllabus of M.Sc. (Analytical Chemistry) Semester – III Paper – II**

Course Code	Topic	Credits
RJSPGCHEA302	Advance Instrumental Techniques	4
<b>UNIT I Spectral Methods I</b>  1.1 Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis.  1.2 Principle, instrumentation and applications of the following: a. Secondary Ion mass spectroscopy. b. Particle-Induced X-Ray Emission c. Low-Energy Ion Scattering and Rutherford Backscattering		1
<b>UNIT II Spectral Methods – II</b> Principle, Instrumentation, and Applications of 2.1 Electron Spin Resonance Spectroscopy (ESR)  2.2 Mossbauer's Spectroscopy  2.3 Atomic Emission Spectroscopy- based on plasma and electrical discharge sources		1
<b>UNIT III Electroanalytical Methods</b> Advanced Electroanalytical Techniques: 3.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography 3.2 Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry. 3.3 Potential Step method- Chronoamperometry 3.4 Controlled potential technique- Chronopotentiometry 3.5 Stripping Voltammetry- anodic, cathodic, and adsorption 3.6 Chemically and electrolytically modified electrodes and ultramicroelectrodes in voltammetry		1

<b>UNIT IV Miscellaneous Techniques</b>  Principle, Instrumentation and Applications of: 4.1 Chemiluminescence techniques 4.2 Chirooptical Methods: ORD, CD 4.3 Photoacoustic spectroscopy 4.4 Spectro electrochemistry	1
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M.Sc.	Semester III Theory
<b>RJSPGCHEA302</b> <b>Paper II</b> Advance Instrumental Techniques	<b>Course Outcome</b> <ol style="list-style-type: none"> <li>1) To understand the basic concept of various spectral methods like ESR, Mossbauer's spectroscopy and atomic Emission Spectroscopy which is based on plasma and electrical discharge sources.</li> <li>2) the basic concept of various Electroanalytical methods like Controlled potential technique- Chronopotentiometry, Stripping Voltammetry- anodic, cathodic, and adsorption, Chemically and electrolytically modified electrodes and ultramicroelectrodes in voltammetry.</li> <li>3) understand the basic concept of various techniques of spectroscopy.</li> </ol> <b>Learning outcomes:</b> <i>After completing this course students will be able to:</i> <ol style="list-style-type: none"> <li>1. understand the basic concept of various surface analytical techniques like secondary ion mass spectroscopy, particle induced X-ray emission method and low energy ion scattering and Rutherford backscattering method.</li> <li>2. the basic concept of various Electroanalytical methods like Normal and Differential Pulse Polarography, Potential Step method like Chronoamperometry.</li> <li>3. understand the basic concept of various techniques like Chemiluminescence techniques, Chirooptical Methods: ORD, CD, Photoacoustic spectroscopy and Spectroelectrochemistry.</li> </ol>

**List of books and references:**

1. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
2. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J. A. Niemann, 5th Edition (1998)
4. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A. Dean and F. A. Settle Jr 6th Ed CBS (1986)
5. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)
6. Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987)
7. Electrochemical Methods, A. J. Bard and L. R. Faulkner, John Wiley, New York, (1980)
8. Electroanalytical Chemistry, J. J. Lingane, 2nd Ed Interscience, New York (1958)
9. Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker, New York, 1980.
10. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (A series of volumes)
11. Techniques and mechanism of electrochemistry, P. A. Christian and A. Hamnett, Blachie Academic and Professional (1994)
12. Wilson and Wilson's Comprehensive Analytical Chemistry, Ed. G. Svehla. (A series of Volumes)
13. Treatise on Analytical Chemistry, Eds. I. M. Kolthoff and Others, Interscience Pub. (A series of volumes).
14. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, (A series of volumes)
15. Polarographic Methods in Analytical Chemistry, M. G. Arora, Anmol Publications Pvt Ltd
- 16 Surface Analysis –The Principal Techniques, 2nd Edition Edited by John C. Vickerman and Ian S. Gilmore 009 John Wiley & Sons, Ltd. ISBN: 978-0-470-01763-0
17. NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry *R. V. Parish*. Ellis Horwood, Chichester

