

Courses (i.e., Papers) Offered (Structure of the Programme): M.Sc., Pharmaceutical Chemistry					
Paper Code	Paper Type	Title of the Paper	Hrs.	Credits	Total Credit points/Semester
<b>FIRST SEMESTER</b>					
PC.HC. 1.01	Hardcore	Inorganic Chemistry	4	4	22
PC.HC.1.02	Hardcore	Organic Chemistry	4	4	
PC.HC. 1.03	Hardcore	Physical Chemistry	4	4	
PC.HC. 1.04	Hardcore	Analytical Chemistry	4	4	
PC.1.05	Practical-I	Inorganic Chemistry	4	2	
PC.1.06	Practical-II	Organic Chemistry	4	2	
PC.1.07	Practical-III	Physical Chemistry	4	2	
<b>SECOND SEMESTER</b>					
PC.HC. 2.01	Hardcore	Advanced Inorganic Chemistry	4	4	24
PC.HC.2.02	Hardcore	Advanced Organic Chemistry	4	4	
PC.HC. 2.03	Hardcore	Advanced Physical Chemistry	4	4	
PC.HC. 2.04	Hardcore	Advanced Analytical Chemistry and Nano Chemistry	4	4	
PC.2.05	Elective	Drug Discovery	2	2	
PC.2.06	Practical-I	Advanced Inorganic Chemistry	4	2	
PC.2.07	Practical-II	Advanced Organic Chemistry	4	2	
PC.2.08	Practical-III	Advanced Analytical Chemistry	4	2	
<b>Total Credit points</b>					<b>46</b>
<b>THIRD SEMESTER</b>			<b>Hrs.</b>	<b>Credits</b>	<b>Total Credit</b>
PC.HC. 3.01	Hardcore	Spectroscopy Techniques	4	4	22
PC.HC. 3.02	Hardcore	Bioorganic Chemistry	4	4	
PC.SC. 3.21	Softcore	Separation Techniques	3	3	
PC.SC. 3.22	Softcore	Pharmaceutical Analysis	3	3	
PC.SC. 3.23	Softcore	Drug discovery and Development	3	3	
PC.3.03	Elective	Dosage Forms And Routes Of Drug Administration	2	2	
PC. 3.04	Practical-I	Synthesis of Drugs and Drug intermediates-I	4	2	
PC.3.05	Practical-II	Separation Techniques	4	2	
PC.3.06	Practical-III	Assay of Drugs by titrimetric and instrumental methods-I	4	2	
<b>FOURTH SEMESTER</b>					
PC.HC. 4.01	Hardcore	Medicinal Chemistry-I	4	4	22
PC.HC.4.02	Hardcore	Medicinal Chemistry-II	4	4	
PC.SC.4.21	Softcore	General Pharmacology	3	3	
PC.SC. 4.22	Softcore	Dosage forms and regulatory aspects	3	3	
PC.SC. 4.23	Softcore	Biopharmaceutics	3	3	
PC.4.03	Practical-I	Synthesis of Drugs and Drug intermediates-II	4	2	
PC. 4.04	Practical-II	Assay of Drugs by titrimetric and Instrumental methods-II	4	2	
PC.4.05	Practical-III	Project work	4	4	
<b>Total Programme Credit points</b>					

Note: Among three soft core papers students have a choice to opt any two.

## FIRST SEMESTER

### Paper 1: PC. HC. 1.01 Inorganic Chemistry

64 Hours

#### Unit-I

##### PERIODIC PROPERTIES

16 Hrs

- Review of periodicity and properties:** Atomic size, ionic radii, ionization potential, electron affinity and electronegativity. Applications of electronegativity.
- General characteristics of s, p, d, f, block elements:** Comparative studies with reference to electronic configuration, relative study of various oxidation states, trends in physical and chemical properties, complexation tendency, Stereochemistry and biological applications.
- Transition elements:** Characteristic properties, Correlation with electronic configuration, 3d, 4d, 5d series, trends in their chemistry.
- Lanthanides and actinides-** General properties, electronic configurations, stable oxidation states, absorption spectra, magnetic properties, lanthanide contraction, causes of lanthanide contraction and comparison of general properties lanthanides with 3d and 4f block elements. General properties of actinides, actinide contraction and comparison of actinides with lanthanides. Noble gas compounds - Preparation and structures of xenon compounds.

#### Unit-II

##### CHEMICAL BONDING

16 Hrs

- Introduction to atomic orbitals, bonding, molecular orbitals- attainment of a stable configuration, types of bonds with examples. Transitions between the main types of bonding.
- Ionic bonding:** Introduction, structure of ionic solids, properties of ionic compounds, ionic radii, factors affecting ionic radii, radius ratio rule, types and structures of simple ionic compounds NaCl, CsCl, TiO<sub>2</sub>. Lattice energy, defects in crystal – Stoichiometric defects Schottky defect and Frankel defect, Non-Stoichiometric defects – F center, interstitial ions and electrons. Born-Landé equation, Born-Haber cycle- applications, size effects, polarizing power and polarisability of ions. Fajan's rule, covalent character in ionic bonds. Hydration energy and solubility of ionic solids.
- Covalent bond:** Valence bond approach, orbital overlaps resonance and hybridization, bond angles and shapes of molecules. MOT-LCAO methods, sigma, pi and delta MO's. Molecular orbital treatment of delocalized pi bonding systems, polarity of covalent molecules, bond energies (bond dissociate) and bond length. Hydrogen bonding: Definition, types with examples and their importance.

#### Unit-III

##### CO-ORDINATION CHEMISTRY

16 Hrs

- Introduction, types of ligands, chelating, bridging and macrocyclic ligands. Nomenclature and isomerism in metal complexes. Bonding in metal complexes. Valence bond, crystal field and molecular orbital theories (salient features) crystal field splitting of 'd' orbital in octahedral, tetrahedral, tetragonal and square planar fields. Magnitude of  $\Delta$ , factor affecting  $\Delta$ , CFSE, spectrochemical series. Shortcomings of CFT. Jahn-Teller distortion in coordination compounds. Evidences for covalency. M.O. treatment of coordination compounds involving sigma bonding.
- Electronic spectra and magnetic properties of complexes: Spectra of transition metal complexes- Spectroscopic terms and microstates for free ions, spin-orbit coupling (L-S) scheme, obtaining terms for p<sup>2</sup> and d<sup>2</sup> configurations. Ground state terms, hole formalism, ground state terms for d<sup>1</sup> to d<sup>9</sup> configurations; splitting of terms in weak crystal fields. Ligand field (d-d) spectra: selection rules for d-d transitions - spin and Laporte selection rules and their relaxation, band intensities, band widths; Racah parameters. Orgel diagrams.

#### Unit-IV

##### MODERN CONCEPTS OF ACIDS AND BASES

16 Hrs

- Bronsted theory conjugate acid base pair, solvent system [or autoionisation] concept; strength of acids and bases –role of solvents, leveling effects of solvents, leveling and differentiating solvents; factors affecting relative strengths acids and bases [including organic acids and bases]; Lux –Flood concept, and Usanovich concept, Lewis concept –Lewis acids and bases, relative strengths of Lewis acids and bases- factors affecting Lewis acidity and basicity; HSAB concept- Pearson's principle, classification of acids and bases as hard and soft; acid –base strengths and hardness and softness; symbiosis, theoretical basis of HSAB concept, application of HSAB concept. Reactions in Non- aqueous solvents types of solvents, physical properties of solvents.

##### REFERENCES

- F.A. Cotton and G. Wilkibnson; John Wiley and sons in Advanced Inorganic Chemistry, 5<sup>th</sup> edition – 1988.
- James E. Huheey, Ellen E. Keither and Richard L Keither, Harper Collins Collage in Inorganic Chemistry, Principles of Structure and reactivity, 3<sup>rd</sup> edition, Pub. 1993.
- Shriver and Atkins in Inorganic Chemistry, Oxford University, 3rd edition, Press 1999.
- J.D. Lee in Concise Inorganic Chemistry, ELBS, Edition 5<sup>th</sup>, 2017, Wiley india (P) Ltd.
- G.S. Manku, Tata in Theoretical Principles of Inorganic Chemistry, 4<sup>th</sup> edition, McGraw Hill 1990.
- B.R. Puri, L.R. Sharma, K.C. Kalia in Principles of Inorganic Chemistry (UGC Syllabus Milestone Publishers, New Delhi, India, 2008.
- S. Chand and - R.D. Madan Company in Modern Inorganic Chemistry, New Delhi, First edition-1957, Reprint 2009.

## Unit- I

16 Hrs

- A. **Acid-Base Concept in Organic Molecules:** Effect of substituents on strength of acids and bases (appropriate examples to be given). Concept of hybridization:  $Sp^3$ ,  $Sp^2$  and  $sp$  hybridization with examples. Inductive, mesomeric, resonance and hyper conjugation effect.
- B. **Reaction Mechanism:** Homolysis and heterolysis of covalent bond. Types of organic reagents, Formation, Structure, Stability and Reactions of Carbocation, Carbanion, Free radical, Nitrene, Carbenes and Aryne intermediates. Types of reactions, (substitution reaction  $SN_1$  and  $SN_2$  reaction, addition reaction, elimination reaction  $E_1$  and  $E_2$  reaction. ) thermodynamic and kinetic requirements of reactions. Concepts of free radicals, electrophilic and nucleophilic reactions. Methods of determination reaction mechanism (Kinetic and non-kinetic methods, Identification of products, Detection of intermediates, Study of catalyst, isotopic labelling, Stereochemical evidences)

## Unit-II

16 Hrs

- A. **Aromaticity:** Aromaticity in benzenoid and nonbenzenoid compounds, alternant, nonalternant hydrocarbons. Huckel's rule, annulenes. Aromaticity, antiaromaticity, nonaromaticity of organic rings systems (3-7membered rings and ring ions).
- B. **Reagents in Organic reactions:** Application of following reagents in Organic reactions. Dicyclohexyl carbodiimide (DCC). Lead tetraacetate (LTA). Osmium tetroxide. DDQ. Selenium dioxide. Phase transfer catalyst. Ionic liquids. N-Bromosuccinamide. Wilkinson's Catalyst. Diazomethane, Fentons reagent, Boron Trifluoride, Anhydrous  $AlCl_3$ , Hydrogen Peroxide, LAH, Periodic acid, Raney Nickel,  $NaNH_2$ ,  $NaBH_4$ , Gillmanns reagent, LDA, 1,3 dithiane and 9-BBN, Ziegler Natta Catalyst.

## Unit-III

16 Hrs

**Named Reactions:** Mechanism and applications of Aldol, Perkin, Stobbe, Dieckmann condensations, Riemer-Tiemann and Reformatsky reactions, Diels-Alder reaction, Friedel Craft's reaction, Wittig reaction, Micheal addition, Robinson annulation, Oppenaur oxidation, Clemmensen, Wolf-Krishner, Meerwein-Varley-Ponndorf and Birch reduction, Stork enamine, Mannich reaction, Sharpless asymmetric epoxidation, Ene reaction, Barton reaction, Hofmann- Loffler-Feyrag reaction, Shapario reaction, Baer-Villiger reaction, Chichibabin reaction.

## Unit-IV

16 Hrs

- A. **Stereochemistry:** Concept of chirality; symmetry elements and chiral structures, Absolute configurations-D, L & R, and S nomenclature. Enantiomers, Epimers, Anomers, Racemic mixtures, Resolution. Diastereomers- in cyclic and acyclic systems, Optical activity in the absence of chiral carbon – Biphenyls, allenes, and spiranes. Cis-trans, syn-anti and E,Z, notations for geometrical isomers. Determination of configuration (physical and chemical methods). Conformational analysis of simple acyclic systems (butane, 1,2-dichloroethane) and acyclic systems (Chair and boat forms of cyclohexane). Effect of conformation on reactivity in acyclic and cyclic systems.
- B. **Chiral technology :** Introduction, Aminoacylase bioresolution of N- acyl aminoacids, Assymmetric hydrogenation of prochiral olefins by rhodium-Duphos catalyst, Asymmetric hydrogenation of prochiral ketones by ruthenium-biphosphin-diamine catalyst, Asymmetric hydroformylation with rhodium phosphate catalyst.

