Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Post-Graduate Program in Chemistry

(Faculty of Science & Technology)

Choice Based Credit System Syllabus (2019 Pattern)
of

M.Sc. (Chemistry) Part-II

Physical Chemistry, Inorganic Chemistry, Organic Chemistry
Drug Chemistry and Analytical Chemistry

for

Colleges Affiliated to Savitribai Phule Pune University

Implemented from Academic Year
2020-2021

Title of the Course: M.Sc. (Chemistry) (Part-II)

1. Structure of the Course:

Basic structure/pattern (Framework) of the proposed postgraduate syllabus for the two years integrated course leading to M.Sc. (Chemistry) in the colleges affiliated to Savitribai Phule Pune University. The general structure for the M. Sc-II year Chemistry (all specializations)is as follows:

Semester - III			
Sr. No.	**Paper No**	**Description**	**Credit**
1	CCTP-7	Core Compulsory Theory Paper	4
2	CCTP-8	Core Compulsory Theory Paper	4
3	CCTP-9	Core Compulsory Theory Paper	4
4	CBOP-3	Choice Based Optional Paper - Theory	4
5	CCPP-3	Core Compulsory Practical Paper	4
Semester-IV			
6	CCTP-10	Core Compulsory Theory Paper	4
7	CCTP-11	Core Compulsory Theory Paper	4
8	CBOP-4	Choice Based Optional Paper - Theory	4
9	CBOP-5	Choice Based Optional Paper – Practical/ Project	4
10	CCPP-4	Core Compulsory Practical Paper	4

Choice of the optional papers: All colleges are encouraged to give the choice of optional papers to the students and conduct the separate classes if 40% or more students opt a different course than 60% or less students.

The specializations are:

1. **Physical Chemistry**
2. **Inorganic Chemistry**
3. **Organic Chemistry**
4. **Drug Chemistry**
5. **Analytical Chemistry**
6. **Biochemistry**

2. Teaching Hours

a) Theory – Each credit of theory is equivalent to 12 teaching hours + 3 tutorial hours. For 1 credit of theory there will be 1 L of 1 hour per week. Thus, 1 theory course will have total 15 weeks of teaching and it will be distributed as of 48 h for teaching and 12 h for tutorials and internal evaluation. In case of theory paper consisting of sections, each section is of 2 credits and time allotted will be 24 h teaching and 6 h for tutorials and internal evaluation.

b) Practical – Each credit of practical is equivalent to 24 teaching hours + 6 tutorial hours. For 1 credit of practical there will 2 L of 1 h per week. Thus, 1 practical course will have total 15 weeks of teaching and it will be distributed as of 96 h for performing practical and 24 h for tutorials and internal evaluation. i) Each experiment will be allotted 4 h time (one practical session) and for 1 course two sessions of 4 h per week should be allotted or ii) In case practical course is extended for one year, then total 30 weeks (15 week per sem.) and 4 h

(one practical session) per week should be allotted to one practical course. ***There shall not be more than 10 students in one batch of practical.***

3. Examination: Each theory and practical course carry 100 marks equivalent to 4 credits. Each course will be evaluated with Continuous Assessment (CA) and University Assessment (UA) mechanism. Continuous assessment shall be of 30 marks (30%) while university Evaluation shall be of 70 marks (70%). To pass the course, a student has to secure 40% mark in continuous assessment as well as university assessment i.e. 12 marks in continuous assessment and 28 marks in university assessment.

For Continuous assessment teacher must select variety of procedures for examination such as: i) Written test / Mid Semester test (not more than one for each course), ii) Term paper, iii) Viva-Voce, Project / survey / field visits iv) Tutorials v) Group discussion vi) Journal / Lecture / Library notes vii) Seminar presentation, viii) Short quiz ix) assignment x) research project by individual student or group of student xi) An open book test, etc.

Each practical course will be extended over the year and practical examination will be conducted at the end of academic year.

1. M.Sc. (II) Physical Chemistry

Course Structure

Sr. No.	Paper No. & Code	Course Name	Credits
Semester III			
1	CCTP-7, CHP-310	Quantum and Solid State Chemistry	4
2	CCTP-8, CHP-311	Nuclear, Radiation and Polymer Chemistry	4
3	CCTP-9, CHP-312	Physicochemical Methods of Analysis	4
4	CBOP-3, CHP-313	A) Photochemistry and Techniques in Polymer Chemistry	4
		B) Special Topics in Physical Chemistry	4
5	CBOP-3, CHP-314 Practical	Physical Chemistry **Practical : I**	4
Semester IV			
6	CCTP-10, CHP-410	Molecular Structure and Spectroscopy	4
7	CCTP-11, CHP-411	Surface Chemistry and Electrochemistry	4
8	CBOP-4, CHP-412	A) Materials Chemistry and Catalysis	4
		B) Biophysical Chemistry and Special Topics in Nuclear and Radiation Chemistry	4
9	CBOP-4, CHP-413 Practical	A) Physical Chemistry **Practical III**	4
		B) Project	4
10	CCPP-4, CHP-414 Practical	Physical Chemistry **Practical: II**	4

Equivalence to Old Syllabus

New syllabus (2020)	Old Paper (2014 pattern)
Semester III	
CCTP-7, CHP-310	CHP-310
CCTP-8, CHP-311	CHP-311
CCTP-9, CHP-312	CHP-312
CBOP-3, CHP-313(A)	CHP-313
CBOP-3, CHP-313(B)	CHP-314
CCPP-3, CHP-314 Practical-I	CHP-315 Practical
Semester IV	
CCTP-10, CHP-410	CHP-410
CCTP-11, CHP-411	CHP-411
CBOP-4, CHP-412(A)	CHP-412
CBOP-4, CHP-412(B)	CHP-413
CBOP-5, **CHP-413(A** Practical III **CHP-413(B)** Project	CHP-415 Practical/Project
CCPP-4, CHP-414: Practical: II	CHP-316 Practical

Detailed Course wise syllabus of physical Chemistry, M. Sc.-II

Semester -III

CCTP-7 CHP-310: Quantum and Solid-State Chemistry [48 L +12 T]

Section-I: Quantum Chemistry [24 L +6 T]

1. Basic postulates of quantum mechanics, properties of quantum mechanical operators, Eigen functions and Eigen values, Hermitian, linear, ladder, and angular momentum operators. Spin –orbit coupling, regular and inverted multiples. **(10L)**
2. Approximation methods: non-degenerate perturbation method and the variation method, theorem and applications. **(5L)**
3. Calculation of ground state energy and wave function of Helium atom (two electron system) using Variation principle, Pauli's exclusion principle and Slater determinant. **(6L)**
4. Calculation of wave function for multi-electron system: Hartree - Fock self consistent Method. **(3L)**

Section II: Solid State Chemistry [24 L +6 T]

1. Imperfections and related phenomenon: Defects in solids: point defects, line defects, diffusion in solids- mechanism, elastic and plastic deformations. **(4L)**
2. Crystal growth techniques: General principles, Methods of crystal growth: solution method, flux growth method, evaporation method. Theory of crystal growth. **(4L)**
3. Solid state reactions- Reactions of single solids: Thermal decomposition reactionsand their kinetic characteristics, gas solid reactions and their characteristics, Solid –Solid reactions: addition and double decomposition reactions with and without electron transfer photographic process. **(5L)**
4. Properties of Insulators: Electrical properties- Dielectric properties, Piezoelectricity, electric breakdown, Optical Properties-Colour centres in ionic crystals: types, creation. Magnetic properties- exchange interactions, Antiferromagnetism, Ferrimagnetism. **(5L)**
5. Properties of metals and semiconductors: band theory, types of solids, intrinsic and extrinsic semiconductors, p-n junctions, optical properties, photoconductivity of crystals. **(6L)**

Reference Books

1. Quantum Chemistry (4th edition), Ira N.Levine, Prentice Hall, Englewood Cliffs, N. J.
2. Quantum Chemistry, A.K. Chandra
3. Quantum Chemistry, D. A. McQuarrie,, Viva Books, New Delhi (2003)
4. Introduction of Solids L.V Azaroff , Tata McGraw Hill
5. Principles of the Solid State H. V. Keer, Wiley Eastern (1993)
6. Selected Topics in Solid State Physics Vol. 12, The growth of crystals from liquids
–J. C. Brice, North Holland/American Elsevier (1973)
7 Defects and Diffusion in Solids. S. Mrowec, Elseivier Publ.(1960)
8 Treatise on Solid State Chemistry, ED-N.B. Hannay, Plenum Press Vol –2 (1975)

CCTP-8 CHP-311: Nuclear, Radiation and Polymer Chemistry [48 L +12 T]

Section I: Nuclear and Radiation Chemistry [24 L +6 T]

1. Nuclear reactions: Bethe's notation, types of nuclear reactions, conservation in nuclear reactions, compound nucleus theory, experimental evidence, specific nuclear reactions, photonuclear and thermonuclear reactions. **(5L)**
2. Nuclear reactors :- General aspects of reactor design, thermal, fast and intermediate reactors, reactor fuel materials, reactor moderators and reflects, coolants, control materials, shield, regeneration and breeding of fissile matter, types of research reactors. **(6L)**
3. Nuclear structure-: The liquid drop model, calculation of nuclear binding energies, properties of isobars, missing elements, the nuclear shell model, magic numbers, filling of nucleon shells, the collective and unified models. **(5L)**

4. Ion beam analysis techniques: Particle induced X-ray emissions- projectile accelerator and target preparation, ionization and X-ray emission detection,analysis and applications. Rutherford back scattering – scattering reaction, surface analysis, depth profiling, channelling effects and applications **(4L)**
5. Radiation detectors: Scintillators and their properties inorganic and organic, solid state semiconductor detectors-theory, surface barrier, Li drifted and intrinsic detectors **(4L)**

Section II: Polymer Chemistry [24 L +6 T]

1. Basic concepts of polymer science, classification of polymers as biological - nonbiological, linear branched network, condensation, addition homo- and heterochain, thermoplastic - thermosetting, History of Macromolecular Science, molecular forces and Chemical bonding in polymers. (**5L)**
2. Thermodynamics of polymer solutions: Entropy and heat of mixing of polymer solutions - ideal behaviour and deviations. Experimental results, flory - Krigbaum theory - Thermochemistry of chain polymerization. **(7L)**
3. Copolymerization: Kinetics of copolymerization, the copolymer equation, monomer reactivity ratios, instantaneous composition of polymer. **(4L)**
4. Measurements of molecular weights: characterization of polymers, Molecular weight averages, fractionation and molecular weight distribution - methods for determination of average molecular weight (end group analysis) colligative property measurements, osmometry, diffusion light scattering, viscosity, ultracentrifugation. **(8L)**

Reference Books

1. Essentials of Nuclear Chemistry, H. J Arnikar, Wiley Eastern Limited, 4th Edition.(1995)
2. Nuclear and Radiochemistry, G. Friedlander, J. W. Kennedy and J. M. Miller, John Wiley (1981)
3. Introduction to Radiation Chemistry, J. W. T. Spinks and R. J. Woods, John Wiley (1990)
4. Introduction to Nuclear Physics and Chemistry, B.G. Harvey, Prentice hall (1963).
5. Sourcebook on Atomic Energy-S. Glasstone, Van Nostrand Company (1967)
6. Radiochemistry and Nuclear methods of analysis-W.D.Ehman and D.E. Vance, John Wiley (1991)
7. Textbook of Polymer Science - F. W. Billmeyer Jr., John Wiley & Sons Inc. (1971)
8. Principles of Polymer Systems - F. Rodrigues, Tata McGraw Hill Publishing Company, New Delhi
9. Principles of Polymer Chemistry - P. J. Flory, Cornell University Press, Ithaca New York (1953)
10. Polymer Chemistry - An Introduction, Seymour-Carraher, Marcel Dekker Inc, New York
11. Polymer Science - Gowarikar, Vishwanathan&Sreedhar, Wiley Eastern Ltd. New York (1988)
12. Handbook on Conducting Polymers - T. A. Skotheim, Ed., Marcel Dekker Inc, New York, 1&2 (1986)

CCTP-9 CHP-312: Physicochemical Methods of Analysis [48 L +12 T]

Section I: Physicochemical Methods of Analysis I [24L +6 T]

1. X-ray methods: Generation and properties of X-rays, X-ray absorption, Concept of absorptive edge, applications, X-ray absorptive apparatus, applications, X ray fluorescence, fundamental principles, instrumentation, wavelength dispersive and energy dispersive, qualitative and quantitative analysis, electron microprobe. **(10 L)**
2. Electron spectroscopy for chemical analysis: Theory, spectral splitting and chemical shift. ESCA satellite peaks, Apparatus used for ESCA, applications**. (7L)**
3. Thermal methods of analysis: TGA, DTA, DSC and thermometric titrations – principle, instrumentation, factors affecting TGA curve, applications. **(7L)**

Section II: Physicochemical Methods of Analysis II [24 L +6 T]

1. Amperometric Titrations: Introduction, Apparatus used for Amperometric Titrations,

Technique of Amperometric Titrations, Dead stop and point method or titration with two indicator electrode, Advantages of Amperometric Titrations, Applications of Amperometric Titrations (3L)

2. Voltammetry: Excitation signals, instrumentation, Hydrodynamic voltammetry, cyclic voltammetry, pulse voltammetry, applications. **(7L)**
3. Inductively coupled plasma atomic emission spectroscopy: principle, instrumentation, analysis and applications (**4L)**
4. Luminescence, chemiluminescence, electrochemiluminescence, apparatus,fluorescence, phosphorescence, theory, factors affecting intensity, apparatus, and analytical applications. **(5L)**
5. Coulometry: Current-voltage relationship, coulometric methods, controlled potential coulometry. **(5L)**

Reference Books

1) Introduction to Instrumental Analysis-R. D. Braun, McGraw Hill (1987).

2) Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th edition.

3) Instrumental Methods of Analysis – Willard, Merritt, Dean and Settle

4) Instrumental Methods of Chemical Analysis- Gurdeep R. Chatwal and Sham K. Anand

CBOP-3 CHP- 313:(A) Photochemistry and Techniques in Polymer Chemistry (B) Special topics in Physical Chemistry

CBOP-3 CHP- 313(A): Photochemistry and Techniques in Polymer Chemistry

[48 L +12 T]

Section I: Photochemistry [24 L +6 T]

1. Introduction: Laws of photochemistry, interaction of light with matter, theory of photoluminescence, general features of photochemical and photophysical processes **(4L)**
2. Mechanism of absorption and emission of radiation: Einstein's treatment, selection rules, Life times of excited electronic states of atoms and molecules Types of electronic transitions in organic molecules photochemical pathways, Jablonski diagram, Fluorescence, Phosphorescence **(5L)**
3. Photophysical kinetics of uni and bimolecular processes, delayed fluorescence mechanisms, kinetics of collisional quenching, Stern-Volmer equation, quenching by added substances charge transfer mechanism, energy transfer mechanism **(6L)**
4. Photolysis, Laser-general principles, types of lasers: two, three and four level lasers, solid state Ruby and Nd/YAG laser, self-phase modulation, single photon counting, experimental techniques, flash photolysis: conventional microsecond flash photolysis, Nanosecond laser flash photolysis, Actinometry **(5L)**
5. Frontiers of photochemistry: Picosecond, Femtosecond flash photolysis, Applications: Solar energy, conversion and storage, photosynthesis **(4L)**

Section II: Techniques in Polymer Chemistry

1. Morphology and rheology of polymers - configuration of polymer chains crystal structure, crystallization processes, viscous flow, rubber elasticity, viscoelasticity, the glassy state and glass transition, mechanical properties of crystalline polymers. **(8L**)
2. Polymer structure and physical properties - The crystalline melting point Tm- the glass transition temperature (Tg) - properties involving small and large deformations- polymer requirements and polymer utilization. **(4L)**
3. Polymer processing - Plastic technology - moulding, other processing techniques fibre technology - textile and fabric properties, spinning fibre after treatments, elastomer technology- natural rubber, vulcanization, reinforcement, carbon blocks**. (5L)**
4. Radiation induced polymerization - kinetics and mechanism of polymerization in the liquid and solid phases, effect of irradiation on polymers - degradation and cross-linking, block copolymerization. **(4L)**
5. Conducting polymers - Basics, synthesis, conduction mechanism, applications. **(3L)**

Reference Books

1. Fundamentals of photochemistry by K.K.Rohatgi-Mukherjee New Age International Publishers Revised Edition (Reprint 2003)
2. Chemistry and light by Paul Suppan, The Royal Society of Chemistry
3. Textbook of Polymer Science - F. W. Billmeyer Jr., John Wiley & Sons Inc. (1971)
4. Principles of Polymer Systems - F. Rodrigues, Tata McGraw Hill Publishing Company, New Delhi
5. Principles of Polymer Chemistry - P. J. Flory, Cornell University Press, Ithaca New York (1953)
6. Polymer Chemistry - An introduction, Seymour-Carraher, Marcel Dekker Inc, New York
7. Polymer Science - Gowarikar, Vishwanathan&Sreedhar, Wiley Eastern Ltd. New York (1988)
8. Handbook on Conducting Polymers - T. A. Skotheim, Ed., Marcel Dekker Inc, New York, 1&2 (1986)

CBOP-3 CHP-313(B): Special Topics in Physical Chemistry [48 L + 12 T]

Section I: Special Topics in Physical Chemistry I [24 L +6 T]

1. **Ionic equilibria and pH calculations:** Solution of an equilibrium problem, numericals, mass balance, proton condition, charge balance, exact solution, approximations on the equations, Graphical representations – the distribution diagram, the logarithmic concentration diagram. Numericals, pH concept of polyprotic acids, pH calculations. **(10L)**
2. **Data analysis:** Error and classification of error, minimisation of error, accuracy, precision, significant figure. Statistical treatment of data-Mean and standard deviation, least square analysis, correlation and its significance, correlation coefficient, Regression analysis, coefficient of determination. Permutation and combinations, probability. **(8L)**
3. **Nephelometry and Turbidimetry:** Introduction, Turbidimetry and colorimetry, Nephelometry and Fluorimetry, Choice between Nephelometry and Turbidimetry, Theory, Comparison of Spectrophotometry, Nephelometry and Turbidimetry, Instrumentation, Applications of Nephelometry and Turbidimetry **(6L)**

Section II: Special Topics in Physical Chemistry II [24 L +6 T]

1. **Nanoscience and Nanotechnology:** Introduction to Nanoworld, Metals, Semiconductor, Nanocrystals, Ceramics, Metal nanoparticles: Double layers, Optical properties & Electrochemistry, Magnetism, Chemical and catalytic aspects of Nanocrystals, Applications of nanoparticles **(8L)**
2. **Hydrogen Storage:** Fundamentals of Physisorption, temperature and pressure influence, chemisorption, adsorption energy, electrochemical adsorption. Practical adsorption-Storage of hydrogen with carbon materials, activated carbon graphene, carbon nanostructures, fullerene, carbon nanofibers and graphite. Electrochemical storage of hydrogen in carbon materials. **(10L)**
3. **Smart Materials:** Definition of smart materials (SM), Design of intelligent materials, actively smart and passively smart materials and their characteristics. e.g. - smart ceramics, oxides, smart polymers and gels, shape memory alloys, electrorheological fluids, ferrofluides, smart windows, smart sensors, smart electroceramics. Magnetostrictive materials, bio mineralisation and bio sensing. Integration to smart clothes, smart rooms. **(6L)**

Reference Books

1. Ionic Equilibrium
: A Mathematical Approach, J.N.Butler, Addison- Wesley Publishing Co. Inc.
2. Analytical chemistry by G.D. Christian, 6th edition
3. Mathematical Preparation for Physical Chemistry by Farrington Daniels
4. Principles of Physical Chemistry by Puri, Sharma, Pathania
5. Instrumental Methods of Chemical Analysis- Gurdeep R. Chatwal and Sham K. Anand

6. Introduction to Instrumental Analysis-R. D. Braun, McGraw Hill (1987).
7. Tushar K. Ghosh, Energy Resources and Systems: Volume 2: Renewable Resources, Volume 2 of Energy Resources and Systems, Energy Resources and Systems, Springer Link: Bücher, Springer, 2011
8 Strobel a, J Garche b, P Moseley c, L J Orissen b, Golfdeview Hydrogen storage by carbon materials." Journal of Power Sources (WWW.Sciencedirect.com) 159 (June 2006): 781–801.
9. Agata Godula-Jopek, Walter Jehle, Joerg Wellnitz, Hydrogen Storage Technologies: New Materials, Transport, and Infrastructure, John Wiley & Sons, 2012
10. Yury Gogotsi, Carbon Nanomaterials, illustrated Volume 1 of Advanced Materials Series, Advanced Materials and Technologies Series, CRC Press, 2006 5.Robert A.Varin, Tomasz Czujko, Zbigniew S. Wronski , Nanomaterials for Solid State Hydrogen Storage Fuel Cells and Hydrogen Energy illustrated Springer, 2009
11. Intelligent materials – Craig A. Rogers, Scientific American, 1995,p.122
12. Smart structures and materials by B.Culshaw (Artech House, Norwood,MA1998)
13. Intelligent Gels Y. Osada and S.B. Ross – Murphy-Scientific American May1993
14. Introduction to Nanoscale science &technology Massimiliano Di Ventra, Stephane Evoye and James Heflin, Springer Publication
15. Physical Chemistry- P.W. Atkins, 8th Edn.

CCPP-3 CHP-314: Physical Chemistry Practical-I (Any 24 practical)

[96 L + 24T]

1) Thermodynamic data of electrochemical cell by e.m.f. measurements.
2) Simultaneous determination of two ions by polarography.
3) Determination of the equilibrium constant of triiodide ion formation
4) Magnetic susceptibility measurement by Gouy technique.
5) Determination of dipole moment of liquid at various temperatures.
6) Kinetics of iodination of aniline: pH effect and base catalysis.
7) Dissociation constant of an acid- base indicator by spectrophotometry.
8) Actinometry – photolysis of uranyl oxalate.
9) Absorption coefficient and half thickness of lead for gamma radiation.
10) Radiation dose measurement by Fricke dosimeter/ceric sulphate dosimeter.
11) Flame Photometric determination of Na / K by calibration curve method.
12) Flame Photometric determination of Na and K from mixture.
13) Estimation of Na / K by using internal standard method (Li as internal standard).
14) Estimation of K by standard addition method.
15) A photometric titration of a mixture of Bi and Cu with EDTA (-745nm).
16) Demonstration practical on AAS: setting of fuel to oxidizer ratio, choice of conc. of metal ion for AAS (Linearity range) (Use metal ion of which lamp is available with your laboratory).
17) The reaction between potassium persulphate and potassium iodide by colorimetry.
18) Determination of the chain linkage in poly (vinyl alcohol) from viscosity measurements.
18) Calibration of Gamma ray spectrometer and determination of energy of given Radioisotope.
19) To determine concentration of Boric acid titrating with NaOH by Conductometry.
20) Stability constant of silver thiosulphate by potentiometry.
21) Determination of SO_4^{2-} by turbidimetric titration / calibration curve method.
22) Determination of SO_4^{2-} by turbidimetric titration / calibration curve method.
23) Determination of Riboflavin by Photoflurometry calibration curve method.
24) Determination of quinine sulfate by Photoflurometry by standard addition method.
25) Determination of Fe / Cu/ Zn / Mn / B by AAS from soil sample.

References

1. Findlay's Practical Chemistry, S P Levitt (Editor), Longman Group Ltd
2. Experimental Physical Chemistry, Farrington Daniels and others, McGraw-Hill Book Company.

3. Experiments in Physical Chemistry, J.M. Wilson and others, Pergamon Press
4. Practical Physical Chemistry, A.M. James and P.E. Pritchard, Longman Group Ltd.
5. Experimental Physical Chemistry, V. Dathavale, Parul Mathur, New Age International Publishers.
6. Experimental Physical Chemistry, Das and Behera, Tata McGraw-Hill. Practical Physical Chemistry, D.V. Jahagirdar
7. Advanced physical Chemistry experiments by A. Gurtu, J.N. Gurtu
8. Vogel's textbook of quantitative chemical analysis, 6th Ed.