**Detailed syllabus of M.Sc. (Analytical Chemistry) Semester – III Paper – III**

Course Code	Topic	Credits
RJSPGCHEA303	Bioanalytical Chemistry and Food Analysis	4
<b>UNIT I Bioanalytical Chemistry</b> 1.1 Body Fluids 1.1.1 Composition of body fluids and detection of abnormal levels of glucose, creatinine, uric acid in blood, protein, ketone bodies and bilirubin in urine leading to diagnosis of diseases. 1.1.2 Physiological and nutritional significance of vitamins (water soluble and fat soluble) and minerals.		1

1.1.3 Analytical techniques (including microbiological techniques) for vitamins.	
<b>UNIT II Immunological Methods</b>  2.1 General processes of immune response, antigen-antibody reactions, precipitation reactions, radio, enzyme and fluoro-immuno assays.  2.2 Human Nutrition: Biological values and estimation of enzymes, carbohydrates, proteins, essential amino acids and lipids.	1
<b>UNIT III Food Analysis - I</b> 3.1 <b>Fuel value of food</b> and importance of food nutrients 3.2 <b>Food Additives:</b> General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. Analysis of food products for flavoring agents and colour. 3.3 <b>Food Contaminants:</b> Trace metals and pesticide residues, contaminants from industrial wastes (polychlorinated polyphenols, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants.	1
<b>UNIT IV Food Analysis - II</b> 4.1.1 Food packaging: Introduction, types of packing materials, properties and industrial requirements.  4.1. 2 Processing and Quality requirements of Milk and milk products (cheese, butter and ice cream), vegetables and fruits, meat and meat products.  4.2 <b>Analysis of Milk:</b> Fat content, proteins, acidity, bacteriological quality and milk adulterants. 4.3 <b>Analysis of Oils and Fats:</b> acid value, sap value, iodine value. Determination of rancidity and antioxidants. 4.4 <b>Analysis of spices:</b> (cloves, cinnamon, pepper, mustard) Determination of volatile oils and fixed oils.	1

M.Sc.	Semester III Theory
<b>RJSPGCHEA303</b> <b>Paper III</b>	<b>Course Outcome</b> to understand the basic concept of various techniques of 1) Analysis of biofluids like blood urine etc

<b>Bioanalytical Chemistry and Food Analysis</b>	<ol style="list-style-type: none"> <li>2) Analysis of various components of biofluids like glucose, protein and vitamin</li> <li>3) Immunological system, immuno assays.</li> <li>4) Fuel value of food, Food Additives, Food Contaminants Food packaging, Processing and Quality requirements, analysis of food products.</li> </ol> <p><b>Learning outcomes:</b></p> <p>On successful completion of this course students will be able to understand the basic concept of various techniques of</p> <ol style="list-style-type: none"> <li>1) Analysis of biofluids like blood urine etc.</li> <li>2) Analysis of various components of biofluids like glucose,protein and vitamin</li> <li>3) Immunological system, immuno assays.</li> <li>4) Fuel value of food, Food Additives, Food Contaminants Food packaging, Processing and Quality requirements, analysis of food products, like milk ,oil fat and spices.</li> </ol>
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#### List of books and References:

1. General, organic and biological chemistry, H. Stephen Stoker, Cengage Learning.
2. Advance dairy chemistry, vol 3, P. F. Fox, P. L. H. McSweeney Springer.
3. Physiological fluid dynamics vol 3, Nanjanagud Venkatanarayanasastri Chandrasekhara Swamy Narosa Pub. House, 1992
4. Molecular Biological and Immunological Techniques and Applications for food, edited by Bert Popping, Carmen Diaz-Amigo, Katrin Hoenicke, John Wiley & sons.
5. Food Analysis: Theory and practice, Yeshajahu Pomeranz, Clifton E. Meloan, Springer.
6. Principles of package development, Gribbin et al
7. Modern packaging Encyclopedia and planning guide, Macgra Wreyco.
8. Food Analysis, Edited by S. Suzanne Nielsen, Springer
9. Analytical Biochemistry, D, J. Homes and H. Peck, Longman (1983)
10. Bioanalytical Chemistry, S. R. Mikkelesen and E. Corton, John Wiley and sons 2004 Analysis of food and beverages, George Charalanbous, Accademic press 1978