## REFERENCES

1. J. Marchin in Advanced Organic Chemistry, Willey Interscience, 1994.
2. A. Carey and Sundberg in Advanced Organic Chemistry – Part A & B, 3<sup>rd</sup> edition, Plenum Press, New York, 1990.
3. Comprehensive Organic Chemistry, Pergamon Press, New York, Vol 1, 1996,
4. H. Pine, Hendrickson, Cram and Hammond in Organic Chemistry, Mac Grow Hill, New York, 1987.
5. I.Finar in Organic Chemistry, ELBS Longmann, Vol. I & II, 1984
6. A. Carey and Sundberg in Advanced Organic Chemistry – Part A & B, 3<sup>rd</sup> edition,
7. Plenum Press, New York, 1990.
8. M. Trost and I. Fleming series in Comprehensive Organic Synthesis, Pergamon Press, New York, 1991.
9. S. K. Ghosh in Advanced General Organic Chemistry, Book and Alleied (P) Ltd, 1998.

## FIRST SEMESTER

### PC.HC. 1.03: PHYSICAL CHEMISTRY

64 Hours

#### Unit- I

16 Hrs

**Thermodynamics.** Terminology of thermodynamics - types of system, state of system, state variables thermodynamic process. Brief resume of thermodynamics, combined form of first and second law, concept of entropy, work and free energy function. Variation of free energy change with temperature and pressure. Maxwell relation, thermodynamic equation of state. Gibbs Helmholtz equation and its application. Partial molar properties-partial molar volume partial molar free energy chemical potential and its significance. Third law of thermodynamics. Concept of residual entropy. **Real gases:** Definition of Fugacity, the relation between fugacity and pressure. Concept of activity and activity coefficient.

#### Unit- II

16 Hrs

- A. **Elementary Quantum Chemistry:** Brief resume of black body radiation (Classical and Planck quantum theories and atomic spectra Bohr model and its limitations, Term Symbols). Photoelectric and Compton affects, de-Broglie hypothesis, Heisenberg's uncertainty principle, Postulates of quantum mechanics, operator concept, Eigen values and Eigen function, Schrödinger's wave equation-elementary application to particle in one dimensional box.
- B. **Polymer Chemistry:** Types of polymers with examples. Molecular weight distributions: Number average and weight average molecular weight. Determination of average molecular weight – end group analysis, viscosity method, ultracentrifugation method. Brief introduction to chain and step (condensation) polymerization, chemical and X- ray diffraction analysis of polymers, polymerization in homogeneous systems.

#### Unit- III

16 Hrs

**Chemical Dynamics:** A brief review of basic concepts and terminology in reaction kinetics. Methods of determining rate laws. Arrhenius equation. Collision state theory for bimolecular reaction rates. Transition state theory. Comparison between collision and transition state theories. Lindeman theory of unimolecular reaction rates. Concept and significance of energy of activation. Dynamics in solutions-ionic reactions, effect of ionic strength, primary and secondary salt effects. Study of Fast reactions-study of kinetics by stopped flow technique relaxation method, Flow method.

#### Unit-IV

16 Hrs

**Electrochemistry:** Electrolytic solutions, strong electrolytes, ionic-atmosphere, relaxation and electrophoretic effects, quantitative treatment of Debye –Huckle theory and its extension by Onsagar. Activity and activity coefficients, mean ionic activity coefficient, dependence of activity coefficients on ionic strength (Debye-Huckel limiting law), Debye-Huckel equation for appreciable concentration [Debye - Huckel - Bronsted equation]. Polarization and over voltage, Half-cell reactions, reversible electrodes, standard electrode potentials, electrochemical series, Nernst equation. Electrochemical energy systems - introduction, fundamentals of batteries, dry cell, alkaline MnO<sub>2</sub> batteries and other secondary batteries, Lead acid and alkaline storage batteries. Fuel cells – types, electrochemistry of fuel cells.

## REFERENCES

1. B.R. Puri, L.R. Sharma, M.S. Pathania in Principles of Physical Chemistry (Comprehensive UGC Syllabus), 46<sup>th</sup> Edition, Vishal Publishing House, Jalandhar, India, 2012
2. Donald A. McQuarrie, John D. Simon in Physical Chemistry – A Molecular Approach, , 3<sup>rd</sup> Edition (Viva Student Edition), Viva Books Pvt. Ltd., New Delhi, 2011.
3. N.B. Singh, S.S. Das, R.J. Singh in Physical Chemistry, 2<sup>nd</sup> Edition, New Age International Publishers, New Delhi, 2007
4. S.P. Agarwal and Rajesh Khanna in Physical pharmacy, 2<sup>nd</sup> edition, CBS Publishers and distributors PVT .Ltd New Dehli ,YEAR 2006
5. Peter Atkins, Jolie De Paula, in Physical Chemistry, 8<sup>th</sup> Edition International Student Edition, Oxford University Press, New York, 2010.
6. Ira N Levine in Physical Chemistry, 5<sup>th</sup> Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
7. Francis W. Sears Gerhard L. Salinger in Thermodynamics, Kinetic Theory, and Statistical Thermodynamics, , 3<sup>rd</sup> Edition, Nervosa Publishing House, New Delhi, 1998.

## FIRST SEMESTER

### PC.HC. 1.04: ANALYTICAL CHEMISTRY

64 Hours

#### Unit-I

16 Hrs

**Evaluation of analytical data:** Role of Analytical Chemistry. Classification of analytical methods; type of instrumental analysis; Analytical methods on the basis of sample size. Errors, types of errors-determinate and indeterminate errors, accuracy and precision. Distribution of random errors, frequency-mean, median, range, average deviation, relative average deviation, standard deviation and variance. Student's confidence interval of the mean. Testing for significance comparison of two means and two standard deviation. ANOVA, Criteria for rejection of an observation-Q test. Control charts. Propagation of errors, Significant figures. Least square method of deriving calibration of plots. Principles of sampling the sampling step. Methods for sampling solid, liquid and gaseous samples.

#### Unit-II

16 Hrs

- A. **Titrimetric Methods of Analysis.** Titrimetry: Theory of indicators, indicator action, teoretical basis for titrimetric analysis, classification of titrimetric analysis - acid-base titration - Ibuprofen, Tolbutamide, redox titration Iodimetric method - Analgin, Iodometric method, Cerimetric method -Ascorbic acid, Bromometric titration – Isoniazid, complexometric method – Calcium gluconate, and Non- aqueous titration - Chloroquin, Metronidazole, precipitation titrations in non – aqueous media. Karlfisher titrimetry and its application.
- B. **Gravimetry:** General principles, conditions for precipitation, choice of precipitation, advantages of using organic precipitations, factors influencing the solubility of the precipitate, theories of precipitation, post precipitation, effect of digestion, pH change, ion release reagents, change in oxidation states, use of mixed solvents and analytical applications. Principle and applications of TGA.

#### Unit-III

16 Hrs

- A. **Extraction Techniques:** A. Solvent extraction (liquid-liquid extraction): general principles, nature of partition forces, (dispersion, interaction dipole-dipole interaction, induction interaction, hydrogen bond interaction); Relationship between percentage of extraction and distribution coefficient and distribution ratio, extraction of metal organic complexes and ion association complexes, multiple extraction, continuous extraction and Craig tube. Ultracentrifugation, Supercritical fluid extraction.
- B. **Pure and Impure compounds:** Impurities in drugs, sources of impurities, effect of impurities. Limits of impurities test for purity. Limit test for  $\text{Cl}^-$ ,  $\text{SO}_4$ , Pb, As, heavy metals. Introduction to inorganic pharmaceutical chemistry, Necessity of pharmacopoeia, IP, BP, USP, BPC. Formularies, European formulary, Indian national formulary.

#### Unit-IV

16 Hrs

Instrumentation and applications: Principle, instrumentation and applications of the following techniques: Fluorescence spectroscopy, Flame photometry, Atomic absorption spectroscopy, DSC, SEM, conductometry, potentiometry, and polarimetry, Colourimetry, Spectrophotometry.

## REFERENCES

1. Robert de Levie in Principles of Quantitative Chemical Analysis- International Edition 1997 McGraw Hill Co.
2. Day and Underwood in Quantitative Analysis-, Printic hall India Pvt Ltd, 6<sup>th</sup> edition (1993)
3. G.H.Jaffery, J. Bassett, J. Mendhrn and R.C. Denney ELBS in Vogels Text Book of Quantitative Chemical analysis-Revised by 5<sup>th</sup> edition (1998)
4. D.C.Harris, W.M. Freeman in Quantitative Chemical analysis and Co, NY, USA, IVED, 1995.
5. Gray D. Christian in Analytical Chemistry, 5<sup>th</sup> edition John Wiley and sons, Inc.
6. Skoog, West and Hollar, Harcourt in Fundamentals of Analytical Chemistry- Asia Pvt. Ltd. India, New Delhi 7<sup>th</sup> edition 1998.
7. D.A. Skoog, E.J. Holler, S.R. Crouch in Instrumental Analysis, 11<sup>th</sup> Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, 2012.

## SECOND SEMESTER

### PC.HC.2.01: ADVANCED INORGANIC CHEMISTRY

64 Hours

#### Unit- I

16 Hrs

**Symmetry and Group Theory:** Introduction to symmetry with examples, molecular geometry, polyhydrides, prisms and symmetry operations, Symmetry elements: Rotational axis of symmetry, plane of symmetry, improper rotational axis of symmetry, inversion center or center of symmetry and identity elements. Important relations of symmetry elements, deducing the implied presence of other symmetry elements –  $C_n$  ( $n = \text{even or odd}$ ),  $S_n$  ( $n = \text{even}$ ) and  $S_n$  ( $n = \text{odd}$ ). Mathematical requirements for a point group – closure rule, associative rule, identity rule and inverse rule. Molecular point group-Nomenclature of the point group and identification of the molecular point group - molecules of low symmetry (MLS), Molecules of high symmetry (MHS) and molecules of special symmetry (MSS), Groups, subgroups and classes.

#### Unit- II

16 Hrs

- Organometallic Chemistry:** Introduction, 16 and 18 electron rule, classification of organometallic compounds by bond type, nomenclature.
- Chemistry of organometallic compounds:** synthesis and reactions of organozinc and organolithium reagents ( $n\text{-BuLi}$ ,  $\text{PhLi}$ ).
- Metal Carbonyls Complexes:** Preparation, Structure, chemical bonding in metal carbonyls, physical evidence related to M-CO bonding. Preparation of anionic metal carbonyl complexes and substituted metal carbonyl complexes.
- Metal nitrosyls:** Preparation, linear and bent nitrosyls.
- Cyclopentadienyl Metal Complexes:** Preparation, structures of Cyclopentadienyl Metal Complexes. Reactions and aromaticity of ferrocene. Catalysis by organometallic compounds – alkene hydrogenation and hydroformylation.

#### Unit- III

16 Hrs

- Chemistry of Non-Transition Elements:** General discussion on the properties of non-transition elements. Special features of individual elements (C, N, O and halogens family). Polymorphism of carbon. Synthesis, properties and structures of boranes (diboranes), carboranes, borazines, silicones, phosphazenes. Oxy acids of nitrogen, phosphorous, sulphur, and halogens. Interhalogen pseudohalides.
- Role of Metal Ions in Biological System:** Essential and beneficial metal ions: general role of metal ions in biological systems. Transport across the membrane: Structure of biological membrane, active transport across biological membrane,  $\text{Na}^+/\text{K}^+$ -transporting ATPase, macrocyclic crown ether compounds, and ionophores.