SEMESTER-IV

CCTP-10 CHP-410: Molecular Structure and Spectroscopy [48 L + 12 T]

I: Molecular Structure and Spectroscopy [24 L +6 T]

1. **Nuclear Magnetic Resonance Spectroscopy:** Nuclear spin, nuclear resonance saturation. Shielding of magnetic nuclei, chemical shift and its measurements. Factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant "J" Classification (ABX, AMX, ABC. A2 B2) spin decoupling, basic ideas about Instrument, NMR studies of nuclei other than proton ^{13}C, $^{19}F$and, ^{31}P, FT NMR, advantages of FT NMR, use of NMR in medical diagnostics. **(12L)**
2. **Electron Spin Resonance Spectroscopy:** Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the "g" value. Isotropic and anisotropic hyperfine coupling constants, spin Hamiltonian, spin densities and Mc Connell relationship, measurement techniques, applications. **(8L)**
3. **Nuclear quadrupole resonance spectroscopy:** Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splitting, and applications. **(4L)**

Section II: Molecular Structure and Spectroscopy [24 L +6 T]

1. **X- Ray diffraction:** Index reflections, Identifications of unit cell from systematic absences in diffraction pattern. Structure of simple lattices and X-Ray intensities. Structure factor and its relation to intensity and electron density, phase problems in XRD **(8 L)**
2. **Electron Diffraction: C**attering intensity Vs Scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules, low energy electron diffraction and structure of surfaces. **(4 L)**
3. **Neutron Diffraction analysis:** Scattering of neutron by solids and liquids, Magnetic scattering, Measurement techniques, Elucidation of structure of magnetically ordered unit cell**.(4 L)**
4. **Magnetic susceptibility:** Pascal constant, Diamagnetic susceptibility, paramagnetic susceptibility, Langevin Equation ,Van Vlecks formula, Ferro, Ferri and Antiferromagnetism, Measurement of Magnetic susceptibility by Faraday and Gouy Techniques. **(8 L)**

Reference Books

1. Modern Spectroscopy J.M. Hollas, (John Wiley)
2. Spectroscopy (Atomic and Molecular) Gurdeep Chatwal, Sham Anand (Himalaya Publishing house)
3. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi& F.L. Ho (Wiley interscience)
4. Introduction to Magnetic resonance A. Carrington and A.D Maclachalan , Harper & Row
5. Spectroscopy B.K. Sharma
6. NMR, NQR, & Mossbauer Spectroscopy in Inorganic Chemistry R.V.Parish, Ellis Harr wood
7. Physical methods in Chemistry R.S Drago, Saunders college
8. Introduction to Molecular Spectroscopy G.M. Barro, Mc Graw Hill
9. Basic principles of spectroscopy R. Chang, Mc Graw Hill
10. A text book of Spectroscopy.O.D. Tyagi& M. Yadhav Anmol Publications
11. Introduction to Magento chemistry Alen Earnshaw, Acad Press (1968)
12. Magneto chemistry Sanyl and Dutta

13. Chemist's guide to NM spectroscopy – Mc Comber (Wiley) 2000.

CCTP-11 CHP-411: Surface Chemistry and Electrochemistry

Section I: Surface Chemistry [24 L +6 T]

1. Adsorption at liquid surfaces, Gibbs equation and its verification, Gibbs Monolayers, insoluble films on liquid substrates, states of monomolecular Films, Wetting, flotation, detergency. **(8L)**
2. Adsorption forces, thermodynamics of physical adsorption, heat of adsorption and its determination, measurement of adsorption by different methods, chemisorption and its mechanism. **(8L)**
3. Multilayer adsorption – critical comparison of various multilayer models- BET, Potential and Polanyi models (no derivation). Measurement of surface area of solids by different methods. Harkins and Jura equation. **(6L)**
4. Porous solids – Definition, pore size distribution, methods to determine pore size, hysteresis of adsorption, theories of hysteresis, and Adsorption behaviours of porous materials. **(2L)**

Section II: Electrochemistry [24 L +6 T]

1. Ionics - Ion-ion interaction: Activity and activity coefficients, Debye-Huckel Theory, limited and extended law. Ion transport in solution: Fick's laws of diffusion, Einstein relation between diffusion coefficient and ionic mobilities, The Nernst-Einstein equation, relation between absolute and conventional mobilities. **(12L)**

2. Electrodics – Standard electrode potentials, Liquid junction potential, Zeta potential, electrokinetic phenomena, electrode-electrolyte interface, double layer theories, Butler- Volmer equation, and Tafel equation**. (8L)**

3. Applications -Fuel cells and batteries – primary and secondary power cells, fuel cells, Li ion battery **(4L)**

Reference Books

1. Physical chemistry of surfaces – A. W. Adamson, Interscience publishers Inc New York, 1967.
2. Surface chemistry – Theory and applications, J. J. Bikerman, Academic press, New York 1972.
3. Adsorption, surface area and porosity – S. J. Gregg and K. S. W. Sing, Academic Press Ltd., London 1967.
4. Zeolites and clay minerals as Adsorbents and molecular sieves, R. M. Barrar, Academic Press London.
5. Physical adsorption of gases, D. M. Young and A. D. Crowell, Butterworths, London, 1962.
6. Adsorption, J. Oscik, John Wiley and Sons. New York.
7. Physical chemistry - Peter Atkins, Julio de Paula, 7th Edition Oxford University Press.
8. Modern Electrochemistry - Vol I & II J O'M Bockris and AKN eddy, Plenum Press, N.Y.
9. Fuel cells - heir Electrochemistry, J O'M Bockris and S Srinivasan, McGraw Hill, NY (1969)
10. Fuel cell systems L.I. M Blomen and M.N. Mugerwa, Plenum Press NY (1993)
11. Principles of Physical Chemistry – Samuel

CBOP-4 CHP-412(A): Materials Chemistry and Catalysis [48 L + 12 T]

Section I: Materials Chemistry [24 L +6 T]

1. **Hitech materials**: Defect perovskites, super conductivity in cuprates, preparation & characterization of 1-2-3 & 2- 1-4, Normal state properties, anisotropy, temperature dependents of electrical resistance, optical photon modes, coherent length, elastic constants posion life times, heat capacity, micro wave absorption, pairing & multigap structure in hi tech materials. Application of Hitech materials. **(12L)**
2. **Thin films Langmuir – Blodgett films**: Preparation techniques, sputtering, chemical process, MOCVED, Langmuir – Blodgett films, Photolithography, Applications of LB films. **(5L)**
3. **Superconducting solid materials**: Superconducting state, high critical temperature superconductors, Low critical temperature superconductors **(3L)**
4. **Materials of solid devices**: Rectifiers, transistors, capacitors, IV-V compounds low dimensional quantum structures, optical properties. **(4L)**

Section II: Catalysis [24 L +6 T]

1. **Theories of catalysis-** intermediate compound formation theory and adsorption theory. Catalysis: bio catalysis, autocatalysis, negative catalysis, characteristics of catalytic reactions concept of activity, selectivity, poisoning, promotion and deactivation. Types of catalysis: homogeneous, heterogeneous. Enzyme catalysis, effect of temperature and pH on enzyme catalysis. Heterogeneous catalysis and catalytic kinetics: concept of Langmuir-Hinshelwood **(8L)**
2. **Preparation and Characterization of Catalysts:** General methods for preparation of catalysts: precipitation, sol-gel, hydrothermal, impregnation, hydrolysis, vapour deposition. Activation of catalysts: calcinations, reduction. Catalyst characterization: surface area, pore size distribution, particle size determination, XPS, AES, UV-Vis, FT-IR and thermal methods **(8L)**
3. **Catalysis in green chemistry and environmental applications**: Purification of exhaust gases from different sources: auto-exhaust catalysts (petrol vehicles, diesel vehicles), VOC removal; ozone decomposition. **(3L)**
4. **Photo-catalysis: Photoprocesses at metals, oxides and semiconductors:** concepts and mechanism. Photocatalysis application in organic pollutant degradation present in water and air. Photocatalytic water splitting, photocatalysis in the field of energy and environment. **(5L)**

Reference books

1. Physical Chemistry of Surfaces, W. Adamson, Wiley Intersciences,(5th edition) 1990.
2. Heterogeneous Catalysis: Principles and Applications. Bond, G C, Oxford University Press 1987
3. Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age Publishers
4. Principles of Physical Chemistry by Puri, Sharma, Pathania , 45th edition
5. Catalytic Chemistry, B.C. Gates, John Wiley and Sons Inc. (1992)
6. Solid state physics – N.W. Aschocruts& N.D. Mermin, Saunders College.
7. Material science & Engineering, An Introduction - W.D. Callister, Willey.
8. Principles of solid state – H.V. Keer, Willey.
9. Materials Science – Anderson, Leaver, Alexander, & Rawlings, ELBS
10. Theromotropic liquid crystals Gray, Willey
11. Text Book of liquid crystals – Kelkar&Halz, ChemieVerlag

CBOP-5 CHP-412(B): Biophysical Chemistry and Special Topics in Nuclear Chemistry [48 L + 12 T]

Section I: Biophysical Chemistry [24 L +6 T]

1. Bioenergetics and Thermodynamics: Molecular interpretation of Energy and Enthalpy, Non-covalent reactions, hydrophobic interactions, Protein and Nucleic Acids. Biochemical Applications of Thermodynamics, Thermodynamics of Metabolism, Role of ATP in biological Systems (hydrolysis of ATP). Biological Reactions, Double Stranded Formation in Nucleic Acids, Ionic Effect on Protein–Nucleic Acid Interactions**. (8L)**
2. Kinetics: Basic Concepts, Enzyme kinetics, catalytic antibodies and RNA enzymes-Ribozymes, Michaelis Menten Kinetics, Competition and Inhibition, Monod- Whyman Changeux Mechanism. **(5L)**
3. Spectroscopy of Biomolecules: Spectra of Proteins and Nucleic Acids, Amino acid, Polypeptides, Secondary structure, Rhodopsin: A Chromophoric Protein, Principles of Circular dichorism and optical rotator dispersion, applications to biomolecules. **(6L)**
4. Macromolecular structure and X-ray diffraction: Chain configuration and conformations of macromolecules, proteins and polypeptides, problems of protein folding, Fundamentals of X-rays, Braggs Law, Determination of molecular structure, calculation of diffracted intensities from atomic co-ordinates. **(5L)**

Section II: Special Topics in Nuclear and Radiation Chemistry [24 L +6 T]

1. Radiation hazards and safety ; Natural and manmade sources of radiations, internal and external radiation hazards, safe handling methods, personal dosimetry, reactor safety, the effects of Three miles and Chernobyl accidents, radiation protecting materials. **(5L)**
2. Biological effects of radiations: The interaction of radiations with biological cells, various stages, somatic and genetic effects, maximum permissible dose-ICRP recommendations. **(3L)**
3. Applications of radioisotopes in nuclear medicine and pharmaceuticals: general applications of radiopharmaceuticals, use of nuclear properties of indicator nuclides. In vivo diagnostic procedures, in vitro diagnostic testing therapeutic use of radiations, Use of radiation for food preservation and sterilization**. (8L)**
4. The origin of chemical elements, cosmology, primordial nucleosynthesis, stellar evolution and stellar nucleosynthesis, solar neutrino problem, synthesis of Be, B, Li in the cosmos. (4L)
5. Radioactive waste management: Introduction, Classification of radioactive waste, Origin of Radioactive waste, Treatment of Radioactive wastes: Radioactive waste disposal. **(4L)**

Reference Books

1. Biophysical Chemistry, Gurtu and Gurtu, Pragati Edition, 2007.
2. Physical Chemistry, Principles and Applications in Biological Sciences I. Tinico, K. Sauer, J. Wang and J. D. Puglisi, 4th Edition, Pearson Edition, 2007.
3. Biophysical Chemistry, A. Upadhyay, K Upadhyay and N. Nath, Himalaya Publishing House, 2005.
4. Biophysical Chemistry, James P. Allen,
5. Biophysical Chemistry, C. R.Cantor and P.R. Schimmel, WH Freeman & Company, New York, 2004.
6. Radiation Chemistry: Principles and Applications, Farhataziz and M. A. J. Rodgers (Eds.), VCH Publishers, New York (1987).
7. Radiation Chemistry: Present Status and Future Trends, C. D. Jonah and B. S. M. Rao (Eds.) Elsevier, Amsterdam (2001).
8. Essentials of Nuclear Chemistry: H. J. Arnikar. New Age Publication Ltd. (1995).
9. Radiation chemistry and Nuclear Methods of Analysis W. D. Ehmann, D. E. Vance. John Wiley (1991).
10. Nuclear and Radiochemistry G. Friedelarder, J. W. Kennedy, E.S. Macias, J. M. Miller John Wiley (1981).
11. Source Book of Atomic Energy, S. Glasstone, D. Van Nostrand (1967)
12. Nuclear analytical chemistry- J. Tolgyessy and S. Verga Vol. 2 , University park press (1972)
13. Fundamental of Radiochemistry, D.D. Sood, A.V.R. Reddy, N. Ramamoorthy, IANCAs , Mumbai, 4th Edition

CBOP-5 CHP-413(A): Physical Chemistry Practical III (Perform any 24 practical)

[96 L + 24 T]

1. Hydrolysis constant of aniline hydrochloride by distribution coefficient method.
2. Determination of the dimerization constant of an organic acid in benzene.
3. Differential potentiometric titration.
4. Aerometric titration with platinum microelectrode.
5. Determination of the stability constant of a complex by spectrophotometry.
6. Studies on a clock reaction: determination of the energy of activation

a. Reactions such as bromate-bromide reaction, iodate –iodide reaction,

b. Formaldehyde - bisulphite reaction etc.