### Detailed syllabus of M.Sc. (Analytical Chemistry) Semester – III Paper – IV

Course Code	Topic	Credits
RJSPGCHEA304	Environmental and Certain Industrially Important Materials	4

<b>UNIT I Air Pollution</b> 1.1 Sources, classification, pollutants and permissible limits. 1.2 Sampling methods for air, flue gas, Industrial Exhaust, stag samples etc. 1.3 Importance of automobile exhaust control and its limits  1.4 Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors.  1.5 Carbon credit and global issues related to air pollution. 1.6 Greenhouse gases and their substitutes. 1.7 Environmental Legislation: role of pollution control boards, article 48A and 51A, Motor Vehicle Act and method of analysis with respect to PUC.	1
<b>UNIT II Water Quality Standards</b>  2.1 Water: quality and requirements of potable water, direct and indirect pollutants for potable water reservoirs, quality of potable water from natural sources. 2.2 Bore well water quality and analytical parameters. Quality of bottled mineral water  2.3 Process of purification of bore well water to bottled mineral water. 2.4 Regulatory requirements for packaged drinking water	1
<b>UNIT III Other Types of Pollution</b> <b>3.1 Soil pollution and Soil Analysis:</b> sources of soil pollution and their control, sampling of soil, determination of water holding capacity, determination total nitrogen, ammonia and nitrates, fertility of soil and effect of pollution on it, synthetic fertilizers and their long-term effect on soil quality. <b>3.2 Noise Pollution:</b> sources, effects, methods of measurements and control measures.  <b>3.3 Thermal Pollution:</b> definition, source, impact, control measures, working of cooling towers and cooling ponds, involved economy. <b>3.4 Radioactive pollutants:</b> source, exposure hazards, precautions in handling and safety, long term effects. <b>3.5 Environmental Audits:</b> concept of audit, authorities, evaluation methodology, benefits and certification	1
<b>UNIT IV Industrial Materials</b> 4.1 Insecticides, Pesticides: definition, classification of insecticides pesticides. Biodegradation of insecticides and pesticides.	1

<p>4.2 Soaps and Detergents: classification and composition, qualitative analysis, quantitative analysis of detergents- alkalinity, active ingredients and oxygen releasing capacity. Biodegradable detergents.</p> <p>4.3 Petrochemical products: crude oils, fuels, and calorific values, fractional distillation process and fractions, properties of fuel, composition of fuel, flashpoint, fire point, corrosion test, carbon residue and impact on environment.</p>	
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M.Sc.	Semester III Theory
<b>RJSPGCHEA304</b> <b>Paper IV</b> <b>Environmental and Certain Industrially Important Materials</b>	<p><b>Course Outcome</b></p> <p>On successful completion of this course students will be able to understand the basic concept of</p> <ol style="list-style-type: none"> <li>1) pollutants and permissible limits, Sources, classification, Sampling methods of various gases, Carbon credit, Greenhouse gases, and acts related to it.</li> <li>2) water quality standards purification process of bore well water, Regulatory requirements for packaged water.</li> <li>3) Other Types of Pollution like Soil pollution, Noise Pollution, Thermal Pollution, Radioactive pollutants, Soil Analysis, Environmental Audits.</li> <li>4) Industrial Materials like Insecticides, Pesticides, Soaps and Detergents, Petrochemical products.</li> </ol> <p><b>Learning outcomes:</b></p> <p>On successful completion of this course students will be able to understand the basic concept of</p> <ol style="list-style-type: none"> <li>1) pollutants and permissible limits, Sources, classification, Sampling methods of various gases, Carbon credit, Greenhouse gases, and acts related to it.</li> <li>2) water quality standards purification process of bore well water, Regulatory requirements for packaged water.</li> <li>3) Other Types of Pollution like Soil pollution, Noise Pollution, Thermal Pollution, Radioactive pollutants, Soil Analysis, Environmental Audits.</li> <li>4) Industrial Materials like Insecticides, Pesticides, Soaps and Detergents, Petrochemical products</li> </ol>

**List of Books and References:**

1. Environmental Chemistry, A. K. De, 2<sup>nd</sup> ED. Wiley (1989).
2. Environmental Pollution Analysis, S. M. Khopkar, John Wiely (1993).
3. Air Pollution Sampling And Analysis, Sharad Gokhale, IIT Guwahati, May 2009.