#### Unit- IV

16 Hrs

- Oxygen Carriers:** Introduction to porphyrin system, substituent effects on porphyrin rings, Hemoglobin (Hb) and Myoglobin (Mb) structure, stereochemistry and oxygenation of Hb and Mb, cooperativity, Bohr effect. Non-heme oxygen carriers- hemerythrin and hemocyanin. Synthetic oxygen carriers.
- Electron Carriers** Iron –sulphur proteins (ferredoxins and rubredoxins).
- Metals and Chelation in Medicine:** Metal ion deficiency and treatment (Fe, Zn, Cu and Mg), dependence of biological growth on the concentration of essential toxic element. Metal ion toxicity Metal ion deficiency and treatment (Fe, Zn, Cu and Mg), dependence of biological growth on the concentration of essential toxic element. Metal ion toxicity, Toxic effects of metals: Toxicity of iron, copper and Wilson disease, As poisoning and Hg toxicity. Metals as carcinogens. Metal Chelation and the activity of the multipurpose drug – aspirin. Anticancer activity of Platinum complexes and its toxic effects.

## REFERENCES

- James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi in Inorganic Chemistry – Principles of Structure and Reactivity, 4<sup>th</sup> Edition, Pearson Education, Indian Edition, New Delhi, India, 2013.
- Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong in Inorganic Chemistry, 5<sup>th</sup> Edition, Oxford University Press, UK, 2013.
- James E. Huheey, Ellen A. Keiter, Richard L. Keiter in Inorganic Chemistry – Principles of Structure and Reactivity, 4<sup>th</sup> Edition, Pearson, Indian Edition, New Delhi, India, 2004.
- Gary L. Miessler, Donald A. Tarr in Inorganic Chemistry, 3<sup>rd</sup> Edition, Pearson Education, New Delhi, India, 2004.
- Keith F. Purcell, John C. Kotz in Inorganic Chemistry, First Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, India 2010.
- J.D. Lee in Concise Inorganic Chemistry, 5<sup>th</sup> Edition, Blackwell Science Ltd., London, 2003.
- Satya Prakash, G.D. Tuli, S.K. Basu, R.D. Madan, S. Chand in Advanced Inorganic Chemistry, Volume-I, and Company, New Delhi, India, 2008.

**Unit-I****16 Hrs**

- A. Pericyclic Reactions: Molecular orbital symmetry, Frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system, classification of pericyclic reactions. Woodward-Hofmann correlation diagrams. FMO and PMO approach, Electrocyclic reactions, conrotatory and disrotatory motions,  $4n$ ,  $4n+2$  systems, 2+2 addition of ketenes. 1,3-Dipolar cycloadditions and cheletropic reactions. Sigmatropic rearrangements-suprafacial and antarafacial shifts of hydrogen, sigmatropic shifts involving carbon moieties, 3, 3 and 5, 5 sigmatropic rearrangements, Claisen, Cope and Overman - Cope rearrangements.
- B. **Photochemistry:**  
Laws of photochemistry, quantum yield, factors affecting quantum yield, Jablonski diagram, bonding and antibonding orbitals, singlet and triplet states, relative energies of excited state. Photoreduction of ketones, photooxidation, photoisomerisation, photosensitization. Photolysis-Norrish type-I and type-II reactions. Di- $\pi$ -methane rearrangement. Paterno-Buchi reaction and photochemistry of arenes.

**Unit-II****16 Hrs**

- A. **Chemistry of Heterocyclic Compounds:** Introduction, IUPAC nomenclature of heterocyclic ring systems (containing 3-7 membered rings, up to 3 heteroatoms), Aromaticity of heterocycles, Pyrrole, Furan, Thiophene and Pyridine-methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic and nucleophilic substitutions, acidity and basicity of pyrrole and pyridine.
- B. Introduction to condensed five and six membered heterocycles. Preparation and reactions of indole, benzofuran, benzothiophene, quinoline and isoquinoline with special reference to Fischer indole synthesis, Skraup synthesis and Bischler-Napierlaski synthesis. Mechanism of electrophilic substitution reactions of these heterocycles.

**Unit-III****16 Hrs**

- Molecular Rearrangements:** Classification and general mechanistic treatment of nucleophilic, electrophilic and free radical rearrangements:
- Rearrangements involving migration to electron deficient carbon:** Wagner-Meerwein, Pinacol-Pinacolone, Wolff, benzil-benzilic acid rearrangements.
  - Rearrangements involving migration to electron deficient nitrogen:** Beckmann, Hoffmann, Curtius, Lossen and Schmidt rearrangements.
  - Rearrangements involving migration to electron deficient oxygen:** Bayer-villiger oxidation, Dakin reaction and hydroperoxide rearrangements.
  - Rearrangements involving migration to electron rich carbon:** Fevorskii, Sommelet-Hauser, Naber rearrangements.
  - Aromatic Rearrangements:** Fries, and Claisen rearrangements

**Unit-IV****16 Hrs**

- A. **Disconnection approach:** An introduction to synthons and synthetic equivalent disconnection approach, functional group interconversions. Importance of the Order of events in organic synthesis. One group C-X and two group C-X disconnections. Protecting groups: Principle of protection of alcoholic, amino, carbonyl and carboxyl groups. Chemo selective, Regioselective, and Stereo selective reactions.
- B. **Coupling reactions:** Hiyama cross-coupling reaction, Kumada cross-coupling reaction, McMurry coupling reaction, Negishi cross-coupling reaction, Stille coupling, Suzuki - Miyaura coupling, Ullmann coupling.

**REFERENCES**

- F. A. Carey and Sundberg in *Advanced Organic Chemistry – Part A & B*, 3rd edition, Plenum Press, New York, 1990.
- H. Pine, Hendrickson, Cram and Hammond in *Organic Chemistry*, Mac Grow Hill, New York, 1987.
- I. L. Finar in *Organic Chemistry*, ELBS Longmann, Vol. I & II, 1984.
- F. A. Carey and Sundberg, in *Advanced Organic Chemistry – Part A & B*, 3rd edition, Plenum Press, New York, 1990.
- B. M. Trost in *Comprehensive Organic Synthesis – and I. Fleming series*, Pergamon Press, New York, 1991.
- S. K. Ghosh in *Advanced General Organic Chemistry*, Book and Allied (P) Ltd, 1998.

**Unit- I****CATALYSIS, PHASE EQUILIBRIA AND SURFACE CHEMISTRY****16 Hrs**

- A. Catalysis: Introduction, characteristics of catalytic reactions, acid-base catalysis, mechanism and kinetics of enzyme-catalyzed reactions, Michaelis-Menten equation, effect of temperature, pH and concentration on enzyme catalysis. Heterogeneous catalysis: surface reactions, kinetics of surface reactions, unimolecular and bimolecular surface reactions, pH-dependence of rate constants of catalyzed reactions, oscillatory reactions and their applications.
- B. Phase equilibria: Introduction, derivation of phase rule, applications of phase rule to one-component systems (water and sulphur systems). Two-component systems (potassium iodide-water system and ferric chloride-water system), three-component systems (two solids + one liquid system, and three liquid systems).
- C. Surface Chemistry: Adsorption by solids, types of adsorption isotherms, chemisorption, adsorption of gases by solids, factors influencing adsorption, Freundlich and Langmuir adsorption theories, BET theory of multilayer adsorption (Derivation of BET equation), surface area measurement, types of adsorption isotherms, adsorption from solution, Gibbs adsorption isotherm, insoluble surface films on liquids

**Unit-II****16 Hrs**

**Colloids:** Types of colloids, properties of colloids-Tyndall effect, Brownian movement, Pharmaceutical applications of colloids.

**Coarsedispersions:** Suspension, classification—flocculated, deflocculated suspension. Controlled flocculation, physical stability of suspensions. Emulsions, types of emulsions, theories of emulsification, emulsifying agents—mechanism of action of emulsifying agents, factors to improve physical stability of emulsions.

**Surface and interfacial tension:** Measurement of surface and interfacial tension-Capillary and Drop method spreading coefficient, and its applications. Surfactants-classifications, hydrophilic-lipophilic balance. Solubilization, factors affecting solubilisation, micelle formation, factors affecting micelle formation, determination of critical micelle concentration, detergency and wetting agents. Contact angle, flocculating agents, deflocculating agents, foaming and antifoaming agents. Pharmaceutical applications of surfactants.

**Unit-III****16 Hrs**

**Diffusion & Dissolution:** Concept and importance of diffusion. Steady state diffusion. Fick's first and second law of diffusion (statement). Types of Diffusion. Diffusion cell. Concept & importance of dissolution. Dissolution rate, Factors affecting the Dissolution rates, Dissolution apparatus. Historical development & USP dissolution test. Dissolution model like Hixson-Crowell, Higuchi's Model. Drug release modeling through polymer matrix & laminates. Concept of membrane controlled delivery & its importance in dosage form design.

**Unit-IV****16 Hrs**

**Preformulation studies:** Factors affecting dissolution, diffusion – pH, pKa, pKw, particle size, solubility, etc. Methods to increase solubility of poorly soluble drugs, drug release mechanisms. Factors affecting / necessitating Preformulation of drug.

**Micromeritics:** Introduction, particle size distribution, surface area, Method of determining surface area-adsorption. Air permeability method, derived properties of powder, flow properties of powder, particle size, nature of particles, moisture contents angle of repose, factors affecting powders. Different methods of particle size Determination-Microscopic, sieving, sedimentation, coulter electrical method, Low angle light scattering method.

**REFERENCES**

1. S.P. Agarwal and Ragesh Khanna in physical pharmacy by, 2nd Edition, CBS publishers and Distributors.
2. N.B. Singh, S.S. Das, R.J. Singhin Physical Chemistry, 2nd Edition, New Age International Publishers, New Delhi, 2007.
3. Atkins' Physical Chemistry, Peter Atkins, 8th Edition, Jolio De Paula, International Student Edition, Oxford University Press, New York, 2010.
4. Ira N Levine in Physical Chemistry, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
5. R. Stephen Berry, Stuart A. Rice, John Ross in Physical Chemistry, 2nd Edition, Oxford University Press, New York, 2007.

## SECOND SEMESTER

### PC.HC.2.04: ADVANCED ANALYTICAL CHEMISTRY and NANOCHEMISTRY

64 Hours

#### UNIT- I

16 Hrs

**Molecular spectroscopy:** Characterization of electromagnetic radiation. Quantization of energy level, microwave spectroscopy, classification of molecules based on their moment of inertia. Rotation of rigid diatomic and rotational energy levels. Isotopic effect on rotational spectra, rotational spectra of non-rigid and linear polyatomic molecules. Vibrational Spectra: Vibrational spectra of diatomic molecules, simple harmonic oscillator's models. Vibrational energy levels and vibrational spectra. The anharmonic oscillator model. Hot bands, fundamental bands and overtones. Vibration and rotation spectra, PQR branches, breakdown of Born-Openheimer approximation. Electronic spectra, electronic transition in diatomic molecules,  $V'$  and  $V''$  progression, Frank-Condon principle and pre-dissociation.

#### UNIT-II

16 Hrs

**Raman spectroscopy:** Introduction, Raman and Rayleigh scattering, Stokes and anti-Stokes lines, polarization of Raman lines, depolarization factor, polarizability ellipsoid. Theories of Raman spectra—classical and quantum theory. Rotation, vibration and rotation-vibration Raman spectra. Comparison of Raman and IR spectra, rule of mutual exclusion principle. Advantages of Raman spectra. Molecular data bond length and vibration determined by Raman spectroscopy. X-ray crystallography: Fundamentals of X-ray crystallography, law of interfacial angles, laws of symmetry, Miller indices, crystal systems, Bravais lattice, X-ray diffraction, Bragg equation, Bragg X-ray spectrometer, Experimental methods—powder and rotating crystal method.

#### UNIT-III

16 Hrs

- A. **Mossbauer spectroscopy:** Theoretical basis. Interpretation of Mossbauer spectra— isomer shift— Quadrupole splitting and magnetic hyperfine structure, time and temperature effects. Instrumentation. Applications—structure determination— $I_2Br_2Cl_4$ ,  $Fe_3(CO)_{12}$
- B. **Electron Spin Resonance Spectroscopy:** Basic principles— intensity—width—position and multiple structure. General rules for the interpretation of the spectra. Zero field splitting and Kramer's degeneracy rule. Factors affecting the magnitude of 'g' value. Double resonance—ENDOR and ELDOR. Applications—study of free radicals—structure determination— biological study— coordination compound and analytical applications.