7. Magnetic susceptibility measurements by the Faraday technique.
8. Analysis of fruit juice for vitamin C by HPLC technique.
9. Determination of half-life of two isotopes in a mixture.
10. Study of characteristics of GM counter.
11. Effect of salt on the distribution of acetic acid between water ethyl acetate.
12. To study the effect of addition of a salt on the solubility of an acid in water.
13. Determination of concentration of sulfuric acid, acetic acid and copper sulphate by

conductometric titration with sodium hydroxide.
14. Determine the formula and stability constant of a metal ion complex (Lead Oxalate) by polarography.
15. To determine order of reaction of iodination of aniline.
16. To determine second order velocity constant of ethyl acetate by conductometry.
17. Determination of Molecular weight of a given polymer by turbidimetry
18. Determination of surface tension of water in presence of surfactant and hence surface excess by capillary rise method/Du-Nouy Tensionometer.
19. To investigate reaction between H_2O_2 and KI.
20. Thermodynamic parameters of an electrochemical cell, temperature dependence of EMF.
21. Surface tension and parachor of liquids by stalagmometer and differential capillary method.
22. Determination of activity coefficient of electrolyte/ non electrolyte by cryoscopy.
23. To study the formation of complex ions by cryoscopy.
24. To determine critical composition and critical temperature for given naphthalene bi-phenyl binary phase system.
25. Determination of diffusion coefficient and hydrodynamic radius of $K_3[Fe(CN)_6]$by cyclic voltammetry.

References

1. Findlay's Practical Chemistry, S P Levitt (Editor), Longman Group Ltd.
2. Experimental Physical Chemistry, Farrington Daniels and others, McGraw-Hill Book Company.
3. Experiments in Physical Chemistry, J.M. Wilson and others, Pergamon Press.
4. Practical Physical Chemistry, A.M. James and P.E. Pritchard, Longman Group Ltd.
5. Experimental Physical Chemistry, V. Dathavale, Parul Mathur, New Age International Publishers.
6. Experimental Physical Chemistry, Das and Behera, Tata McGraw-Hill. Practical Physical Chemistry, D.V. Jahagirdar.
7. Advanced physical Chemistry experiments by A. Gurtu, J.N. Gurtu.

CBOP-5 CHP-413(B): Project **[96 L + 24 T]**

Each student will perform project separately. Working hours are same as practical of CHP-413(A) project length should be sufficient and should be equivalent to 24 practical. ***Project report must be written systematically and presented in bound form: The project will consist of name page, certificate, content, summary of project (2-3 page) followed by introduction (4 to 7 pages), literature survey (4-7) pages (recently published about 30 papers must be included), experimental techniques, results, discussion, conclusions, Appendix consisting of i) references, 2) standard spectra / data if any and 3) safety precautions.*** If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. ***Systematic record of attendance of project students must be maintained by a mentor.*** Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.

CCPP- 4 CHP-414:Physical Chemistry Practical-II [96 L + 24 T]

(Perform any 24 practical)

1. Solubility of a sparingly soluble salt by conductometry.
2. Coulometric estimation of arsenite by bromine.
3. Dead stop end point titration.
4. Activity coefficient of electrolyte by emf measurements.
5. Titration of polybasic acid with sodium hydroxide by pH- metry.

6. Formation constant of a complex by pH- metry.
7. Kinetics of the reaction between 2,4-dinitrochlorobenzene and piperidine.
8. Determination of solubility diagram for a three component liquid system.
9. Radiolysis of aqueous iodate solution and determination of G values.
10. Molecular weight of a polymer by end group estimation.
11. Determination of the formula of complexes such as silver –ammonia complex by titration, cuprammonium ion complex by distribution coefficient measurement.
12. Determine the transport number of silver and nitrate ions in aqueous solution from the cell potential of the concentration cell with junction potential.
13. Recording of TGA curve of $CuSO_4$ and NaCl and hence to find the percentage composition of the mixture.
14. Determination of the heat of ionization of phenol/weak acid.
15. Analysis of tertiary mixture by Gas chromatography.
16. To determine the relative strength of acetic acid, chloroacetic acid and tri-chloroacetic acid by conductometry.
17. To determine the solubility of given salt at room temperature from its solubility curve.
18. To study the effect of amount of different salts on critical temperature of phenol water system.
19. Use of thiocynate dosimeter for determining the radiation dose.
20. Determination of rate constant (Oxidation/reduction of Substituted benzene) by pulse radiolysis technique
21. Determination of half-life of radioisotopes in a given mixture.
22. Determination of manganese content of steel sample by neutron activation analysis technique.
23. Study of counting errors
24. Determination of gamma energy of a given source using scintillation counter coupled with single channel analyser.
25. Determination of manganese content of steel sample by neutron activation analysis technique.
26. Kinetics of condensation polymerization by dilatometry.

References

1. Findlay's Practical Chemistry, S P Levitt (Editor), Longman Group Ltd
2. Experimental Physical Chemistry, Farrington Daniels and others, McGraw-Hill Book Company.
3. Experiments in Physical Chemistry, J.M. Wilson and others, Pergamon Press
4. Practical Physical Chemistry, A.M. James and P.E. Pritchard, Longman Group Ltd.
5. Experimental Physical Chemistry, V. Dathavale, Parul Mathur, New Age International Publishers.
6. Experimental Physical Chemistry, Das and Behera, Tata McGraw-Hill. Practical Physical Chemistry, D.V. Jahagirdar
7. Advanced physical Chemistry experiments by A. Gurtu, J.N. Gurtu

2. M. Sc. (II): Inorganic Chemistry

Course Structure

Semester - III			
Sr. No.	**Paper No. and Code**	**Course Name**	**Credit**
1	CCTP-7 CHI-330	Organometallic and Homogeneous Catalysis	4
2	CCTP-8 CHI-331	Inorganic Reaction Mechanism	4
3	CCTP-9 CHI-332	Bioinorganic and Medicinal Inorganic Chemistry	4
4	CBOP-3 Theory CHI-333	A) Modern Instrumental methods in Inorganic Chemistry **OR** B) Inorganic Magneto and Polymer Chemistry	4
5	CCPP-3 CHI-334	**Practical I**-Modern Methods of Inorganic Analysis	4
Semester-IV			
6	CCTP-10 CHI-430	Heterogeneous Catalysis and its Applications	4
7	CCTP-11 CHI-431	Inorganic Nanomaterials: Properties, Applications and Toxicity	4
8	CBOP-4 Theory CHI-432	A) Material Science **OR** B) Inorganic Chemistry Applications in Industry	4 4
9	CBOP-5 Practical CHI-433	**Practical III**-A)Extended Practical in Inorganic Chemistry **OR** B)Project Work	4
10	CCPP-4 CHI-434	**Practical II-** **Section-I**: Inorganic Instrumental analysis and Computer applications **Section-II**: Preparation of Inorganic Compounds	4

Equivalence to Previous Syllabus

Semester - III			
New Syllabus 2019 Pattern		**Old Syllabus 2014 Pattern**	
CCTP-7 CHI-330	Organometallic and Homogeneous Catalysis	CHI-326	Organometallic and Homogeneous Catalysis
CCTP-8 CHI-331	Inorganic Reaction Mechanism	CHI-330	Inorganic Reaction Mechanism, Photochemistry and Magnetic Properties of Coordination Compounds
CCTP-9 CHI-332	Bioinorganic and Medicinal Inorganic Chemistry	CHI-331	Physical Methods in Inorganic Chemistry.
CBOP-3 Theory CHI-333	Modern Instrumental Methods in Inorganic Chemistry **OR** Inorganic Magneto and Polymer Chemistry	CHI-332	Bioinorganic Chemistry
CCPP-3 CHI-334	Modern Methods of Inorganic Analysis	CHI-387	Experiments &Computer Applications in Inorganic Chemistry.
Semester-IV			
CCTP-10 CHI-430	Heterogeneous Catalysis and its Applications	CHI-430	Inorganic polymer &Heterogeneous Catalysis.
CCTP-11 CHI-431	Inorganic Nanomaterials: Properties, Applications and Toxicity	CHI-431	Material Science-I Solid State & other inorganic Materials
CBOP-4 Theory CHI-432	Material Science **OR** Inorganic Chemistry Applications in Industry	CHI-432	Material Science-II Nanomaterials.
		CHI-445	Inorganic Chemistry Applications in Industry
CBOP-5 Practical CHI-433	Extended Practical in Inorganic Chemistry **OR** Project Work	CHI-488	Extended Practical in Inorganic Chemistry
CCPP-4 CHI-434	**Section-I**: Inorganic Instrumental analysis and Computer applications **Section-II**: Preparation of Inorganic Compounds	CHI-388	Practical course II.

The Detailed Syllabus of M. Sc-II Inorganic Chemistry is as Follows:

Semester - III

CCTP-7, CHI- 330: Organometallic and Homogeneous Catalysis [48 L + 12 T]

Section-I: Advanced Organometallic Chemistry [24 L +6 T]

1. Introduction & Recapitulation d-block metal carbonyls. [**2L]**
2. Sigma complexes: Synthesis, bonding, properties and applications. Hydrocarbyl compounds,
3. Metal-Carbon multiple bonded compounds Carbene and Carbynes. [**4L]**
4. π-complexes Alkenes di and polynes. [**2L]**
5. $n^nC_nR_n$: Carbocyclic polyenes: Synthesis, bonding, properties and applications of Allyls Pentadienyls, Cyclobutadienes, Cyclo pentadienyls, Cycloheptetrienyls, Arenes**. [4L]**
6. Phosphine complexesSynthesis, bonding,properties andapplications. **[2L]**
7. Metal-metal bonds Transition metal atom clusters Carbonyl polymers. [**4L]**
8. Transition metal organo-metallics in organic synthesis. As Electrophiles, Nucleophiles, Activating agents, Protecting agents. [**4L]**
9. Fluxional Behaviour of organometallic compounds, [**2L]**

Section-II: Homogeneous Catalysis [24 L +6 T]

1. Introduction to catalysis. basic principles, definition of activity& selectivity catalysis, homogenous *vs.* heterogeneous catalysis. Importance of homogenous catalysis in synthesis of high value chemicals. **[4L]**

2. Characteristics of central metal atom &influence of attached ligands on catalytic activity, Important reaction types: oxidative addition, reductive elimination, migratory insertion, beta hydride elimination. **[4L]**

3. Tollman catalytic cycles. Use of spectral techniques for identification of intermediates. (IR, NMR), [**3L]**

4. Reactions of olefins: **a)** Polymerisation: Catalytic cycle for alkene Polymerisation, Metallocene catalysts-structure, special features advantages and mechanism of action. **b)** Oxidation including catalyst separation in homogeneous catalysis, Fenton Reaction-$FeBr_3/H_2O_2$, Metal catalysed liquid phase oxidation, Epoxidation, Biphasic catalysis –oxidation. **c)** C-C coupling (Cativa process, Heck, Suzuki, Negeshi and cycloaddtion reactions). [**8L]**

5. Metathesis [**2L]**

6. Asymmetric catalysis. [**3L]**

References:

1. Organotransition Metal Chemistry Anthony F. Hill, Royal Society of Chemistry, Tutorial
2. Chemistry Text, 2002.Chapters1-7.
3. Organometallics: A concise Introduction, Ch. Elshebroicn and A. Salzer, VCH, chapters, 12-16
4. Organotransition Metal Chemistry: Applications to Organic Synthesis, S.G. Davies, Permagaon 1982.
5. Inorganic Chemistry 3rd edn D.F. Shriver and P.W. Atkins, Oxford University Press, 1999, Chapter 16.
6. Organometallic Chemistry –R.C. Mehrotra and A. Singh, 1992, Wiley
7. Principles of Organometallic Chemistry, P. Powell, Chapman & Hall
8. Organometallic Compounds, Morries, Sijlirn, IVY Publication House
9. Organometallics in Organic Synthesis – Swan & Black
10. Organometallic Chemistry - E.J. Elias and Gupta
11. Homogeneous Catalysis - G.W.Parshall