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6. Water pollution, Arvind kumar, APH publishing (2004)
7. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paper back publication.
8. Guidelines for drinking-water quality, Third edition, (incorporating first and second addenda). WHO report.
9. Soil pollution, S.G. Misra and Dinesh Mani, APH Publishing Corporation, (2009).
10. Soil Pollution: origin, monitoring and remediation, Abraham Mirsal, Springer (2010).
11. Noise Pollution, Donald F Anthrop, Lexington Books, (1973)
12. Noise Effects Handbook: A Desk Reference to Health and Welfare Effects of Noise (1981) Available at NCL laboratories e- Library.
13. Chemistry, Emission Control, Radioactive Pollution and Indoor Air Quality Edited by Nicolas Mazzeo, InTech Publications (2011).
14. Environmental Protection Against Radioactive Pollution: N. Birsen, Kairat K. Kadyrzhanov, Springer publication , (2003).
15. Environmental law in India, Mohammad Naseem, Wolters Kluwer.
16. Environmental Protection, Law And Policy In *India* Kailash Thakur google books (1997).
17. Green chemistry An Introductory text, Mzike Lancaster, Royal Society of Chemistry (2002)
18. Pesticide Analysis Ed K. G. Das, Dekker (1981)
19. Analytical, Agricultural Chemistry S. L Chpra J.S Kanwar Kalyani publication
20. Soil and plant Analysis C.S Piper, Hans Publication

### **Detailed syllabus of M.Sc. (Analytical Chemistry) Semester – III Paper – IV**

Course Code	Topic	Credits
RJSPGCHEA304	<b>Pharmaceutical and Organic Analysis</b>	4
<b>UNIT I Pharmaceutical Analysis</b> 1.1 General idea regarding the Pharmaceutical Industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries. 1.2 Sources of impurities in pharmaceutical products and raw materials 1.3 Standardization of finished products and their characteristics, official methods of quality control.		1

<b>UNIT II Drugs</b> 2.1 Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests. 2.2 Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies. Polymers in pharmaceuticals and novel drug delivery systems.	1
<b>UNIT III Forensic Science</b> 3.1 Analytical Chemistry in Forensic Science: General idea. 3.2 Forensic Analysis: Blood, DNA profiling, Hair analysis, Alcohol in body fluids, systematic drug identification. 3.3 Analytical Toxicology: Isolation, identification and determination of: 3.3.1 Narcotics: Heroin, morphine and cocaine. 3.3.2 Stimulants: Amphetamines and caffeine. 3.3.3 Depressants: Benzodiazepines, Barbiturates and Mandrax. 3.3.4 Hallucinogens: LSD and Cannabis. 3.3.5 Metabolites of drugs in blood and urine of addicts. 3.3.6 Viscera, stomach wash, vomit and postmortem blood for poisons like– cyanide, arsenic, mercury, insecticides and pesticides.	1
<b>UNIT IV Cosmetic Analysis</b> 4.1 Cosmetics: Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis. 4.2 Deodorants and antiperspirants: Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methenamine, phenol sulphonates and urea. 4.3 Face powder: Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total). 4.4 Hair tonic: 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers) 4.5 Creams and Lotions: Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) 4.6 Lipsticks: General analysis, determination of - nonvolatile matter, lakes and fillers, trichloroethylene-acetone soluble contents.	1

M.Sc.	Semester III Theory
<b>RJSPGCHEA304</b> <b>Paper IV</b>	<b>Course Outcome</b> <b>On successful completion of this course students will be able to</b>