#### UNIT-IV

16 Hrs

**Nanochemistry:** Introduction: Fundamentals and importance. Carbon nano particles: Introduction, carbon molecules, nature of the carbon bond, new carbon structures. Carbon clusters: small carbon clusters,  $C_{60}$ ; Discovery, structure, crystal, alkali doping, super conductivity, fullerenes, other bulky balls. Carbon nano tubes: Fabrication, structure, electrical properties, vibrational properties, mechanical properties, application of nano materials. Methods of preparation: chemical vapour deposition. Applications of nanomaterials in medicine: immunogold labelling, applications in medical diagnosis, nanobased drug delivery.

#### REFERENCES

1. C.N Banwell and E.M. Mc in Fundamentals of molecular spectroscopy by Cash-4th edition, Tata Mc. Graw Hill, New Delhi, 1998.
2. M. Barrow by Introduction to molecular spectroscopy, Mc Graw Hill, New York (International student edition) (1972).
3. P. Straughan and S. Walker, Spectroscopy Vol I and II, John Wiley and Sons Inc, New York. (1976).
4. N. Sathyanarayana by Vibrational spectroscopy, Theory and Applications, New Age International Publications, New Delhi, (1996).
5. H.H Willard, L.L. Merritt and J.A Dean, Instrumental methods of analysis, 7th edition, (1988).
6. R.S Drago, Physical methods Inorganic chemistry, Affiliated East-West Press Pvt. Ltd. (student edition) (1978).
7. D A. Skoog, F J. Holler and T.A. Nieman Principles of instrumental analysis. Fifth edition, Saunders college Publishing, Philadelphia.
8. Gurdeep and Chatwal, Instrumental methods of chemical analysis, Himalya Publishers.

## SECOND SEMESTER

### PC.2.05: ELECTIVE: TITLE: DRUG DISCOVERY

32 Hours

#### UNIT- I

16 Hrs

**Drug discovery through natural products:** Introduction to drug discovery from different sources. Introduction of medicinal plants as medicine, Collection of plant material, preserving of plant material, Methods of extraction of plant material, solvent extraction, cold extractions, hot extraction methods, Preservation of plant extracts and Preliminary biological screening. Methods for compound structural elucidation and identification. Compound development.

16 Hrs

#### UNIT\_II

**Drug discovery through Enzyme Inhibition:** Overview of Enzyme as a catalytic receptors, General concept of enzyme inhibition Reversible enzyme inhibition ex-AZT, Physostigmine. Irreversible enzyme inhibition-Affinity label and active site directed irreversible enzyme inhibitors ex-TPCK Mechanism based irreversible enzyme inactivators - Clavulanic acid and Gabaculin

#### REFERENCES

1. S. D. Satoshkar, Bhandarkar and Nirmala Rege, Pharmacology and Pharmacotherapeutics, 2015, revised 21<sup>st</sup> edition, Elsevier Health Sciences, Netherlands.
2. M. N. Ghosh and Vallabh Prakash, Practical Pharmacology, 2008, 6<sup>th</sup> edition, Hilton and Company, Kolkata, India.
3. Hans Gerhard Vogel, Drug Discovery and Evaluation; Pharmacological assay, 2008, 3<sup>rd</sup> edition, Vol-2, Springer-Verlag Berlin Heidelberg, Germany.
4. P. N. Benett and M. J. Brown, Clinical Pharmacology, 2012, 11<sup>th</sup> edition. Elsevier Ltd.
5. D. G. Graham-Smith and J. K. Aronson, Oxford text book of Clinical Pharmacology and Drug Therapy, 2002, 3<sup>rd</sup> edition, Oxford University Press, U.K.
6. Rama Rao Nadendla, Principle of Organic Medicinal Chemistry, 2005.

## THIRD SEMESTER

### PC.HC. 3.01: SPECTROSCOPIC TECHNIQUES

48 HOURS

#### Unit-I

12 Hrs

- A. **UV-Spectroscopy:** Brief review of electromagnetic spectrum, Interaction of electromagnetic radiation (UV-Visible) with matter and its effects. UV-Visible range, energy, wavelength, frequency and color relationships. The Nature of electronic excitations, Modern Instrumentation and its working principle, Beer's Law, Lambert's law, Chromophores, auxochromes, Shift and their interpretation (including solvent effect). Colorimetry, Effect of solvent and structure on  $\lambda_{\max}$ , prediction of  $\lambda_{\max}$  for polyenes, alpha, beta unsaturated aldehydes and ketones, aromatic systems and their derivatives. (Woodward's-Fisher's rule). Absorption spectra of organic compounds and illustrating the phenomenon and its utilization in qualitative and quantitative studies of drugs.
- B. **Optical Rotatory Dispersion:** Fundamental principles of ORD. Cotton effect curves, their characteristics and interpretation. Octant rule and its application with examples. Circular dichroism and its relation to ORD.

#### Unit-II

12 Hrs

**IR-Spectroscopy:** Introduction, principle and Instrumentation, Types of vibrations, interaction of I.R radiation with organic molecules, selection rules, functional group frequencies and their dependence on chemical environment (bond order, conjugation, hydrogen bonding, ring size, overtones, Fermi resonance). Interpretation of IR spectrum. Practical details of obtaining spectra, including sample preparation for spectroscopy (nujol mull and KBr disc method), qualitative interpretation of I.R spectra, FT-IR and instrumentation.

#### Unit-III

12 Hrs

**NMR Spectroscopy:** Principles of NMR, theory: Types of nuclei (classical and quantum), Magnetic properties of nuclei; Excitation of spin  $\frac{1}{2}$  nuclei, relaxation process, Instrumentation and its working principle: sensitivity, solvent selection, Chemical shift, factors influencing chemical shift, mechanism of shielding, spin-spin coupling, First order spin systems, coupling constant, Application of signal split and coupling constant data for interpretation of spectra. Brief outline of principles of FT-NMR with reference to  $C^{13}$  nucleus. Spin-spin lattice relaxation phenomenon. Free induction decay (FID) proton noise decoupling signal. Nuclear Overhauser enhancement  $C^{13}$  NMR spectra, their presentation, characteristics, interpretation, examples and applications. Introduction to 2D-NMR techniques.

#### Unit-IV

12 Hrs

**Mass Spectrometry:** Basic principles and brief outline of instrumentation. Ion formation and types, molecular ion, Meta stable ions, molecular ion peak, base peak, Meta stable ion peak, Mass analyzers, fragmentation processes. FAB, MALDI, Fragmentation patterns and fragmentation characteristics in relation to parent structure and functional groups. McLafferty rearrangement, Retro Diels alder reaction, ortho effect, structural elucidation of some organic compounds, Relative abundance of isotopes and their contribution of characteristic peaks. Mass spectrum, its characteristics. Presentation and interpretation. Application of mass spectrometry in quantitative and qualitative analysis. Determination of molecular formula and molecular weight.

## REFERENCES

1. R M. Silverstein and F X Webster, David J Kiemle, Spectrometric identification of Organic compounds, Seventh Ed, John Wiley & Sons, New York, 1963.
2. William Kemp, Organic Spectroscopy, 3<sup>rd</sup> Ed, Palgrave Publishers Ltd. 175 fifth Avenue, New York. N Y, 1991.
3. L. Pavia, G. M. Lampman, G. S. Kriz, and J A Vyvyan, Introduction to spectroscopy- A guide for students of Organic chemistry, , Fourth Ed. Fort Worth Harcourt college publishers, Washington. (Latest edition), 2008.
4. D. H. Williams and I. Fleming, Spectroscopic methods in Organic Chemistry, 6<sup>th</sup> Ed, McGraw Hill Education Pvt. Ltd, Bangalore, Karnataka, India, 2005.
5. P. S. Kalsi, Spectroscopy of organic compounds, 6<sup>th</sup> Ed, New Age International (P) Ltd, Daryaganj, New Delhi, India, 2004.
6. Kaur H, Spectroscopy, Praghathi Prakashan Publishers, Western Kutchery Road, Meerut, India, 2009.

### THIRD SEMESTER

#### PC.HC. 3.02: BIOORGANIC CHEMISTRY

64 HOURS

##### Unit-I

16 Hrs

**Chemistry of amino acids and peptides:** Amino acids: Introduction, classification, isoelectric point. Synthesis of amino acids-Streckers synthesis, Gabriel phthalamide synthesis. Erlinmeyers synthesis, Knoop synthesis. Chemical reaction of alpha amino acids: reactions involving a) amino group b) carboxylic acid and c) both carboxylic and amino group.

**Peptides:** Introduction, peptide linkage, Major methods of peptide synthesis: synthesis of following di and tri peptides by using Merrifield resin. a) gly-gly b) gly-ala c) gly-val d) gly-gly gly e) gly-ala-ala f) ala-ala-gly. Stereochemistry features and confirmation features. Determination of primary structure of protein. Blocking agents and deblocking agents used in amino group protection and de protection. Reagents and reaction used in activation of carboxylic group of amino protected amino acids.

##### Unit-II

16 Hrs

###### Alkaloids and Nucleic acids

A. **Alkaloids:** Introduction, Occurrence, Structure elucidation and synthesis of following Alkaloids: Morphine, Nicotine, papaverine. Phytochemical tests for alkaloids.

**Glycosides:** Introduction, General characters and classification of glycosides. Study of general methods of isolation and uses of the following: Cardiac glycosides, Anthracene glycosides and Cyanogenic glycosides.

**Anthocyanins:** Introduction, general nature of anthocyanin. Occurrence, structure and synthesis of anthocyanidins and Flavones. Phytochemical tests for flavonoids.

B. **Nucleic acids:** Classification of nucleic acids, structure of nucleosides, nucleotides and nucleic acids, nucleosides containing pyrimidine and purine bases, sequence of nucleic acids, Crick-Watson model of DNA, structure of RNA (m-RNA, t-RNA and r-RNA).

##### Unit-III

16 Hrs

A. **Steroid Hormones:** Introduction, nomenclature, Structure and biosynthesis of cholesterol, Female and male sex hormones- structures, their significance, development of antifertility agent. Biological importance of bile acids, estrone, progesterone, testosterone, androsterone and corticosterone.

B. **Prostaglandins:** Introduction, Occurrence, Nomenclature, classification, synthesis and structure elucidation of PGE1, Synthesis of PGE series. Biological significance of prostaglandin.

C. **Essential Oils:** a) Introduction, Definition, chemical nature, Classification, General methods of extraction, chemical constituents and uses of Clove oil, Cinnamon oil, Sandalwood oil, Methods of production and analysis. b) Terpenoids: General introduction, classification, isolation, purification and structural elucidation of Menthol and Camphor. Biological importance of terpenoids.

##### Unit-IV

16 Hrs

**Enzymes:** Classification, Characteristics of enzymes, enzyme substrate complex. Concept of active centre, binding sites, stereospecificity and ES complex formation. Effect of temperature, pH and substrate concentration on reaction rate. Activation energy. Transition state theory. Enzyme Kinetics: Michaelis - Menten Equation - form and derivation, steady state enzyme kinetics. Significance of  $V_{max}$  and  $K_m$ . Bisubstrate reactions.

Enzyme inhibition-Overview of enzymes as catalytic receptors, types of inhibitors - competitive, noncompetitive and uncompetitive, their mode of action. Isoenzymes,

General concept of enzyme inhibition-reversible enzyme inhibition eg. Azidothymidine, physostigmine and 5-fluorouracil, Irreversible enzyme inhibition- Affinity labels and active site directed irreversible enzyme inhibitors-TPCK, mechanism based irreversible enzyme inactivators - Clavulanic acid and Gabaculin.