CCTP-8,CHI- 331: Inorganic Reaction Mechanism [48 L + 12 T]

Section-I: Inorganic Reaction Mechanism [24 L +6 T]

1. Types of Mechanisms: Basic concepts as stability and liability, stability constants; HSAB principle, chelate effect, Classification of inorganic reactions, Intimate and stoichiometric mechanism of ligand substitution. **[4 L]**
2. Substitution in square planar complexes: Trans effect, Trans series, applications of trans effect.**[4 L]**
3. Substitution in octahedral complexes: SN_1, SN_2, SN_1CB mechanisms, steric effects on substitution Isomerization and racemization in coordination compounds. **[4 L]**
4. Electron Transfer reactions: Potential energy diagrams as a conceptual tool, Marcus equation Types of and factors affecting electron transfer reactions. **[6 L]**
5. Inner & Outer sphere reactions, exited state outer sphere reactions & their applications**[6 L]**

Section -II: Photochemistry and Reaction of Co-ordinated Ligands [24 L +6 T]

1. Photochemistry of metal complexes [10 L]

Photochemical reactions, Prompt and delayed reactions, quantum yield, recapitulation of fluorescence & phosphorescence, phtotochemical reactions irradiating at d-d and CT band Transitions in metal-metal bonded systems, photochemical reactions involving chlorophyll Kinetics of excited state processes

2. Reactions of coordinated ligand [10 L]

i) Non-chelate forming reactions: Reaction of donor atoms (Halogenation of coordinated N atoms, Alkylation of coordinated S and N atoms, Solvolysis of coordinated phosphorus atoms). Reactions of nondonor atoms (nucleophilic behaviour of the ligand, electrophilic bahaviour of the ligand). ii) Chelate ring forming reactions: (reactions predominantly involving thermodynamic template effects, reactions predominantly involving kinetic affects). iii) Chelate modifying reactions

3. Other reaction types [4 L]

Oxidative addition, reductive elimination, methyl migration and CO insertion

References:

1. Mechanism of Inorganic Reactions- C.F. Basselo, R.G. Pearson, Wiley, NY
2. Mechanism of Inorganic Reactions in Solution – An Introduction, D. Benson, McGraw – Hill Chapt.15, p.465, (1968)
3. Inorganic Chemistry – D.F. Shriver, P.W. Atkins, C.H. Langford – Oxoford, 2nd Edition, 1994.
4. Inorganic Chemistry – Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, 4thedn. Harper Collins College Publ. New York, Chapt.13, p.537-76, (1993).
5. Inorganic Chemistry - Messler and Tarr - Pearson Publishers

CCTP-9,CHI-332:Bioinorganic and Medicinal Inorganic Chemistry [48L + 12T]

Section - I: Bioinorganic Chemistry [24 L +6 T]

1. Recapitulation of Biological roles of Metals and ligands [1 L]

Structure, function and biochemistry of enzymes containing following metals:

2. Zinc [6 L]

Zinc Fingers, Carboxy peptidase, Carbonic anhydrase

3. Copper [6 L]

Type I, Type II, Type III, Blue Proteins Azurins, Plastocynins& Blue Oxidases, Model compounds of Blue copper proteins, Non Blue Proteins eg. Tyrosinase, Galactose oxidase, SOD

4. Cobalt [4 L]

Vitamin B_{12} co-enzymes & model compounds, Actions of Cobalamines, Adenosylcobalamine as a coenzyme, Ribonucleotide reductase, Methylcobalamine as cofactor

5. Molybdenum [3 L]

Mo-cofactors, Antagonism between Cu & Mo, Hydroxylase

6. Manganese [2 L]

7. Non-heme Iron [2 L]

References:

1. Bioinorganic Chemistry: A ShortCourse-RosetteM.Malone3 Wiley Interscience, 2002.
2. Biological Inorganic Chemistry-An Introduction, Robert Crichton, Elsevier Science, 2007.
3. The biological Chemistry of the Elements: The Inorganic Chemistry of Life–J. J. R.
4. Fraustoda Silva and R. J. P. Williams. Clarendron Press, Oxford, 1991.
5. Bioinorganic Chemistry: Inorganic elements in the Chemistry of life., An Introduction and Guide—Wolfgang Kaim, Brigille Schwedrski John Wiley and sons, 1994.
6. Principles of Bioinorganic Chemistry –S.J. Lippard and J.M.Berg, University Science Books, 1994.
7. The Biological Chemistry of the Elements: The Inorganic Chemistry of Life– Silva, J. J.
8. R. Fraustoda and R. J. P. Williams; 2nd Ed. Oxford University Press, 2012.

Section- II: Inorganic Pharmaceuticals and Medicinal Chemistry [24 L +6 T]

1. Overview [2 L]

Introduction, Metal Ions in Disease, Use of chelating agents, Metalloproteins as Drug Targets, Matrix Metallopreteinases, Modulation of Cellular responses by Metal-Containing, Drugs Metal-Based Chemotherapeutic, Drugs Metal Complexes as Diagnostic Agents

2. Cisplatin-based Anticancer Agents [3 L]

Introduction, Clinical Properties, Cisplatins carboplatin, Iproplatin, Determination of Platinum Drug Levels and Pharmakokinetics, Platinum Chemistry Mechanism of Action, Structure-Specific Damage-Recognition Proteins, Mechanisms of Resistance to Cisplatin/Carboplatin, Circumvention of Tumor Resistance to Cisplatin, Development of New Platinum Drugs, Dose Intensification of Cisplatin/Carboplatin, Modulation of Platinum Resistance Mechanisms, Dinuclear and Trinuclear Platinum Complexes as Anticancer Agents.

3. Transition Metal Complexes as Chemical Nucleases [4 L]

Interaction of Metal Complexes with DNA, Reactions of Metal Complexes with DNA, Nuclease activity of $[Cu(phen)2]^{+}$

4. Biomedical Uses of Lithium [3L]

Chemistry of Lithium, Distribution of Lithium in the body and in Cells, Studies using Lithium isotopes, Biochemistry of Lithium

5. Bismuth in Medicine [3L]

The Chemistry of Bismuth, Properties of the element, Bi(III) Compounds, Bi(V) Compounds Bismuth in Medicine, Helicobacter Pylori bacterium, Methods for the study of Bi, Bismuth Citrate Complexes, Bismuth Complexes with Biomolecules, Bismuth binding to oxygen-containing molecules, Bismuth Complexes with thiolate ligands, Bismuth(III) complexes with Metallothionine and Transferrin, Enzyme Inhibition

6. Gold Complexes with Anti-arthritic, anti-tumor and Anti-HIV activity [4L]

Introduction, Chrysotherapy, History of Medicinal Uses, Gold Chemistry, Oxidation states, Gold(I) complexes, Gold(III) Complexes, Oxidation-Reduction Potentials, Gold Biochemistry and Pharmacology In-vivo metabolism and ligand displacement, Anti-tumor Activity, Anti-HIV activity

7. Vanadium Compounds as Possible Insulin Modifiers [3L]

Introduction, Characterization of Vanadium's Insulin-mimetic Effects, Sites of Action of Vanadium, Animal Studies and Human Trials, Toxicological Considerations, Improved Tissue Uptake with Metal Chelation

8. Therapeutic Radiopharmaceuticals: [2L]

Introduction, Therapeutic radio nuclides, β- Particle emitting radionuclides, α- Particle emitting radionuclides, Low energy electron emitters, Therapeutic radiopharmaceuticals for routine medical use, ^{131}I – sodium iodide, Intra-cavity and Intra-arterial radiopharmaceuticals, Radio-therapeutic agents for bone cancer treatment ^{89}Sr-chloride, ^{153}Sm- EDTMP,

References

1. Uses of Inorganic Chemistry in Medicine Ed. Nicholas P. Farrell
2. Metal Complexes as drugs and chemotherapeutic agents
3. Metal Complexes as Enzyme inhibitors A.Y. Louie and Thomas Meade Chem. Rev., 1999, 99, 2711.

CBOP-3,CHI-333: Theory

A) Modern Instrumental Methods in Inorganic Chemistry [48L + 12T]

OR

B) Inorganic Magneto and Polymer Chemistry [48L + 12T]

CBOP-3,CHI-333: Theory

A) Modern Instrumental Methods in Inorganic Chemistry [48L + 12T]

Section-I: Inorganic Thermal and Spectroscopic Methods of Characterization [24 L +6 T]

Chapter 1: Thermal techniques. [12L]

Principle, instrumentation, working and applications of following spectroscopic techniques

1. TGA
2. DTA
3. DSC
4. TPD study

Chapter 2: Spectroscopic techniques. [12L]

Principle, instrumentation, working and applications of following spectroscopic techniques:

1. X-Ray diffraction
2. NMR
3. ESR
4. Auger
5. FT-IR
6. Fluorescence

Section-II: Imaging and Analytical Techniques [24 L +6 T]

Chapter 1: Imaging techniques. [12L]

Principle, instrumentation, working and applications of following spectroscopic techniques:

1. TEM
2. SEM
3. XPS
4. STEM
5. UV

Chapter 2: Analytical techniques. [12L]

Principle, instrumentation, working and applications of following spectroscopic techniques:

1. Cyclic voltammetry
2. Flame Photometer
3. Magnetic susceptibility
4. Photodegradation

Reference Books:

1- Instrumental methods of analysis by B.K Shrama
2- Instrumental methods of chemical analysis- Chatwal and Anand
2- Introduction to Instrumental Analysis- R. D. Braun, Pharma ed Press, Indian
3- Principles of Instrumental Analysis, 5th edition- D. A. Skoog, F.J. Holler, T. A. Nieman, Philadelphia Saunders College Publishing (1988)
5- Materials characterization, Introduction to microscopic and spectroscopic methods, Yang Leng, John Wiley and Sons Pvt.ltd.

OR

CBOP-3,CHI-333: Theory
B) Inorganic Magneto and Polymer Chemistry [48L + 12T]

Section-I: Magneto-chemistry [24 L +6 T]

1. Introduction [4 L]

Definition of magnetic properties and types of magnetic substances, magnetic susceptibility, anisotropy in magnetic susceptibility, experimental arrangements for determination of magnetic susceptibility: Gouy method, Faraday method, Evans method, SQUID.

2. Paramagnetic Susceptibility [2 L]

Simplification and application of Van-Vleck susceptibility equation, temperature independent paramagnetism.

3. Magnetic properties [6 L]

Magnetic properties of transition metal complexes in cubic and axially symmetric crystal fields, low spin, high-spin crossover, magnetic behaviour of lanthanides and actinides, magnetic exchange interactions.

4. Anti-ferromagnetism [2 L]

Transition metal monoxides and halide salts of transition metals, ferrimagnetism (ferrites), magnetic anisotropy.

5. Anomalous magnetic moments [4 L]

Anomalous magnetic moments in magnetically dilute and concentrated system in various symmetrical environments of coordination complexes. Study of mixed valence compounds, their magnetic behaviour

6. Magnetic materials [6 L]

Soft and hard ferrites, i.e. structure and magnetic interactions in spinels, garnets, hexagonal ferrites. Application of magnetic materials, Molecular magnets, Single chain magnet, Photoinduced magnetism, Spin canting, Magnetic ordering.

Reference Books:

1. Elements of Magnetochemistry, 2nd Edn., R. L. Datta and A. Syamal (1993) Affiliation, East-Wiley Press (p) Ltd.
2. Introduction to Magnetochemistry, A. Earnshaw, Academic Press, (1968).
3. Magnetism and Transition Metal Complexes, F. E. Mabbs and D. J. Machin (1973) Chapman and Hall, London.

Section - II: Inorganic Polymer [24 L +6 T]

1. **Inorganic polymers: [8 L]**

Overview and classification of polymers. Coordination Polymers: Homopolar and heteropolar inorganic polymers.Polyphosphazenes, Polysilanes, Polysiloxanes, Boron Polymers, Borazines, Phosphorous based polymer, polymeric compounds of sulphur, polythiazoles, silicates with reference to preparation, properties, structures, bonding and applications.

2. **Natural polymers [4 L]**

Natural polymers and reactions yielding coordination polymers. Synthesis of coordination polymers.

3. **Pre-ceramic Inorganic polymers**: [**6 L]**

Silicon carbide, Boron nitride, Aluminium nitride, Phosphorous nitride.

4. **Applications of Inorganic Polymers**: [**6 L]**

Metal containing polymer for medical purposes, Inorganic polymers as catalysts, Luminescent Inorganic polymers.