<p><b>Pharmaceutical and Organic Analysis</b></p>	<p><b>understand the basic concept of</b></p> <ol style="list-style-type: none"> <li>1) General idea regarding the Pharmaceutical Industry, formulations, dosage forms. Role of FDA in pharmaceutical industries, Sources of impurities, Standardization of finished products and their characteristics</li> <li>2) Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies. Polymers in pharmaceuticals, assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays</li> <li>3) Analytical Chemistry in Forensic Science, Forensic Analysis, Analytical Toxicology.</li> <li>4) Cosmetics, Deodorants and antiperspirants, Face powder, Hair tonic, Lipsticks, Creams and Lotions and their analysis.</li> </ol> <p><b>Learning outcomes:</b></p> <p><b>On successful completion of this course students will be able to understand the basic concept of</b></p> <ol style="list-style-type: none"> <li>1) General idea regarding the Pharmaceutical Industry, formulations, dosage forms. Role of FDA in pharmaceutical industries, Sources of impurities, Standardization of finished products and their characteristics</li> <li>2) Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies. Polymers in pharmaceuticals, assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays</li> <li>3) Analytical Chemistry in Forensic Science, Forensic Analysis, Analytical Toxicology.</li> <li>4) Cosmetics, Deodorants and antiperspirants, Face powder, Hair tonic, Lipsticks, Creams and Lotions and their analysis.</li> </ol>
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## References

- 1) Analytical Biochemistry, David J Holmes and Hazel Peck, Longman, 1983.
- 2) Bioanalytical Chemistry, Susan R Mikkelesen and Eduardo Cotton, John Wiley and Sons, 2004.
- 3) Analysis of food and beverages, George Charalanbous, Academic press, 1978.
- 4) Harry's Cosmetology, 7<sup>th</sup> Ed, Longman Scientific Co.
- 5) Formulation and Function of Cosmetics, Joseph Stefan Jellinek, Wiley Interscience, 1971.

- 6) Cosmetic Technology, Edward Sagarin, Interscience Publishers, 1957.
- 7) Modern Cosmetics, Edgar George Thommsen, Francis Chilson, Drug and Cosmetic Industry, 1947.
- 8) Encyclopedia of Industrial Chemical Analysis, Foster Dee Snell et al, Interscience Publishers, 1967.
- 9) Government of India Publications of Food, Drug and Cosmetic Act and Rules.
- 10) The Handbook of Drug Laws, M L Mehra, University Book Agency, Ahmedabad, 1997.
- 11) Chemical Analysis of Drugs, Takeru Higuchi, Interscience Publishers, 1995.
- 12) Text book of Pharmaceutical Analysis, Kenneth Antonio Connors, Wiley, 2001.
- 13) Food Processing and Preservation, B Sivasankar, Prentice - Hall of India Private Limited, 2007.
- 14) Food Additives, R M Pandey and S K Upadhyay, INTECH, Open Science/Open Minds.
- 15) Food Science, B Srilakshmi, New Age International (P) Ltd. Publishers, 2003.
- 16) Food Contaminants: Sources and Surveillance, Edited by C Creaser, R Purchase, Elseiver, 1991.
- 17) The Chemical Analysis of Food and Food Products, Morris B Jacobs.
- 18) FSSAI (Food Safety and Standards Authority of India) Manuals of Methods of Analysis of Foods (Oils and Fats, Milk and Milk Products, Food Additives), Ministry of Health and Family Welfare, Government of India.
- 19) Fundamentals of Urine and Body Fluid Analysis, Nancy A Brunzel, Elsevier health Sciences, 2013.
- 20) Lab Manual on Blood analysis and Medical Diagnostics, Dr Gayatri Prakash, S Chand and Company Ltd, New Delhi.
- 21) Manual of Medical Laboratory Techniques, S Ramakrishnan and K N Sulochana, Jaypee brothers Medical Publishers (P) Ltd, 2012.
- 22) Indian Pharmacopeia, Volume I and II.
- 23) Forensic Chemistry, Suzanne Bell, Pearson Prentice Hall Publication, 2006.
- 24) Forensic Chemistry, David E Newton, Infobase Publishing, 2007.
- 25) Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, 1995.
- 26) AOAC Volume I and II.