### REFERENCES

1. David W. Martin, Peter A. Mayes, Victor W. Rodwell, Haper's review of biochemistry, Lange Medical Publications, Los Altos, California, 1987.
2. A L Lehninger, D L Nelson and M M Cox, Principles of Biochemistry, Second Edition, Worth, New York, 1993.
3. Conn E E, Stumpf P K. outlines of Biochemistry, Fourth edition, John Wiley, New York, 1987.
4. Gurudeep R Chatwal, The Chemistry of Organic Natural Products, Volume 2, Himalaya Publishing House, Bengaluru, Karnataka, India, 1983.
5. I L Finar, Textbook Organic chemistry, volume 2, fourth edition, Longmans Green and Co. Harlow, United Kingdom, 1964,
6. Nichols Price and Lewis Stevens, Fundamentals of Enzymology: The Cell and Molecular biology of Catalytic Proteins, third edition, Oxford university Press, USA, 2000.
7. Malcom Dixon and Edwin C Webb, Enzymes, Academic press, New York, 1980.
8. W. Moss, Isoenzymes, PP 204, Chapman and Hall Ltd. London. U.K, 1982.

**Unit-I****12 Hrs**

**Paper, Thin layer chromatography and Column chromatography:** Introduction, Terminology, Classification of chromatographic methods. Paper chromatography: Introduction, principle, methods: ascending, descending, ascending-descending, 2D, radial and applications.

**Thin Layer chromatography:** Introduction, principle, types of adsorption, preparation techniques and applications, Types of adsorbent for TLC, mobile phase selection, reversed phase TLC, 2D- TLC, quantitative methods in TLC. Detection methods, comparison of paper chromatography and TLC.

**Column chromatography and HPTLC:** Introduction, adsorption phenomenon, differential migration, types of adsorbents, such as nature of adsorption forces: Vander Waals forces, inductive (dipole) forces, hydrogen bonding forces, solvent system (mobile phase solvent system-elutotropic series, choice of solvents as eluents for column chromatography), Packing techniques (wet packing techniques and dry packing techniques). HPTLC: Introduction, Instrumentation and applications.

**Unit-II****12 Hrs**

**Gas chromatography:** Principle and Instrumentation, types of column, packed and capillary column. Column efficiency parameters, the vandeemeter equation. Resolution, liquid stationary phases, derivatization methods of GC including Acylation, Perfluoroacylation, Alkylation and Esterification. Detectors (TCD-thermal conductivity detector, FID-flame ionization detector and ECD-electron capture detector, examples of GC applications in pharmaceutical analysis. Interfacing gaschromatography with mass-spectrometry.

**High Performance Liquid Chromatography (HPLC):** Principle, instrumentation in HPLC, Reversephase HPLC, packing materials (normal and reversed phase). Column selection (standard column (analytical, preparative), narrow bore, micro bore columns, short column, guard columns). mobile phase selection, efficiency, retention, resolution and selectivity parameters, detectors in HPLC(UV-visible absorbance detector, refractive index detector, electrochemical detector, opticalactivity detector, mass detector). Comparison of GC and HPLC.

**Unit-III****12 Hrs**

Definition, principle, and application of the following techniques: **Ion-exchange chromatography (IEC)** Ion-exchangers, cation exchange resins, anion-exchange resins, ion-exchange mechanism, factors affecting ion exchange equilibrium, ion-exchange capacity, affinity scale, instrumentation, techniques for ion-exchange, liquid ion-exchanger, applications of IEC, experimental IEC,

**Affinity chromatography:** Introduction, classification, Selection of matrix, role of spacerseg. Affinity ligands, applications of affinity chromatography in the separation of biomolecules. Exclusion chromatography.

**Electrophoresis:** Overview, basis for electrophoretic separations, Moving boundary electrophoresis, Zone electrophoresis, isotachopheresis, isoelectric focusing and immune electrophores, and Continuous electrophoresis (preparative), applications. Capillary electrophoresis: Introduction, Principle, Instrumentation and applications.

**Unit-IV****12 Hrs**

**Capillary supercritical fluid and Gel chromatography:** Supercritical fluid chromatography. General introduction, theory & working of capillary supercritical fluid & principle, instrumentation of Capillary supercritical fluid chromatography.

**Gel chromatography:** General Introduction, Principle, experimental techniques, gels used for separation by exclusion chromatography application of gel chromatography.

**Size exclusion chromatography:** General introduction Theory Distribution coefficient (KD) performance, materials, working principle of SEC apparatus, Application of sample detectors & application of size exclusion chromatography in pharmaceutical analysis.

**REFERENCES**

1. A H Beckett and J B. Stanlake. Practical Pharmaceutical Chemistry, Volume 52, First Ed, The Athlone Press, University of London, 2 Gower Street, London,SC, May 1963.
2. K. A. Connors, A Text book of pharmaceutical analysis third Ed, John Wiley and Sons, Inc., Ansari Rd, Daryaganj, New Delhi, India, - 1982.
3. E B Hassan and T Higuchi, Pharmaceutical Analysis Vol 51, Issue I, Inter Science Publishers, Inc, 250 Avenue, New York, N.Y, 1961.
4. P.D. Sethi Quantitative analysis of drugs in. pharmaceutical formulations, third edition, 1997.
5. D A Skoog and D M West. Fundamentals of Analytical Chemistry, Fourth Ed, Saunders College Publishing, New York, N.Y, 1983.
6. Gary D Christian Analytical Chemistry, 6th Ed., John Wiley and Sons, Inc. in. University of Washington. USA, 2004.

**Unit-I****12 Hrs****AUTOMATIC METHODS AND THERMAL METHODS OF ANALYSIS.**

- A. **Automatic methods of analysis:** specifications and performance of automated methods, automation strategy, advantages and disadvantages of automated techniques, infrared process analyzers, selection of on-line analyzers, on-line potentiometric analyzers, chemical sensors (optodes and microsensors), automatic chemical analyzers, discrete analyzers, continuous analyzers (single channel and multi channel), continuous flow methods, flow-injection analysis, centrifugal analyzers, automatic elemental analyzers, laboratory robots.
- B. **Thermal methods of analysis:** Introduction, thermogravimetric methods, thermogram, factors affecting thermogram, thermogravimetric analysis (TGA) – instrumentation and applications (TGA analysis of polymers and inorganic compounds), static and dynamic thermogravimetry. Differential thermal analysis (DTA) – theory, instrumentation and applications (DTA analysis of polymers and inorganic compounds). Differential scanning calorimetry (DSC): theory, instrumentation and applications, factors affecting DTA and DSC.

**Unit-II****12 Hrs**

- A. **Capillary supercritical fluid and Gel chromatography:** General introduction, theory & working of capillary supercritical fluid & principle, instrumentation of Capillary supercritical fluid chromatography  
**Gel chromatography:** General Introduction, Principle, experimental techniques, gels used for separation by exclusion chromatography application of gel chromatography  
**Size exclusion chromatography:** General introduction Theory Distribution coefficient (KD) performance, materials, working principle of SEC apparatus, Application of sample detectors & application of size exclusion chromatography in pharmaceutical analysis.
- B. **Cyclic voltammetry:** Basic principles, cyclic voltammogram of  $K_4[Fe(CN)_6]$  system, irreversible and quasi-reversible curves, instrumentation and applications.  
**Electrogravimetry:** Theory, electrode reactions, over-voltage, characteristics of a good deposit, completeness of deposition, separation of metals at controlled cathode potential. Estimation of copper and nickel in Cu-Ni alloy

**Unit-III****12 Hrs**

Definition, principle, and application of the following techniques: **Ion-exchange chromatography (IEC)** Ion-exchangers, cation exchange resins, anion-exchange resins, ion-exchange mechanism, factors affecting ion exchange equilibrium, ion-exchange capacity, affinity scale, instrumentation, techniques for ion-exchange, liquid ion-exchanger, applications of IEC, experimental IEC, Supercritical fluid chromatography: **Affinity chromatography:** Introduction, classification, Selection of matrix, role of spacerseg. Affinity ligands, applications of affinity chromatography in the separation of biomolecules. Exclusion chromatography.

**Unit-IV****12 Hrs**

**Electrophoresis:** Overview, basis for electrophoretic separations, Moving boundary electrophoresis, Zone electrophoresis, isotachopheresis, isoelectric focusing and immune electrophoresis, and Continuous electrophoresis (preparative), applications. Capillary electrophoresis: Introduction, Principle, Instrumentation and applications.

**REFERENCES**

1. A H Beckett and J B. Stanlake. Practical Pharmaceutical Chemistry, Volume 52, First Ed, The Athlone Press, University of London, 2 Gower Street, London, S C, May 1963.
2. K. A. Connors, A Text book of pharmaceutical analysis- third Ed, John Wiley and Sons, Inc., Ansari Rd, Daryaganj, New Delhi, India, 1982.
3. E B Hassan and T Higuchi, Pharmaceutical Analysis. Vol 51, Issue I, Inter Science Publishers, Inc, 250 Avenue, New York, N.Y, 1961.
4. P.D. Sethi Quantitative analysis of drugs in pharmaceutical formulations, third edition, 1961.
5. D A Skoog and D M West. Fundamentals of Analytical Chemistry, Fourth Ed, Saunders College Publishing, New York, N.Y, 1983.
6. Gary D Christian Analytical Chemistry, 6th Ed., John Wiley and Sons, Inc. in. University of Washington. USA, 2004.

## THIRD SEMESTER

### PC.HC. 3.23: DRUG DISCOVERY AND DEVELOPMENT

48 HOURS

#### Unit-I

12 Hrs

**Drug discovery from natural products and through enzyme inhibition:** Introduction, drug discovery and design a historical outline, sources of Drugs and lead compounds, classification of drugs, Route of administration, the pharmaceutical phases, Introduction to drug action: ADME process Bioavailability of drug, the pharmacodynamics phase. Introduction to medicinal plants: preparation of initial extracts and preliminary biological screening, Methods for compound structures elucidation, compound development, a brief explanation on the development of natural product drugs.

#### Unit-II

12 Hrs

**Drug Design:** General approach to discovery of new drugs – lead discovery- lead modification- physicochemical principles of drug action- drug stereochemistry- drug action, -3D database search – computer aided drug design - docking- molecular modeling in drug design – structure based drug design- pharmacophores- QSAR.

#### Unit-III

12 Hrs

**Drug Design and of functional groups to pharmacological activity:** Introduction to drug discovery: Introduction, stereochemistry and drug design: structurally rigid groups, confirmation, and configuration. Solubility and drug design: The importance of water solubility, solubility and drug structure: The type of group, reversibility and irreversibility attached groups, the position of water solubilizing group, Methods of introducing of solubilizing groups.

Introduction, relationship between molecular structure and biological activity, selectivity of drug action and drug receptors. Discovery and structural modification of lead compounds. Drug discovery through random screening of synthetic compounds. Refinement of lead structure. Functional group modification.

#### Unit-IV

12 Hrs

- A. **Vitamins:** Introduction, classification, properties, biological significance of vitamins. Synthesis and Biological importance (Occurrence, Chemical properties, Deficiency and Excess defect) of following vitamins: Retinal, Thiamine, Ascorbic acid, Pantathoonic acid, vitamin K.
- B. **Lipids:** Nomenclature, classification, purification, structure and synthesis of lipids, phospholipids, sphingolipids. Biological importance of lipids: Lecithin, sphingolipids, oils and fats.

#### REFERENCES

1. Thomas L Lemke, David A Williams, Victoria F Roche, S. W. Zito, Foye's Principle of Medicinal Chemistry, 2012, 7<sup>th</sup> edition, Lippincott Williams and Wilkins, Wolters Kluwer Business, Baltimore, USA.
2. John Marlowe Beale, John H. Block, Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 2011 12<sup>th</sup> edition, Lippincott Williams and Wilkins, Wolters Kluwer Business, Baltimore, USA.
3. John B. Taylor and David J. Triggle, Comprehensive Medicinal Chemistry I-VI, 2006, Elsevier, Netherlands.
4. Gareth Thomas, Fundamentals of Medicinal Chemistry, 2007, 2<sup>nd</sup> edition, John Wiley and Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO198SQ, England.
5. Stuart Warren and Paul Wyatt, Organic Synthesis, The Disconnection approach, 2008, 2<sup>nd</sup> edition, John Wiley and Sons, New Jersey, USA.