Reference Books:

1. I. S. Butler and J. F. Harrod, Inorganic Chemistry – Principles and Applications, The Benjamin/Cummings Publishing Co., Inc., Redwood City, California (USA) (1989) Chapter 15 to 17, pp 441-503.

2. Ranald D. Archer, Inorganic and organometallic polymers, A John Wiley and Sons, Inc. publication (USA) 2001
3. N. H. Ray, Inorganic Polymers, Academic Press (1978).

CCPP-3, CHI-334: Modern Methods of Inorganic Analysis [96L + 24T]

A. Analysis (12 experiments)

1-2. Stainless steel Alloy. [iron, chromium and nickel from sample]
2-3. Ilmenite Ore [acid-insoluble matter (combined oxides), iron and titanium from ore]
4-5. Analysis of Cement (Al(III), Mg(II), Fe(III), Ca(II)]
6. Analysis of zinc-chrome Pigment [e.g. Chromium from Zinc chrome]
7-8. Pharmaceutical products **any two** i) magnesium from tablet of "Milk of magnesia", calcium from calcium supplementary tablet, ii) iron from iron supplementary capsule iii) zinc from iron-zinc supplementary capsule or insulin.
9. Consumer products [e.g. aluminium from alum]
10. Ion exchange chromatography [separation and estimation of mixture of anions
11-12. Purity & Percentage of Metal in Coordination Complexes.
13-14. Organometallic Compounds: Synthesis and characterization of Acetyl ferrocene.
15. Preconcentration of Co(II) using ion exchange resin and colorimetric estimation. (Ref-7)

B. Inorganic Practical (12 experiments)

1. Photometric Titrations Cu Vs. EDTA, Fe Vs. EDTA using salicylic acid.
2. Photochemistry of ferrioxalate a) Preparation b) Photochemistry
3. Preparation of complex and Kinetics by conductometry.
4. Preparation of complex and Kinetics by spectrophotometry.
5. To study metal-DNA interaction spectrophotometrically.

6-7. A) Synthesis of Tetrakis(triphenylphosphine)nickel(0) and its application for cross coupling reactions.
8-9. Synthesis of Ferrocene and its derivative such as Acetyl Ferrocene.
10-11. Flame photometry: determination of the ppm of i) sodium by calibration curve method and ii) calcium by standard addition method in the water sample.
12. Determination of phosphate in detergent by spectrophotometry.
13. Atomic absorption spectrophotometer (AAS): Demonstration and determination of amount of iron from tap water sample.
14. Chemical mineralization of pollutants by Fenton's Process (Ref-5)
15. Estimation of Vitamin-C by reaction with Fe(III) and estimation of Fe(II) colorimetrically. (Ref-6)

Each experiment includes standardization of reagents, calibration of instrument with known reagents and analysis of an unknown.

Reference Books:

1) Text book of Quantitative Analysis, A.I. Vogel 4th edn (1992).
2) Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.
3) Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
4) General Chemistry Experiments, Anil. J Elias, University press (2002)
5) Environmental Chemistry, Microscale Laboratory Experiments, Jorge G. Ibanez, Margarita Hernandez-Esparza, Carmen Doria-Serrano, Arturo Fregoso-Infante, Mono Mohan Singh, published by Springer.
6) Vitamin C as a Model for a Novel and Approachable Experimental Framework for Investigating Spectrophotometry, Journal of Chemical Education, DOI:10.1021/acs.jchemed.9b00197.
7) Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier

Semester-IV

CCTP-10,CHI-430: Heterogeneous Catalysis and its Applications [48L + 12T]

Section - I: Heterogeneous Catalysis [24 L +6 T]

1. Principles of Heterogeneous Catalysis [**1L]**
2. Development of industrial heterogeneous catalysis, Important milestones [**2L]**
3. Quantitative aspects of adsorption on solid surfaces [**2L]**
4. Basic Adsorption Isotherms and their applications [**1L]**
5. Classification of heterogeneous catalysts [**1L]**
6. Metals, Bimetals, metal oxides, supported metal catalysts [**2L]**
7. Preparation of Solid Catalysts: Precipitation and co-precipitation, impregnation, High temperature fusion and alloy leaching, Hydrothermal synthesis, vacuum pore impregnation, impregnation of porous support [**3L]**
8. Post synthetic treatment: Drying, calcinations, activation and forming [**2L]**
9. Characterization of Solid Catalysts: BET surface area, temperature programmed techniques (TPD, TPR, TPS, TPO), spectroscopic techniques (XRD, SEM TEM, XPS, FTIR, solid state NMR) [**3L]**
10. Metal–Support Interactions, Support selection and role of support [**1L]**
11. Chemistry of zeolites: [**2L]**
    a. General Introduction, Nomenclature and classification of zeolites
    b. Hydrothermal synthesis Zeolite (eg. ZSM-5) and factors influencing on zeolite synthsis.
    c. Zeolite framework structure and selected zeolite framework type such as Sodalite,LTA, FAU, MFI (ZSM-5),MEL(ZSM-11), BEA (zeolite beta).
    d. Zeolite characterization by powder XRD method.
12. Factors Influencing Catalytic Action: Promoters and Poisons, Deactivation and Regeneration of catalyst [**1L]**
13. Heterogenization of Transition Metal Complexes to Inorganic Oxides: supported aqueous phase catalyst (SAPC), Supported ionic liquid phase catalyst (SILPC), and Phase transfer catalysis [**2L]**
14. Types of Chemical reactors [**1L]**

Section - II: Applications of Heterogeneous catalysis in organic synthesis [24 L +6 T]

1. Catalysis by acidic solids: Application of zeolites in catalysis: Hydrocracking, Shape selective catalysis, Hydrogen transfer, Catalytic reforming, oxidation catalyst. **[2L]**
2. The Fischer–Tropsch (FT) Synthesis Process [**2L]**
3. Water Gas Shift Reaction [**1L]**
4. Methanol Synthesis [**1L]**
5. Alkylation of Aromatics [**1L]**
6. Selective Hydrogenation of Hydrocarbons [**2L]**
7. Heterogeneous Catalysis for Oxidation of Alcohols [**2L]**
8. Photocatalysis: semiconducting oxides w.r.t. Titanium Oxide as Photocatalysts [**2L]**
9. Use of $BiMoO_4$ as Oxidation and Ammoxidation catalysts [**2L]**
10. Conversion of biomass on solid catalysts [**1L]**
11. MCM-41 as a catalyst [**2L]**
12. Clays and Intercalated clays as catalyst [**1L]**
13. Industrial Electrocatalysis [**2L]**
14. Catalysis in Environmental Protection: Automotive Exhaust catalysts:The catalytic converter, Perovskite and related oxides as catalysts [**3L]**

References:

1. Handbook of Heterogeneous Catalysis: Wiley International Wiley-VCH Verlag GmbH & Co. KGaA, 2008
2. Catalysis: Concepts and Green Applications: Gadi Rothenberg, Wiley-VCH; First edition, 2015

3. Heterogeneous catalysis by B.Viswanathanand D. K.Chakrabarty , New Age International Private Limited, 2007.
4. Heterogeneous Catalysis for the Synthetic Chemist By Robert L. Augustine, Marcel Dekker Inc.New York,1996
5. Gerard, V. S.; Ferenc, N. Heterogeneous Catalysis in Organic Chemistry; Academic Press; New York. First edition, 2006.

CCTP-11,CHI-431: Inorganic Nanomaterials: Properties, Applications and Toxicity [48L + 12T]

Section - I: Nano-structural Materials and its Applications [24 L +6 T]

Chapter1: Nanoscience and Nanotechnology: [6L]

a) What is nanoscience and nanotechnology?
b) Natural and artificial nanoparticles
c) Ancient Nanotechnology
d) Stalwarts of nanotechnology- Feynman, Drexler and Taniguchi
e) Moore's law
f) Basics of nanophotonics.

Chapter 2: Effects of making into small [6L]

a) Size dependence of material properties
b) Special properties
   i. Structural properties
   ii. Thermal properties
   iii. Chemical properties
   iv. Mechanical properties
   v. Magnetic properties
   vi. Optical properties
   vii. Electronic properties
   viii. Biological properties

Chapter 3: Classification of nanotechnology [6L

a) Classification of nanomaterials
b) Classification of Nanotechnology
   i. Wet nanotechnology
   ii. Dry nanotechnology
   iii. Computational nanotechnology
c) Concept of 0D,1D, 2D and 3D nanostructures.

Chapter 4: Applications of nanomaterials [6L]

a) Carbon nanomaterials
b) Nanocomposites include metal nanomaterials such as single particle as well as coreshell nanomaterials.
c) Polymer Nanotechnology
d) Organic Electronics
e) Nanotribology
f) Nanobiotechnology

Section - II: Nanotoxicology and Biosafety [24 L +6 T]

Nanotoxicology

1. Introduction to Nanotoxicology [**3L]**
2. Nano etymology [**3L]**
3. Nanotoxicology challenges [**2L]**
4. Physico-chemical characteristic dependent toxicology [**4L]**
5. Epidemiological evidences **[4L]**

6. Mechanism of nanotoxicity [**4L]**
7. Assessment of nanomaterial toxicity: In vitro toxicity assessment-cell viability and in vivo toxicity assessment [**4L]**

Reference Books:

1. The Chemistry of Nanomaterials edited by C.N.R.Rao, A.Muller, A.K.Cheetham Wiley-VCH Verlag GmbH & co. Volumes 1&2.
2. Nanomaterials by Dr. Sulbha Kulkarni.
3. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., 2012
4. Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2008
5. Handbook of Nanotoxicology, Nanomedicine and Stem Cell Use in Toxicology. Saura C Sahu, Daniel A Casciano

CBOP-4, CHI-432: A) Material Science (4 Credits) [48L + 12T]

OR

B) Inorganic Chemistry Applications in Industry[48L + 12T]

CBOP-4,CHI-432, Theory: A) Material Science [48L + 12T]

Section – I: Crystal Defects, Magnetic and Superconducting Materials [24 L +6 T]

1. Crystal defects and Non stoichiometry, Diffusion in solids, phase transformation in solids, solid state reactions and crystal growth. Preparation methods of solids. [**4L]**

2. Magnetic Materials [**12L]**

Atomic magnetism and solids, type of magnetic materials, exchange interactions, hysteresis loop and their classification, calculation of magnetic moment from saturation magnetisation, magnetic domains, examples of magnetic materials, soft & hard ferrites, structure & magnetic interactions in spinel, garnet hexagonal ferrites, application of magnetic materials

3. Superconducting materials [8L]

Definition, superconductivity, critical temperature, critical field, BCS theory, properties & classification of superconductors, high Tc superconductors, examples with structure and applications, fullerenes, intermetallic superconductors, synthesis, applications

Section-II: Ceramic, composite, Cementitious and Bio Materials [24 L +6 T]

1. CeramicMaterials [6L]

Classification of ceramics, dielectric properties and polarization properties of ceramics, piezo-, pyro- and ferro-electric effect of ceramics, sol-gel processing of ceramics. Examples and application of ceramics: oxides, carbides, borides, nitrides.

2. CompositeMaterials [6L]

Definition, glass transition temperature,fibersfor reinforced plastic composite materials (i.e. glass fibers, carbon fibres, and aramid fibers); concrets and asphalt materials. Application ofcomposite material

3. Cementitious Materials [8L]

Difference between Blended and Non-Portland cements; Non-portland cements; high alumina cements, calcium sulfoaluminate cements, phosphate cements.Chemicals in cement hydration; hydration process, set retardersandaccelerators, plasticizers, slip-casting processing. Application of cementitousmaterials.

4. Bio-materials [4L]

Definition of biomaterials and biocompatibility;, Type of bio-materials: Metallic materials, Biopolymeric materials, Bioceramic materials (dense hydroxyapatite ceramics, bioactive glasses,and bioactive composites); Basic requirement of bone implants; Coating of hydroxyapatite on porous ceramics; Biomaterials in tissue attachments; Application of Biomaterials

References

1. Solid state Chemistry: An Introduction – L.E. Smart & E.A. Moore, CRC, Taylor & Francis, 3rd Edn.
2. Materials Science & Engineering – V. Raghvan, 2nd Edn.
3. Introduction to Solids – L.V. Azarroff, 2nd Edn. 1980
4. Elements of materials science and engineering – Van Vleck, 5th Edn.
5. Insight to Speciality Inorganic Chemicals – D. Thompson, Royal Society of Chemistry, 1995.