### **M.Sc. (Analytical Chemistry) Semester – III Practicals**

RJSPGCHEPRA301	Quality In Analytical Chemistry Practical
<ol style="list-style-type: none"> <li>1. Determination of the pK value of an indicator.</li> <li>2. Determination of copper and bismuth in mixture by photometric titration.</li> <li>3. Estimation of strong acid, weak acid and salt in the given mixture conductometrically.</li> <li>4. Analysis of mixture of carbonate and bicarbonate (present in ppm range) using pHmetry.</li> <li>5. Determination of copper by extractive photometry using diethyldithiocarbamate.</li> </ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRA301 Practical I Group A Quality In Analytical Chemistry Practical	<p>Course Outcome:</p> <ul style="list-style-type: none"> <li>➤ To impart the knowledge of various ways of analyzing various chemicals</li> </ul> <p>Learning outcome:</p> <ul style="list-style-type: none"> <li>➤ Have experience of handling various instruments and preparation of samples for it.</li> </ul>

RJSPGCHEPRA302	Advance Instrumental Techniques Practical
<ol style="list-style-type: none"> <li>1. Estimation of drugs by non-aqueous titration: Pyridoxine hydrochloride, sulphamethoxazole.</li> <li>2. Determination of percentage purity of methylene blue indicator.</li> <li>3. Estimation of cholesterol and Uric acid in the given sample of blood serum</li> <li>4. Estimation of fluoride in a tooth paste.</li> <li>5. Determination of silica by molybdenum blue method.</li> </ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRA302 Practical II Group B Advance Instrumental Techniques Practical	<p>Course Outcome:</p> <p>To impart the knowledge of various ways of analyzing various commercial samples, biofluids drugs etc.</p> <p>Learning outcome:</p> <p>Have experience of handling various instruments and preparation of samples for it.</p>

RJSPGCHEPRA303	Bioanalytical Chemistry & Food Analysis Practical
<ol style="list-style-type: none"><li>1. Total reducing sugars before and after inversion in honey using: (a) Cole's Ferricyanide (b) Lane - Eynon method.</li><li>2. Analysis of lactose in milk</li><li>3. Estimation of Caffeine in tea</li><li>4. Estimation of Vitamin C in lemon Juice/squash by Dichlorophenol-indophenol method</li><li>5. Iodine value of oil / fat</li><li>6. Analysis of alcoholic beverages (Beer) for alcohol content by distillation followed by specific gravity method, acidity by titration, total residue by evaporation.</li></ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRA303 Practical III Group C Bioanalytical Chemistry & Food Analysis Practical	<p>Course Outcome:</p> <p>To impart the knowledge of various ways of analyzing various food samples.</p> <p>Learning outcome:</p> <p>Have experience of handling various instruments and preparation of samples for it.</p>

RJSPGCHEPRA304	Pharmaceutical & Organic Analysis Practical
<ol style="list-style-type: none"><li>1. To analyze Pyrolusite for: Fe by colorimetry and / or Mn by volumetry.</li><li>2. To analyze Magnesium for Mg by complexometry.</li><li>3. Analysis of Bauxite for Ti by colorimetry / Al by gravimetry / Fe (volumetry)</li><li>4. Analysis of water sample: Total hardness and salinity.</li><li>5. Analysis of water sample: Acidity and sulphate(Benzidine method).</li></ol>	

M.Sc.	Semester III Practical
RJSPGCHEPRA304 Practical III Group D Pharmaceutical & Organic Analysis Practical	Course Outcome:  To impart the knowledge of various ways of analyzing various alloys and water sample  Learning outcome:  Have experience of handling various instruments and preparation of samples for it.

**NOTE:**

1. The candidate is expected to submit a journal certified by the Head of the Department / institution at the time of the practical examination.
2. A candidate will not be allowed to appear for the practical examination unless he / she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate. Use of non-programmable calculator is allowed both at the theory and the practical examination.