## THIRD SEMESTER

### PC.3.03: ELECTIVE: DOSAGE FORMS AND ROUTES OF DRUG ADMINISTRATION

32Hours

#### Unit-I

16 Hrs

**Dosage Forms: Different dosage forms:** Oral solids, oral liquids, solution properties; suspension, emulsion, parenteral, aerosols, inhalation products, Topical semi solids, ophthalmic products.

**Routes of Drug Administration:** Advantages and disadvantages

1. Local application
2. Oral or enteral routes
3. Parenteral route: Different types of parenteral routes of drug administration: inhalation, injections, transcutaneous, trans-mucosal.

#### Unit-II

16 Hrs

**Novel Drug Delivery Systems:** Fundamentals of Novel Drug Delivery: Rationale of sustained/controlled release (CR), physicochemical and biological factors influencing design and performance of CR products. Pharmacokinetic and Pharmacodynamics basis of NDDS. Bioavailability assessment of CR systems. Regulatory requirements. Theory of mass transfer. Fick's law and its application in NDDS. Polymers in CR: classification, properties biocompatible & biodegradable polymers. Modeling of drug release from porous polymer; drug release from non-porous and hydrophobic polymers. Diffusional release and dissolution-controlled release from monolithic devices, microporous systems. Oral Controlled Drug Delivery Systems, Mucosal Drug Delivery System, Ocular Drug Delivery Systems, Parenteral Drug Delivery systems, Transdermal Drug Delivery Systems.

#### REFERENCES

1. S.D. Satoshkar, Bhandarkar and Nirmala Rege, Pharmacology and Pharmacotherapeutics, 2015, revised 21st Edition, Elsevier Health Sciences, and Netherlands.
2. M. N. Ghosh and Vallabh Prakash, Practical Pharmacology, 2008, sixth edition, Hilton and Company, Kolkata, India.
3. Hans Gerhard Vogel, Drug Discovery and evaluation; Pharmacological assay, 2008, 3rd Edition, Vol-2. Springer-Verlag Berlin Heidelberg, Germany
4. P.N. Benett and M.J. brown, Clinical pharmacology, 2012, 11th Edition, Elsevier Ltd.
5. D. G. Graham-Smith and J. K. Aronson, Oxford text book of Clinical Pharmacology and Drug Therapy, 2002, 3rd Edition, Oxford University Press, U.K.
6. Rama Rao Nadendla, Principle of Organic Medicinal Chemistry, 2005

## FOURTH SEMESTER

### PC.HC. 4.01: MEDICINAL CHEMISTRY-I

64 Hours

#### Unit-I

16 Hrs

- A. **Local Anti-infective agents:** Introduction, classification, mechanism of action, Synthesis and SAR of nitrofurazone and furazolidones
- B. **Sulfonamides:** Introduction, classification, mechanism of action, Synthesis and SAR of sulfisoxazole and sulfamethoxazole
- C. **Antibiotics:** Introduction, classification, mechanism of action, Synthesis and SAR of Penicillin G, cephalosporins and tetracyclines.

#### Unit-II

16 Hrs

- A. **Antitubercular and antileprotic agents:** Introduction, classification, mechanism of action, Synthesis of isoniazid, ethambutol, clofazimine, dapsone.
- B. **Analgesic and anti-inflammatory agents:** Introduction, classification, mechanism of action, Synthesis of Ibuprofen, phenylbutazone, acetaminophen, diclofenac sodium.
- C. **Anticancer/antiviral, hypoglycaemic agents:** Introduction, classification, mode of action, Synthesis of 5-fluorouracil, azidothymidine, Tolbutamide and tolazamide.

#### Unit-III

16 Hrs

- A. **Antihistamine:** Introduction, classification, mode of action, Synthesis of Pheniramine maleate, pyrilamine, ranitidine, cimetidine.
- B. **Cardiovascular Agents:** Introduction, classification, mechanism of action, Synthesis of Antiarrhythmic agents verapamil, Antihypertensive agent clonidine and hydralazine derivatives
- C. **Psychopharmacological agents:** Introduction, classification, mechanism of action, Synthesis of Benzodiazepines: diazepam, Phenothiazines: chlorpromazine, Amitriptyline.

#### Unit-IV

16 Hrs

- A. **Antimalarials:** Introduction, classification, mechanism of action, Synthesis of Chloroquine, mefloquine, primaquine. SAR of antimalarial agents.
- B. **Anti-amoebic agents:** Introduction, classification, mechanism of action, Synthesis of Metronidazole and iodoquinol
- C. **Anticonvulsant:** Introduction, classification, mechanism of action, Synthesis of Phenytoin sodium, carbamazepine.
- D. **Sedatives and hypnotics:** Introduction, classification, mechanism of action, Synthesis of Phenobarbital, Chlordiazepoxide
- E. **General anaesthetics:** Introduction, classification, mechanism of action, Synthesis of Halothane, Methohexital sodium

## REFERENCES

1. Thomas L Lemke, David A Williams, Victoria F Roche, S. W Zito, Foye's Principles of medicinal Chemistry, seventh edition, Lippincott Williams and Wilkins, Wolters Kluwer business, Baltimore, USA, 2012.
2. M. S. Chorgade, John Wiley and sons, Drug discovery and development, vol-2, New Jersey, US.
3. Wilson and Gisvold's: Text Book of Medicinal Chemistry, Lippincott Williams and Wilkins, Wolters Kluwer, Philadelphia, 2010.
4. C. Hanch, Comprehensive Medicinal Chemistry - series- 1-VI (Academic Press).
5. Donald Abraham, Burgers Medicinal chemistry and drug discovery, Volume-1 to Volume 6, John Wiley and sons, New Jersey, US, 2016.

## FOURTH SEMESTER

### PC.HC. 4.02: MEDICINAL CHEMISTRY-II

64 Hours

#### Unit-I

16 Hrs

- A. i). Basic considerations, historical evolution. ii). Fundamental aspects of drugs: Forms, application, biological action, placebo effect, metabolism, drug interactions, adverse effects. iii). classification of drugs. iv). nomenclature of drugs. v). drug combinations. vi). the selection of essential drugs. Physicochemical properties of drug molecules in relation to biological activity; solubility, partition coefficient, hydrogen bonding, protein binding, chelation,  $p^{ka}$  values, isomerism Geometrical and optical isomers, steric effect, ionization.
- B. **SAR and QSAR:** SARs, changing size and shape, introduction of new substituents-the introduction of a group in an unsubstituted position, the introduction of a group by replacing the existing group. QSAR- Lipophilicity, partition coefficient (log P), lipophilic substitution constants( $\pi$ ). Electronic effect (Hammett constant  $\sigma$ ), steric effect, Taft's steric parameter ( $E_s$ ), Hansch analysis and application, Craig plot, Free-Wilson analysis and application.

#### Unit-II

16 Hrs

**Prodrugs:** Enzyme activation of drugs, Utility of prodrugs, types of prodrugs, mechanism of drug activation-Carrier linked prodrugs, carrier linkages for various functional groups, carrier linked bipartite prodrugs. Bioprecursor prodrugs (Proton activation, hydrolytic activation, elimination activation, oxidative activation, reductive activation, nucleotide activation, phosphorylation activation, sulfation activation, decarboxylation activation.

#### Unit-III

16 Hrs

**Selective examples of drug action at some common target areas:** Introduction, Examples of drugs that disrupt cell membranes and walls-Antifungal agents, Azoles, Allylamines, Phenols, Antibacterial agents- Ionophoric antibiotic action, Cell wall synthesis inhibition, Drugs that target enzymes- Reversible inhibitors, Irreversible inhibition, Transition state inhibitors, Drugs that target receptors- Agonists, Antagonists, Partial agonists. Drugs that target nucleic acids- Antimetabolites, Enzyme inhibitors, Intercalation agents, Alkylating agents, Antisense drugs, Chain cleaving agents, Antiviral drugs -Nucleic acid synthesis inhibitors, Host cell penetration inhibitors, Inhibitors of viral protein synthesis.

#### Unit-IV

16 Hrs

- A. **Combinatorial Chemistry and Drug metabolism:** Introduction, the design of combinatorial synthesis, the general techniques used in combinatorial synthesis, the solid support method, parallel synthesis, Furka's mix and split techniques, Encoding methods -Sequential chemical tagging method, stills binary core tag system, computerized tagging, combinatorial synthesis in solution, screening and deconvolution.
- B. **Drug metabolism:** Introduction, sites of drug biotransformation, phase-I and phase-II reactions, role of Cytochrome P-450, Factors affecting drug metabolism.

## REFERENCES

1. Y.C. Martin, Qualitative drug Design: A critical Introduction, 2nd Edition, CRC press, May 6, 2010.
2. Crowin and Hansch, Comprehensive Medicinal Chemistry, Vol-6, Pergamon; July-1990.
3. Donald J. Abraham, David P. Rotella, Burger's Medicinal Chemistry, Drug Discovery and Development, 7th Edition, Vol-8, Wiley, 2010.
4. H. John Smith, Hywel Williams Introduction to the Principle of Drug Design and action, 4thEdn, CRC press, 2005.
5. Thomas L. Lemke, David A. Williams, Foye's Principles of Medicinal Chemistry, Lippincott Williams and Wilkins, 2008.
6. Richard B. Silverman and Mark W. Holladay, The organic Chemistry of Drug Design and Drug Action, 3rd Edition, Elsevier Inc, 2015.

## FOURTH SEMESTER

### PC.SC. 4.21: GENERAL PHARMACOLOGY

48 Hours

#### Unit-I

12 Hrs

**General pharmacology:** Introduction, definition, sources and active ingredients of drugs, routes of drug administration, Drug distribution, fate of drug, drug excretion, plasma half-life and its significance, methods of prolonging the duration of action of a drug, special drug delivery system. Factors modifying drug effects, drug toxicity, acute, sub-acute, and chronic toxicity. LD50, ED50, tolerance, habituation, and addiction. Drug response relationship, drug interaction- basic concept of drug interaction (both in vitro and in vivo), preclinical and clinical evaluations.

#### Unit-II

12 Hrs

**Sterilization and Screening methods:** Sterilization, types of sterilization methods General principles of screening of drugs, general screening methods, clinical trials. Experimental animals used in pharmacological assays, in vitro, in vivo studies. Bioassay, scope, principles involved in bioassay. Screening for analgesic, anti-inflammatory, anti-implantation, anthelmintic, antidiabetic and antiulcer, Methodology for microbial assay of Penicillin, and Miconazole. Enzyme inhibition studies: DNA gyrase, COX inhibition studies.

#### Unit-III

12 Hrs

**Drug receptor Interaction and Adverse Drug receptor:** Introduction, history, affinity - the role of chemical bonding, conformation, stereochemistry of labetalol. Drug receptors, Drug action, sites of drug action, Mechanism of drug action, drug receptors, types of receptors- ligand gated ion channels, voltage gated ion channels, G-protein coupled receptors, intracellular receptors, dose response relationship, adverse drug relationship. Drug allergy.

#### Unit-IV

12 Hrs

**Immunology and Microbiology:** Microbial Drug Development - Introduction to Microbiology and classification of Microbes. Characterization and Screening of Microbes fermentation process, Microbial growth, kinetics, Isolation and Improvement of Individual micro- organism, fermenter designing, Media designing, antimicrobial assays; Down Stream process and effluent treatment (Microbial and Chemical) Immunology and Immunopharmacology- Overview of the immune system and its role, Adaptive and innate Immunity. Immune response and the underlying mechanisms, Regulation of immune response. Hypersensitivity, immunodeficiency, Autoimmunity, Immunization, Immunosuppressant's, Immunomodulators, Immunological techniques. Agglutination, precipitation, RIA and ELISA.