CBOP-4, CHI-432, Theory: B) Inorganic Chemistry Applications in Industry [48L + 12T]

Section - I: Inorganic Chemistry Applications in Industry [24 L +6 T]

1.Inorganic Chemicals as metallicCorrosionInhibitors [2L]

Introduction, Principles of corrosion inhibitors, corrosion as an electrochemical process, Practical aspects of corrosion inhibition, Anion inhibitor properties in neutral electrolytes, some application of corrosion inhibitors (cooling water circulation-once through and open systems, engine radiation & cooling systems, central heating system, refrigeration plants and high chloride systems, water for steam raising, corrosion inhibitors for paintcoating).

2. Industrialgases: [4L]

Introduction, Separation of gases from air,Hydrogen, Carbon dioxide, Carbon monoxide, Oxygen, Acetylene, Sulphur dioxide, Nitrous oxides.

3. Chemical explosivesandpropellants: [6L]

Introduction, Potential energy of explosives , Properties of explosives, Manufacture of explosives , Explosives made by nitration, Dynamite , Commercial high explosives containing no nitroglycerine , Initiating devices, Sporting and military explosives , Disruptive explosives for military use, Handling and storage of explosives.

4. Metalfinishingtechnology: [4L]

Fundamental considerations, Electrodepositions of Copper , Nickel, Gold, Silver, Tin and Tin alloys for Lead free solder, Electrodeposition of Chromium , Electrodeposition of semiconductors , Elctoroless deposition of Copper and Nickel, Environmental aspects of electrodeposition , Ionic Liquid treatments for enhanced corrosion resistance of Magnesium basedsubstrates.

5. Safety consideration in chemicalprocessindustries: [5L]

Introduction , Concern for chemical safety , Hazards and their control in petrochemical industries , Hazards and their control in petroleum refineries and LPG boiling plants , Hazards in storage , Handling and use of chemicals, Chemical storage- safety issues, Observations related to safety aspects , Specific recommendation for hazard control and improved plant safety, Chemical plant safety- from concept to decommissioning.

6. Green Chemistry: [3L]

Introduction, Designing a Green synthesis, Basic Principles of Green Chemistry, Green Chemistry in Day-to- Day life, Green Chemistry in sustainable development.

References:

1. Handbook of Industrial Chemistry,Vol.1, by K.H.Davis,F.S.Berner,Edited by S.C. Bhatia (CBS Publishers, Bangalore,2004)
2. Industrial inorganic chemistry, Karl Heinz Buchel, Hans-Heinrich Moretto, Peterwoditsch
3. Modern Electroplating, By M. Schlesinger and M. Paunovic (John Wiley and sons, Hoboken , New Jersey, 5th Edition2010)
4. Insight into Specialty Inorganic Chemicals-David Thompson (The Royal Society of Chemistry,1995)- Chapter15.
5. New Trends in Green Chemistry (2nd Edition)-V.K.Ahluwalia and M.Kidwai (AnamayaPublishers, 2007)

Section-II: Inorganic Chemistry Applications in Environments [24 L +6 T]

1. **Introduction to waste water Analysis: [10L]**
   Specification of treated waste water for disposal into surface water, Screening chamber, Grit Chamber, Oil & Grease removal, designing of biological unit- stabilisation pond, Aerated lagoon, Trickling filters, Anaerobic treatment.
2. **Water Pollutants: [4L]**
   Types, Disease causing agents, oxygen consuming waste, suspended solids and sediments, Dissolved solids, Regulation of water quality, Analysis of solids by different techniques.
3. **Applications of Biotechnology for the treatment of waste water [4L]**
   Introduction, Role of microorganism for the treatment of waste water, Application of biotechnology for a. high strength waste. b. Primary and secondary sludge c. Phenol & cyanide removal d. Solid phase extraction
4. **Energy sources for future: [6L]**
   a. Solar Energy-Solar heating for homes and other buildings, electricity from solar thermal power collectors, electricity from photovoltaic cells.
   b. Energy from biomass- Production of biomass, biofuels, biodiesel.
   c. Geothermal energy,
   d. water power
   e. Tidal power.
   f. Fuel Cells-Polymer electrolyte membrane fuel cells, Phosphoric acid fuel cell, Direct methanol fuel cell, Alkaline fuel cell, Regenerative(reversible) fuel cell, Clean cars for the future, Energy sources for the twenty first century.

References:

1. Environmental Chemistry by A. K. Bagio.
2. Principles of Environmental Chemistry by James Girard Bartlett Publishers.
3. Waste Water Engineering by Calf& Eddy.
4. Waste Water treatment for pollution control by Arceivala.
5. Principles of water quality Control by T. H. Y Tebbut.
6. Manual on Sewage &Sewage treatment, Ministry of Works, New Delhi.

CBOP-5, CHI-433: A) Extended Practical in Inorganic Chemistry [96 L + 24T]

A. Preparation and Purity of following complexes of

1. DMG
2. 8-hydroxy quinoline
3. Salicylaldoxime
4. Thiourea
5. Thiocarbamate ligand

With Copper, Nickel, Iron, Chromium & Manganese (any three metals)

B: Structural determination of above complexes using following techniques

1. UV-Visible spectroscopy
2. Magnetic susceptibility
3. Thermogravimetric analysis
4. IR
5. Solution conductivity

C. Introduction to literature survey

Each experiment includes standardization of reagents, calibration of instrument with known reagents and analysis of an unknown.

Reference Books:

1) Text book of Quantitative Analysis, A.I. Vogel 4th edn (1992).
2) Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science

(Horwood publishing, Chichester) 1999.
3) Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
4) General Chemistry Experiments, Anil. J Elias, University press (2002)

CBOP-5,CHI-433; B) Project Work [96L + 24T]

Each student will perform project separately. Working hours are same as practical of CHI-433(A). Project length should be sufficient and should be equivalent to minimum 24 practical session of 4 h. ***Project report must be written systematically and presented in bound form: The project will consist of name page, certificate, content, summary of project (2-3 page) followed by introduction (4 to 7 pages), literature survey (4-7) pages (recently published about 30 papers must be included), experimental techniques, results, discussion, conclusions, Appendix consisting of i) references, 2) standard spectra / data if any and 3) safety precautions.*** If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. ***Systematic record of attendance of project students must be maintained by a mentor.*** Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.

CCPP-4:CHI-434; Practical -Inorganic Instrumental Analysis and Inorganic Preparations [96L + 24T]

Section-I: Inorganic Instrumental analysis (Equivalent to 12 practical)

1. Magnetic Susceptibility – 2 samples
2. Thermogravimetric studies – 2 samples
3. Catalytic hydrogenation Kinetics of Aquation/Isomerisation - 2experiments
4. Photochemical reactions using Nanoparticles
5. Table work – Four techniques IR, ESR, XRD, CV, NMR
6. Metal DNA interactions (Viscosity & spectrophotometry)
7. Synthetic Copper Oxidase (Copper catalysed oxidation of 2,6,disubstituted Phenols)
8. Cyclic Voltametric study of i)Potassium ferricyanide ii) Ferrocene

Section-II: Preparation of Inorganic Compounds (Equivalent to 12 practical)

Part B Preparation of Inorganic compounds:

Metal complexes

1. Trans-dichloro-bis(ethylene diamine) cobalt (III) chloride
2. [Mn(Salen)]
3. $[Mn(acac)_3]$
4. Hg $[Co(SCN)_4]$
5. $[Cu(o\text{-}phen)_2]$
6. Hexa thiocyanato chromate
7. Tris(triphenylphosphine)nickel(II) sulphate.
8. Chloroaquotetraaminocobalt(III) sulphate.
9. $[Fe\ (DTC)_3]$

Synthesis of Solid State Materials

1. Zinc Ferrite
2. NiO
3. Nickel Ferrite
4. Nano particles of MnO_2

Each experiment includes standardization of reagents, calibration of instrument with known reagents and analysis of an unknown.

Reference Books:

1) Text book of Quantitative Analysis, A.I. Vogel 4th edn (1992).
2) Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.
3) Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
4) General Chemistry Experiments, Anil. J Elias, University press (2002)

3. M.Sc. (II) Organic Chemistry

Course Structure

Sr. No.	Paper No. & Course Code	Course Nam e	Credits
		Semester - III	
1	**CCTP-7** CHO-350	Organic Reaction Mechanism and Biogenesis	4
2	**CCTP-8** CHO-351	Structure Determination of Organic Compounds by Spectroscopic Methods	4
3	**CCTP-9** CHO-352	Stereochemistry and Asymmetric Synthesis of Organic Compounds.	4
4	**CBOP-3** CHO-353 Theory	CHO-353-A) Protection - De-protection, Chiron approach and Carbohydrate Chemistry	4
		Or	
		CHO-353B**)** Designing Organic Syntheses and Heterocyclic Chemistry	4
5	**CCPP-3** CHO-354	**Practical I**: Solvent Free Organic Synthesis	4
		Semester – IV	
6	**CCTP-10** CHO-450	Chemistry of Natural Products	4
7	**CCTP-11** CHO-451	Organometallic Reagents in Organic Synthesis	4
8	**CBOP-4** CHO-452 **Theory**	CHO-452 A) Medicinal Chemistry CHO-452 B) Applied Organic Chemistry	4 4
9	**CBOP-5** CHO-453 Practical	**Practical III: Select any two Sections**	4
		Section-I: Ternary Mixture Separation	2
		Section-I: Carbohydrates Synthesis and Isolation of Natural Products	2
		Section-I: Project / Industrial Training/ Internships/ Summer Project	2
10	**CCPP-4** CHO-454	**Practical II**: Convergent and Divergent Organic Syntheses.	4

Equivalence of Previous Syllabus

New Course (2019 Pattern)	Old Course – 2014 Pattern
CHO-350: Organic Reaction Mechanism and Biogenesis	CHO-350 Organic ReactionMechanism
CHO-351: Structure Determination of Organic Compounds by Spectroscopic Methods	CHO-351 Spectroscopic Methods in Structure Determination
CHO-352: Stereochemistry and Asymmetric Synthesis of Organic Compounds.	CHO-352 Organic Stereochemistry
CHO-353A: Protection - De-protection, Chiron approach and Carbohydrate Chemistry.	CHO-452 Carbohydrate and Chiron Approach/ Chiral Drugs and Medicinal Chemistry
CHO-353B: Designing Organic Syntheses and Heterocyclic Chemistry	CHO-453 Designing Organic Synthesis and Asymmetric Synthesis
CHO-354: **Practical I**: Solvent Free Organic Synthesisis	CHO-347 Single Stage Preparations
CHO-450: Chemistry of Natural Products	CHO-450 Chemistry of Natural Products
CHO-451: Organometallic Reagents in Organic Synthesis	CHO-451 Advanced Synthetic Organic Chemistry
CHO-452B: Medicinal Chemistry	
CHO-452B: Applied Organic Chemistry	CHO-353 Pericyclic Reactions, Photo-chemistry and Heterocyclic Chemistry
CHO-453: **Practical III**: **Select any two Sections from I, II,III** Section-I: Ternary Mixture Separation Section-II: Carbohydrates Synthesis and Isolation of Natural Products Section-III: Project / Industrial Training/ Internships (including Summer Project)	CHO-448 Project/Industrial Training/ Green Chemistry and Chemical Biology Experiments
CHO-454: **Practical II**: Convergent and Divergent Organic Syntheses.	CHO-447: Double Stage Preparation Preparation

The detailed course wise syllabus of M. Sc-II Organic Chemistry is as follows:

Semester-III

CCTP-7, CHO-350: Organic Reaction Mechanism and Biogenesis [48L+12T]

Section I: Organic Reaction Mechanism, [24 L + 6 T]

1. Methods for determining Reaction Mechanisms
(Kinetic and nonkinetic methods), Ref -1, **[4 L]**

2. Free Radicals: Generation, stability, reactivity, Free radical substitution, addition to multiple bonds, radicals in synthesis, Inter- and intra-molecular bond formation via mercury hydride, tin hydride, thiol donors, cleavage of C-X , C-Sn, C-S, O-O bonds, Oxidative coupling, C-C bond formation in aromatics, SNAr reactions, Free Radicals in Organic Synthesis. ***(Ref**-2, 3, 6, 7).* **[8 L]**

3. Linear Free Energy Relationships, *Ref. 3, 4*. **[6 L]**

4. Hammet plots, Hammet equation, substituent constants, reaction constants, use of Hammet plots, calculation of k and K, Deviations from straight line plots, Taft equation, solvent effects. *Ref. 3, 4, 5* **[6 L]**