## REFERENCES

1. R.S. Satoskar, N. Rege, S. D. Bhandarkar, Pharmacology and Pharmacotherapeutics, 24th Edition, Elsevier India, 2015.
2. M.N. Ghosh, Fundamentals of Experimental Pharmacology Paperback, 6th Edition, HILTON and COMPANY, 2008.
3. H. G. Vogel, Drug Discovery and Evaluation: Pharmacological assays, Vol 2, 3rd edition, Springer, 2008.
4. Robert E. Notari, Biopharmaceutics and clinical pharmacokinetics, 4th Edition, Marcel Dekker, Inc, New York, 1987.
5. G.R. Chatwal, Biopharmaceutics and pharmacokinetics, 2nd Edition, Himalaya Publishing House, 2014.
6. S.N. Jogdand, Biopharmaceutics, Himalaya Publishing House, 2006.
7. Walter Land, Pharmaceutical codex- principles and practice of pharmaceutic, XII Edition, London: The Pharmaceutical Press, 1994.
8. Gareth Thomas, Medicinal Chemistry: An introduction, Wiley India Exclusive, 2015.

## FOURTH SEMESTER

### PC.SC. 4.22: DOSAGE FORMS AND REGULATORY ASPECTS

48 Hours

#### Unit-I

12 Hrs

**Dosage forms and regulations:** Different dosage forms: Oral solids, oral liquids, solution properties, suspensions, emulsions, parenteral, aerosols, inhalation products, topical semisolids, typical lipids, and powders, ophthalmic products, rectal and vaginal products. Oral solids: Tablets, types of solids, methods of tablet production – wet granulation, coating of tablets. Quality control methods and measurement of tablet properties. Oral liquids: Introduction, types, oral suspensions and oral emulsions.

**Novel Drug Delivery Systems:** Fundamentals of Novel Drug Delivery: Rationale of sustained/controlled release (CR), physicochemical and biological factors influencing design and performance of CR products. Pharmacokinetic and Pharmacodynamics basis of NDDS. Bioavailability assessment of CR systems. Regulatory requirements. Theory of mass transfer. Fick's law and its application in NDDS. Polymers in CR: classification, properties biocompatible & biodegradable polymers. Modeling of drug release from porous polymer; drug release from non-porous and hydrophobic polymers. Diffusional release and dissolution-controlled release from monolithic devices, microporous systems. Oral Controlled Drug Delivery Systems, Mucosal Drug Delivery System, Ocular Drug Delivery Systems, Parenteral Drug Delivery systems, Transdermal Drug Delivery Systems.

#### Unit-II

12 Hrs

- A. **Stability of medicinal products:** Chemical stability: Hydrolysis, dehydration, oxidation, isomerisation, racemisation, polymerization, photochemical reactions, factors affecting chemical stability.
- B. **Physical stability:** Volatility, change in the water content of solids, changes in the crystal properties, physical changes in emulsions and suspensions. Stability of medicines in pharmaceutical practice, e.g. glycerol trinitrate tablets.
- C. **Physical characteristics:** Particle size, shape, surface area, Solubilization, surfactants and its importance, temperature, pH, co-solvency; Techniques for the study of crystal properties and polymorphism.
- D. **Chemical characteristics:** Degradation, Hydrolytic, oxidative, reductive, photolytic degradations; Biopharmaceutics characteristics: Solubility, dissociation, Dissolution rate, diffusibility, and drug stability in GI tract. Physicochemical characteristics of new drug molecules with respect to different dosage forms.

#### Unit-III

12 Hrs

**Current good manufacturing practice, Clinical trials:** Introduction, requirements of good manufacturing practice and quality management, guide lines to manufacturing practice for medicinal products, premises and equipments, documentation and production and quality control. Process development: Introduction, solid dosage forms and granulation and safety, plan for, process development – equipments, validation batch record. Regulatory aspects of process development: In process tests, validation of equipments and definition of batch size, packing, clinical trials and SOPs.

#### Unit-IV

12 Hrs

- A. **Pharmaceutical Laws and Acts:** An introduction of following laws with regard to drug product design, manufacture and distribution in India (**with latest amendments**):  
Drugs and Cosmetics Act 1940 and its rules 1945, National Pharmaceutical Pricing Authority (NPPA), Intellectual property rights - Indian Patent Act and its rules, Law of Copyright and Designs, law of trademark and geographical indications, Patent Procedure in India.
- B. **Registration Requirements:** Forms, Clinical Trial Registration, Test License, Commercial Import License, Sale License, Manufacture License, Certificate of pharmaceutical Product (CoPP)
- C. **Regulatory requirements:** For import and product registration of New Drugs, DCGI & RCGM requirements, Generics, Medical Devices, Biologics, Herbals, Cosmetics & Fixed Dose, Combinations, Export of drugs, traditional drugs, narcotics.
- D. **Pharmaceutical Regulations:** USA Organization and structure of FDA. Federal register and CFR, History and evolution of FDC act, Hatch Waxman act and Orange book, Regulatory Approval Process for IND, NDA, ANDA. Regulatory requirements for Orphan drugs and Combination Products, SUPAC & PMS. Changes to an approved NDA / ANDA.
- E. **European Union:** Organization of EMA & Marketing Authorization procedures in EU (CP, DCP, MRP, NP). EudraLex directives for human medicines, Variations & extensions, IMPD. Requirements for BA/BE studies, Compliance of European Pharmacopoeia (CEP)/ Certificate of Suitability (CoS)
- F. **Emerging Markets:** Overview, Regulatory Requirements for generic drug registration, new drugs and post approval requirements in BRICS countries (Brazil, Russia, India, China, South Africa) and Egypt.

## REFERENCES

1. David B. Troy, Paul Beringer, Remington: The Science and Practice of Pharmacy, Lippincott Williams & Wilkins, Vol. I & II, 21st edition, New Delhi, 2006.
2. Arun Bhatt, Clinical Trials and Good Clinical Practice in India, Arun Bhatt, 1st edition, D.K. Publications, Mumbai 2006.
3. K.N. Jayaveera, Y. Sudhakar, Novel drug delivery systems and regulatory affairs, S. Chand publications Pvt. Ltd, new Delhi, 2014.
4. D.T. Baviskar, D.K. Jain, Novel Drug Delivery Systems, Nirali Prakashan, Oct-8, 2012.

## FOURTH SEMESTER

### PC.SC. 4.23: BIOPHARMACEUTICS

48 Hours

#### Unit-I

16 Hrs

##### **PREFORMULATION**

- A. **Absorption of Drugs:** Structure of Cell membrane, Gastro-intestinal absorption of drugs, mechanisms of drug absorption, Factors affecting drug absorption: Biological, Physiological, Physico-chemical, pharmaceutical. Absorption of drugs from non-per oral routes, Methods of determining absorption: In-vitro, in-situ and In-vivo methods.
- B. **Bioavailability:** Objectives and considerations in bioavailability studies, Concept of equivalents, measurement of bioavailability, Determination of the rate of absorption, Bioequivalence and its importance, bioequivalence studies.
- C. **Dosage Regimen:** Multiple dosing with respect to IV and oral route, Concept of loading dose, maintenance dose, Accumulation index, Adjustment of dosage in renal and hepatic impairment, Individualization of therapy, Therapeutic Drug Monitoring.

#### Unit-II

16 Hrs

- A. **Scale up Pilot Plant Scale up Techniques, Pharmaceutical Production Planning and Control:** Significance of pilot plant scale up study, large scale manufacturing techniques (formula, equipment, process, stability and quality control) of solids, liquids, semisolid and parental dosage forms, General principles, Types of production systems, calculation of standard costs, production or process planning, Routing, Loading, Scheduling, Dispatching of records, Production control.
- B. **Pharmaceutical Pre-approval inspections, Post operational activities:** Evaluation of FDA, Pre-new drug application approval inspection, FDA risk based approach to inspections, Critical role Pharmaceutical scientist in product development and preparing for pre- approval inspection, Training requirements in product development, System based pre-approval inspection, cGMP risk assessment, and Management strategy, concepts in quality by design for drug development manufacture, Equipment cleaning during pharmaceutical product development and its importance to pre-approval inspection, Distribution, Recalled products, Returned products, Complaints and adverse effects, Drug product salvaging documents and formats.

#### Unit-III

16 Hrs

- D. **Pharmaceutical Laws and Acts:** An introduction of following laws with regard to drug product design, manufacture and distribution in India (**with latest amendments**):
  - i. Drugs and Cosmetics Act 1940 and its rules 1945
  - ii. National Pharmaceutical Pricing Authority (NPPA)
  - iii. Intellectual property rights - Indian patent Act and its rules, Law of Copyright and Designs, law of trademark and geographical indications
  - iv. Patent Procedure in India.
- E. **Registration Requirements:** Forms, Clinical Trial Registration, Test License, Commercial Import License, Sale License, Manufacture License, Certificate of pharmaceutical Product (CoPP)
- F. **Regulatory requirements:** For import and product registration of New Drugs, DCGI & RCGM requirements, Generics, Medical Devices, Biologics, Herbals, Cosmetics & Fixed Dose, Combinations, Export of drugs, ztraditional drugs, narcotics etc.

#### Unit-IV

16 Hrs

- G. **Pharmaceutical Regulations:** USA Organization and structure of FDA. Federal register and CFR, History and evolution of FDC act, Hatch Waxman act and Orange book, Regulatory Approval Process for IND, NDA, ANDA. Regulatory requirements for Orphan drugs and Combination Products, SUPAC & PMS. Changes to an approved NDA / ANDA.

- H. **European Union:** Organization of EMA & Marketing Authorization procedures in EU (CP, DCP, MRP, NP). EudraLex directives for human medicines, Variations & extensions, IMPD. Requirements for BA/BE studies, Compliance of European Pharmacopoeia (CEP)/ Certificate of Suitability (CoS)
- I. **Emerging Markets:** Overview, Regulatory Requirements for generic drug registration, new drugs and post approval requirements in BRICS countries (Brazil, Russia, India, China, South Africa) and Egypt.

## REFERENCES

1. Arun Bhatt, Clinical Trials and Good Clinical Practice in India, Arun Bhatt, 1st edition, D. K. Publications, Mumbai, 2006.
2. David B. Troy, Paul Beringer, Remington: The Science and Practice of Pharmacy, Lippincott Williams & Wilkins, Vol. I & II, 21st edition, New Delhi, 2006.

## Practical Syllabus of M.Sc., Pharmaceutical Chemistry

### Semester-I

#### Practical-I, PC: 1.05: Inorganic Chemistry

##### A] Complexometric titrations

1. Determination of temporary, permanent and total hardness of water.
2. Estimation of Ca ions.
3. Estimation of Mg ions.

##### B] Redox titrations

1. Estimation of Fe (II) ions.
2. Estimation of Fe (III) ions.
3. Estimation of Cu from copper sulphate solution.

##### C] Preparation of metal complexes

###### Preparation of coordination compounds

1. Preparation of chloropentammine cobalt (III) chloride
2. Preparation of potassium trisoxalato ferrate (III) tri hydrate c complex
3. Preparation of mercury (II) tetrathiocyanato cobaltate complex
4. Preparation of hexaminecobalt (III) chloride

###### Analysis of coordination compounds for metal and ligands contents:

1. Analysis of chloropentammine cobalt (III) chloride
2. Analysis of potassium trisoxalato ferrate (III) trihydrate complex

##### Books recommended:

1. Vogel's qualitative inorganic analysis. Revised by G. Suchla Longarman group ltd.
2. Inorganic quantitative analysis – A.I. vogel. ELBS.
3. Fundamentals of analytical chemistry- D.A. Skoog, D.M. West and F.T. Holler, sauder college publication.
4. Advanced inorganic chemistry- F.A. Cotton and Wilkinson. John Wiley.
5. Concise inorganic chemistry- J.D. Lee.

#### Practical-II, PC: 1.06: Organic chemistry

##### Qualitative organic analysis of binary mixture.

Acid+ Base, Acid+Neutral, Base+Neutral, phenol+ neutral, Acid + Phenol and Base + phenol.

##### Books Recommended

1. Quantitative chemical semi micro analysis – V.N. Alexeyo
2. Practical chemistry – Dr. O.P. Pandey, D.N. Bajpai and Dr. S. Giri

#### Practical-III, PC: 1.07: Physical Chemistry

1. Acid catalysed hydrolysis of methyl acetate.
2. Determination of rate constants of hydrolysis of ester (ethyl acetate/methyl acetate) catalyzed by 0.5N HCl and determine the energy of activation of the reaction.
3. Effect of ionic strength on rate of per sulphate–Iodide reaction.
4. Determination of molecular weight of a polymer by using viscometer.
5. Adsorption characteristic of acetic acid on charcoal.
6. Determination of strength of strong acid (HCl) using standard NaOH by conductometric titration.
7. Determination of percentage composition of a given acid mixture (HCl+CH<sub>3</sub>COOH) by conductometric titration.
8. Determination of the pH of the given acid using NaOH by pH titration.
9. Determination of pK<sub>a</sub> value of weak acid (formic acid) by potentiometric method.
10. Determination of strength of weak acid (CHCOOH) by using standard NaOH solution by conductometric titration.

#### **Books Recommended**

1. Practical physical chemistry – B. Vishwanathan and P.S. Raghavan
2. Advanced practical physical chemistry – Dr. J.B. Yadav
3. Physical chemistry – P.W. Atkins.
4. Practical physical chemistry – Findlay.
5. Advanced experimental chemistry by Dr. J.N. Gurthu R Kapoor
6. Experimental inorganic chemistry ( first edition) by Ayodhya Singh.
7. An introduction to practical physical chemistry by K.K. Sharma, D.S. Sharma.
8. Practical physical chemistry by Khosla and others.

#### **Semester-II**

##### **Practical-I, PC: 2.06: Inorganic Chemistry**

Inorganic Qualitative Analysis of two acidic and two basic radicals.

##### **Books Recommended:**

1. Practical chemistry – Dr. O.P. Pandey, D.N. Bajpai and Dr. S. Giri
2. Inorganic Qualitative analysis by A.I. Vogel.

##### **Practicals – II, PC: 2.07: Advanced organic chemistry Synthesis of organic compounds**

1. Acetylation of aniline(N-acetylation)
2. Benzoylation of phenol (O-Benzoylation)
3. P- nitroacetanilide from acetanilide
4. Hydrolysis of p-nitro acetanilide to p-nitro aniline
5. P-bromoacetanilide from acetanilide (nucleous bromination)
6. Synthesis of heterocyclic compounds related to syllabus.

**Estimations of following mixture:** Estimation of acid and amide Estimation of acid and ester

##### **Books recommended:**

1. Advanced organic chemistry – reactions, mechanism and structure – Jerry March
2. Practical organic chemistry – A.I. Vogel

3. Practical organic chemistry – Ahluwalia
4. Organic chemistry vol-I and vol-II – I.L.Finar.
5. Practical organic chemistry – Vishnohi
6. Reactions, rearrangement and reagents – S.N. Sanyal.

### **Practicals – III, PC: 2.08: Bioanalytical techniques**

#### **A] Analysis of biologically important samples.**

1. Glucose by a) DNS method, b) Fehling's solution method.
2. Estimation of the following compounds by spectrophotometer.
  - a) Cholesterol, b) uric acid, and c) creatinine.

#### **B] Isolation of following constituents from the Natural sources:**

- a) Caffeine from tea powder.
- b) Piperine from black pepper.
- c) Nicotine from tobacco.
- d) Other constituents from natural sources.

#### **Books Recommended:**

1. Inorganic quantitative analysis- A.I. Vogel, ELBS.
2. Practical of organic chemistry- Vogel.
3. Practical organic chemistry – Vishnohi
4. Practical chemistry – Dr. O.P. Pandey, D.N. Bajpai and Dr. S. Giri

### **III Semester:**

#### **Practical-I, PC: 3.04: Synthesis of drugs and drug intermediates-I**

##### **A] Synthesis:**

1. Aspirin
2. Paracetamol
3. Iodoform
4. Coumarin derivative
5. Benzimidazole
6. Benzotriazole
7. Synthesis of pharmaceutically important molecules

##### **B] Identification of pharmaceuticals by the analysis of their spectral data:**

Give the photocopies of UV, IR, NMR and Mass data of standard compounds for the elucidation of structure.

#### **Books Recommended:**

1. A.I. Vogel, Practical Organic Chemistry, 1989, fifth edition, longman scientific and technical, Harlow, U.K.
2. V. K. Ahluwalia, R Agarwal, Comprehensive Practical Organic Chemistry : Preparation and Qualitative Analysis, 2001, University Press.
3. I.L. Finar, Textbook of Organic Chemistry, 1964, volume 2, fourth edition, Longmans Green and Co. Harlow, United Kingdom.
4. N. k. Vishnoi, Advanced Practical Organic Chemistry, 2009, third edition, Vikas publishing house, Noida, UP, India.
5. S.N. Sanyal, Reactions, rearrangement and reagents, 2004, Bharathi Bhavan Publications.

- R.M. Silverstein and F X Webster, David J Kiemle, Spectroscopic Identification of Organic Compounds, 1963, Seventh Edition, John Wiley and Sons, New York.
- Jerry March, Advanced Organic Chemistry- reactions, mechanism and structure, 2006, sixth edition, Wiley India pvt. Ltd.

**Practical-II, PC: 3.05: Separation techniques:**

- Analytical thin layer chromatography: Qualitative separation of given mixture containing following compounds.
  - Phenol and Resorcinol
  - O-nitro aniline and p-nitro aniline.
  - Aspirin and acetaminophen and
  - Sulphaisoxazole and Sulphamethoxazole.
- Preparative thin layer chromatography- Quantitative separation of given mixture of compounds.**
- Paper chromatography: Qualitative separation of given mixture containing amino acids Glycine, Tyrosine, Tryptophan and Histidine.**
- Column chromatography- Separation of given mixture and quantification of the compounds.**

**Books Recommended:**

- A. H. Beckett and J. B. Stenlake, Practical pharmaceutical chemistry, May 1963, volume 52, 1 Edition, The Athlone Press, University of London, 2 Gower Street, London.
- Gurudeep R Chatwal and Shamk Anand, Instrumental Methods of Chemical Analysis, 2015, Himalaya Pub House, New Delhi.
- R.A.Day. Jr, and A.L.Underwood m K Anand, Quantitative analysis, 1991, sixth edition, Pearson, London, England.
- Gurudeep R Chatwal, Analytical Chromatography, 2006, revised edition, Himalaya Publishing House, pvt, Ltd. Bangalore, India.

**Practical- III, PC: 3.06: Assay of drugs by titrimetric and instrumental methods - I**

- Assay of Aspirin
- Assay of Analgin
- Assay of Ibuprofen
- Assay of Paracetamol
- Calcium gluconate
- Assays of new biologically important molecules

**Books Recommended:**

- R.C. Denny, J.D. Barnes, M.J.K. Thamas and others, Vogel's text book of quantitative chemical analysis, 2000, sixth edition, Prentice hall, New Jersey, United States.
- A. H. Beckett and J.B. Stenlaker, Practical Pharmaceutical Chemistry, May 1963, volume 52, 1 Edition, The Athlone press, University of London, 2 Gower Street, London.
- Dr. O.P. Pandey, D.N. Bajpai and Dr. S. Giri, Practical Chemistry, 2014, Revised Edition,
- S. Chand and Company Ltd. New Delhi, India.
- Anees A. Siddique, Lab manual – selected experiments of pharmaceutical analysis, 2016, CBS Publishers and Distributors, Daryaganj, new Delhi, India.
- Sethi. P.D, Quantitative Analysis of Drugs in Pharmaceutical Formulations, 1997, third Editin, CBS Publishers, New Delhi, India.

#### IV-Semester:

##### Practical –I, PC: 4.03: Synthesis of Drugs and Drug intermediates-II

1. 2-hydroxy naphthaldehyde
2. Schiff base
3. Chalcone
4. 3-acetyl coumarin
5. Sulphonamide drugs
6. Other important compounds.

##### Books Recommended:

1. A. I. Vogel, A. r Tatchell, B.. Furnis, A.J. Hannaford, P.W. G. Smith, Vogel's Textbook of Practical organic chemistry, fifth edition, by Prentice Hall, published on feb-19,1996.
2. V.K. Ahluwalia, S. Dhingra Practical Organic Chemistry, Universities Press, Jun-1,2004.
3. I.L. Finar, Organic Chemistry vol 2 (3rd.ed. ) Longmans Green and Co. 1964 Acrobat.
4. N.K. Vishohi, Advanced Practical Organic Chemistry, Vikas Publishing House Pvt. Limited, Apr-1-1996.
5. S.N. sanyal, Reactions, rearrangement and reagents, Publisher: Bharati Bhavn, 2004.
6. R.M. Silverstein, F.X. Webster, D.J. Kiemle, D.L. Beyce, Spectroscopic identification of organic compounds, sixth edition, John Wiley and sons, 29-sep-2014.
7. Michael Smith, Jerry March, Advanced Organic Chemistry, reactions, mechanism and structure, John Wiley and sons, Inc, 2007.

##### Practical-II, PC: 4.04: Assay of drugs by titrimetric and instrumental methods - II

1. Isoniazid
2. Ascorbic acid
3. Hexamine
4. Ampicillin
5. Amoxicillin
6. Aspirin
7. Paracetamol
8. Other drugs of interest.
9. Demonstration: Estimation of potassium in agricultural water supply by flame photometry.

##### Books Recommended:

1. R.C. Denny, J.D. Barnes, M.J.K. Thomas, J. Mendham, Vogel's text book of quantitative chemical analysis, sixth edition, Prentice Hall, April-7, 2000.
2. A. H. Beckett, J.B. Stenlake, Practical pharmaceutical chemistry, fourth edition, part-II, A and C Block,1988.
3. O.P. Pandey, D.N. Bajpai and Dr. S. Giri, Practical Chemistry, S. Chand Limited,2005.
4. Anees A. Siddique, Lab manual-selected experiments of pharmaceutical analysis, CBS Publishers and Distributors Pvt. Ltd,2016.
5. P.D. Sethi, Quantitative analysis of drug in pharmaceutical formulations, third edition, Feb- 15, 2007.

##### Practical-III, PC: 4.05: Project Work

Project work Involving appropriate or relevant work in the field of Pharmaceutical Chemistry. Work is assigned to research project and submit the results at the end of the semester in the form of a dissertation which will be valued for 100 marks (75 for dissertation and 25 for Viva voce). Project work involving multistage synthesis or isolation of active molecules present in medicinal plants or pharmacokinetic studies or evaluation of biological activities.

**Question Paper Pattern – 2025-2026**

**M.Sc. Examination (CBCS Scheme) PHARMACEUTICAL CHEMISTRY**

**Paper Title and Code:**

[Time: 3hrs]

[Max. Marks: 75]

Note: 1) Answer Part-A and any FIVE questions from Part-B.

2) Figures to the right indicate marks.

**PART - A**

1. Answer the following:

a), b), c), d), e), f), g), h), i) and j)

10 x 2 = 20

(Answer any FIVE questions)

**PART – B**

5 x 11 = 55

- |    |            |            |
|----|------------|------------|
| 2. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |
| 3. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |
| 4. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |
| 5. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |
| 6. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |
| 7. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |
| 8. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |
| 9. | a) 5 Marks | a) 4 Marks |
|    | b) 6 Marks | b) 7 Marks |

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**Question Paper Pattern - 2025-2026**

**M.Sc. Examination (CBCS Scheme)**

**PHARMACEUTICAL CHEMISTRY (Elective Paper)**

**Paper Title and Code:**

[Time: 1 ½ hrs]

[Max. Marks: 40]

Note: 1) Answer Part-A and any THREE questions from Part - B

2) Figures to the right indicate marks.

**PART - A**

1. Answer the following: (At least 03 Questions should be selected from each Unit)

a), b), c), d), e)

5 x 2 = 10

**PART – B**

(Answer any THREE questions)

3 x 10 = 30

2. a) 5 Marks      a) 4 Marks

b) 5 Marks      b) 6 Marks

3. a) 5 Marks      a) 4 Marks

b) 5 Marks      b) 6 Marks

4. a) 5 Marks      a) 4 Marks

b) 5 Marks      b) 6 Marks

5. a) 5 Marks      a) 4 Marks

b) 5 Marks      b) 6 Marks

6. a) 5 Marks      a) 4 Marks

b) 5 Marks      b) 6 Marks

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