Section II: Biogenesis: The Bbuilding Blocks and Cconstruction Mmechanism, [24 L + 6 T]

1. Terpenoids: Mono-, Sesqui-, Di-, tri-terpenoids and cholesterol, *Ref.- 8, 9, 10* **[6 L]**

2. Alkaloids: Derived from ornithine, lysine, nicotinic acid, tyrosine and tryptophan. *Ref.- 8, 9, 10* **[6 L]**

3. The Shikimate pathway: Cinnamic acids, lignans and lignin, coumarins, flavonoids and stilbens, isoflavanoids and terpenoid quinones. *Ref.- 8, 9, 10* **[6 L]**

3. A case study: Alkaloids isolated from the Roots of ***Piper nigrum,*** *Ref. -11, 12* **[6 L]**

References:

1. Mechanism and structure in Organic Chemistry E. S. Gould (Holt, Rinehart and Winston)
2. Advanced Organic Chemistry –J. March, 4th edition
3. Advanced Organic Chemistry- Part A: Structure and Mechanism- F. A. Carey and R. J. Sundberg, 5th Edition, Springer 2007)
4. A guidebook to mechanism in Organic Chemistry- Peter Sykes
5. The Hammett Equation by C. D. Johnson
6. Organic Chemistry-J. Clayden, N. Greeves, S. Warren, P. Wothers, Oxford University Press
7. Radical in Organic Synthesis- B. Giese, Pergamon Press (1986)
8. Natural Product Biosynthesis: Chemical Logic and Enzymatic Machinery by Christopher T Walsh, Yi Tang
9. From Biosynthesis to Total Synthesis: Strategies and Tactics for Natural Products- Editor Alexandros L. Zografo
10. Medicinal Natural Products: A Biosynthetic Approach, 3rd Edition By Paul M. Dewick
11. J. Nat. Prod. 2004, 67, 1005-1009.
12. J. Org. Chem. 2005, 70, 4, 1164–1176

Additional Study Material: Organic Reaction Mechanism

https://nptel.ac.in/courses/104/101/104101005/
https://nptel.ac.in/courses/104/101/104101115/

CCTP-8, CHO-351: Structure Determination of Organic Compounds by Spectroscopic Methods [48L +12L]

Section-I: NMR Spectroscopy [24 L + 6 T]

1. NMR in Stereochemistry Determination: Homotopic, enatiotopic and distereotopic protons, Chemical and Magnetic equivalence; First and second order splitting, Complex multiplicity patterns and coupling constants in asymmetric compounds; Simplification of complex spectra, NOE, Diastereomerism, Atrop or axial chirality, % Enantiomeric excess, chiral NMR solvents etc in structure elucidation. **[10 L]**

2. ^{13}C NMR spectroscopy - APT, DEPT and INEPT **[6 L]**

3. ^{15}N, ^{19}F and ^{31}P NMR spectroscopy

Fundamentals and applications in structure elucidation of organic compounds, catalysts and biomolecules. *(**Self learning and for internal assessment only). [*0 L]**

4. 2D NMR spectroscopy in structure elucidation: (a)Homonuclear: COSY, TOCSY, 2D-INADEQUATE, 2D- ADEQUATE, NOESY, ROESY (b) Heteronuclear: HSQC, HMQC, HMBC **[8 L]**

Section-II: Mass Spectrometry [24 L + 6 T]

1. Mass Spectrometry: Principle, ionization methods like EI, CI, ES, MALDI and FAB-Fragmentation of typical organic compounds, stability of fragments, Rearrangements, factors affecting fragmentation, ion analysis, ion abundance, High-Resolution mass spectrometry in determination of molecular formula. **[6 L]**

2. Applications of Mass Spectrometry: Determination of the elemental composition, Isotopic Abundance in structure establishment; Analysis of Biomolecules: Proteins and Peptides, Oligonucleotides and Oligosaccharides **[6 L]**

3. Problems solving: Structure elucidation using UV, IR, 1D (1H and13C) NMR and 2D NMR (1H-1H, 13C- 1H COSY /HETCOR only), APT, DEPT and MS data as well as spectra. **[12 L]**

References:

1. Spectrometric Identification of Organic Compounds by R. M. Silverstein, G. C. Bassler and T. C. Morrill, John Wiley.
2. One and Two dimensional NMR Spectroscopy by Atta-Ur-Rehman, Elsevier (1989).
3. Organic Structure Analysis-Phillip Crews, Rodriguez, Jaspars by Oxford University Press (1998).
4. Organic Structural Spectroscopy by Joseph B. Lambert, Shurvell, Lightner, Cooks, Prentice-Hall (1998).
5. Organic Structures from Spectra by Field L.D. Kalman J.R. and Sternhell S. 4th Ed. John Wiley and Sons Ltd.
6. Mass Spectrometry Basics by Christopher G. Herbert Robert A.W. Johnstone
7. Mass Spectrometry Principles and Applications by Edmond de Hoffmann and Vincent Stroobant.

CCTP-9, CHO-352: Stereochemistry and Asymmetric Synthesis of Organic Compounds [48L + 12T]

Section I- Stereochemistry [24L + 6T]

1. Conformations of polysubstituted cyclohexane, six membered rings with SP^2 carbon, heterocycles with N and O, anomeric effect, stereochemical principles involved in reactions of six membered rings and other than six membered rings, concept of I- Strain. ***(Ref.** 1, 2, 3, 4, 5, 6)* **[8 L]**

2. A) Stereochemistry of fused and bridged ring systems: Nomenclature, synthesis; stereochemical aspects of Perhydrophenanthrene, Perhydroanthracene, hydrindane, Steroids; Bridged system (bi, tri and polycyclo system) including heteroatoms, Bredt's Rule. **(*Ref.-1, 2, 3, 4, 5, 6)*. 2. B) Conformations of following compounds with**

justification of each: cis and trans -1,3- and l,4-di-t-butyl-cyclohexanes; Cis-4-di-t-butyl-cis-2,5-dihydroxycyclohexane; Twistane; bicyclo- [2.2.2]octane; Trans-anti-trans-Perhydro-anthracene and the lactone; cyclohexane-l,4-dione; 1,2,2,6,6-penta-methyl-4-hydroxy-4-phenylpiperidine; ψ-tropine; 2-hydroxy-2-phenyl quinolizidine; 4-t-butyl-4-methyl-l,3-dioxane; cis- and trans-2,5-di-t-butyl-l,3-dithianes;cis-2,5-di-t-butyl-l,3,2-dioxaphosphorinan-2-one ***(Ref.** 1, 7, 8)* **[8 L]**

3. Determination of configuration, Cram's rule, Cram's cycle model, Cram's dipolar model, Felkin-Anh Model; Resolution and analysis of stereomers - formation of racemization and methods of resolution. (***Ref.*** 1, 2, 4), Stereochemistry of a polymer chain – Types and examples of Tacticity **(Ref. 7)**, **[8 L]**
4. Decalols, Decalones, Octahydronaphthalenes, decahydroquinolines

***(Self learning and for internal assessment only)** **[*0 L]**

1.

References:

1. Stereochemistry of Carbon compounds - E. L. Eliel
2. Stereochemistry of carbon compounds - E. L. Eliel and S. H. Wilen
3. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers 1st. Ed.
4. Stereochemistry of organic compounds –Nasipuri
5. Stereochemistry of organic compounds-P. S. Kalsi
6. Organic stereochemistry – Jagdamba Singh
7. Topics in Stereochemistry (Volume 2) By Norman L. Allinger and Ernest L. Eliel.
8. Topics in Stereochemistry (Volume 8) By Ernest L. Eliel and Norman L. Allinger.

Additional Study Material: Stereochemistry

https://nptel.ac.in/content/syllabus_pdf/104105086.pdf
https://nptel.ac.in/courses/104/105/104105086/

Section II- Asymmetric Synthesis [24L + 6T]

1. Introduction of Asymmetric Synthesis, Chirol pool and Chiral auxillaries.
2. Asymmetric Organocatalysis
3. Asymmetric Aldol Reaction, Enantioselective, diastereoselective and double diastereoselective Aldol reactions.
4. Transition Metal-Catalyzed Homogeneous Asymmetric Hydrogenation
5. Transition Metal-Catalyzed Homogeneous Asymmetric Hydroxylation and Epoxidation
6. Asymmetric Phase-Transfer and Ion Pair Catalysis **(*Self learning)**

References:

1. Catalytic Asymmetric Synthesis, 3rd ed,Ed: I. Ojima, John Wiley & Sons, New Jersey, 2010
2. Catalysis in Asymmetric Synthesis by Vittorio Caprio and Jonathan M. J. Williams
3. Angew. Chem. Int. Edn. 2008, 47, 4638–4660.
4. Principles and Applications of Asymmetric Synthesis by Guo-Qiang Lin, Yue-Ming Li, Albert S. C. Chan, A John Wiley & Sons, Inc., Publication.

15. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers 2nd. Ed.

Additional Study material: Catalytic Asymmetric Synthesis

https://nptel.ac.in/content/syllabus_pdf/104103067.pdf
https://nptel.ac.in/courses/104/103/104103067/

CBOP-3, CHO-353(A): Protection - De-protection, Chiron approach and Carbohydrate Chemistry OR CHO-353(B): Designing Organic Syntheses and Heterocyclic Chemistr [48L + 12T]

CBOP-3, CHO-353(A): Protection - De-protection, Chiron approach and Carbohydrate

Section I: Protection - De-protection, Chiron approach [24L + 6T]

1. Protection and de-protection of functional group in organic synthesis: Hydroxyl group- alkyl ether, benzyl ether,acyl, PMB, Trityl, TMS, TBDMS, THP, MOM, MEM, MIP ether; **Diol** - Acetone,Cyclohexanone; **Amines**- Benzyl, Acyl, CBZ, BOC, FMOC, **Carboxyl group**-Ester, DCCI, DIPCDI; **Ketone and aldehydes**- Glycol, Thioglycol, Ketal, Acetal; Othroesters as protecting groups, Protection de-protection approach - In Solid phase synthesis of polypeptide; polynucleotide, cyclitols, and amino-sugars. ***(Ref. 1, 2, 3, 4)*****[12 L]**

2. Chiron approach: a) Introduction, b) The concept of chiral templates and chirons wherein the carbon skeleton is the chiral precursor, c) Utilization of the basic concepts in synthesis of (S) Propanediol, (R) and (S) – Epichlorohydrin, L (+)-Alanine, (-) Multistratin, (-) Pentenomycin and (-) Shikimic acid (***Ref.*** 2, 5, 6, 7). **[12 L]**

Section - II: Carbohydrate Chemistry [24 L + 6T]

a) Basics of Carbohydrates: Introduction of sugars, structures of monosaccharides, triose, tetrose, pentose, hexose, D/L forms of aldoses and ketoses in Fisher projections, cyclic hemiacetal forms of monosaccharides, representation of monosaccharide structure (Fisher, Zig-zag, Mills, Haworth projection and Chair conformation), The structure of Glucose, the anomeric configuration, mutarotation (D-Glucose), Conformations of monosaccharides, the anomeric effect. Modified monosaccharides, Alditols, Cyclitols, Nomenclature of monosaccharides, Cyclic forms of the α and β-D-aldoses.

b) Synthesis of Glycosides: glycosyldonar acceptor concept, general methods for glycosyl bond formation: Glycosyl halides, Trichloroacetimides, Glycals and Glycal derivatives, Thioglycosides, Phosphites, n-Pentyl glycosides, SulfoxidesDiazarines, Alkylation of reducing sugars

c) Synthesis of disachharides, trisachharides, polysaccharies: Stereoselective synthesis of □-Mannosides, Synthesis of 2-Deoxy Sugars, Orthogonal strategy in Oligosaccharide synthesis, Effect of protecting groups on glycosylation stereoselectivity and coupling efficiency, Intramolecular glycosylation, Total synthesis of natural products: Oligosaccharides and Glycoconjugates. (**Ref. 5, 8, 9, 10, 11, 12)**

[24 L]

References:

1. Greene's protective groups in organic synthesis – Peter G. M. Wuts and Theodor R. A. Green 4th Edn. Wiley-India
2. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press)
3. Modern organic synthesis-An introduction- George S. Zweifel, Michael H. Nantz.
4. Advanced Organic chemistry, Part B – F. A Carey and R. J. Sundberg, 5th edition (2007)
5. Chiron Approach in organic synthesis – S. Hanessianh
6. Organic Chemistry – R. P. Morrison and R. N. Boyd
7. Organic Chemistry – I. L. Finar, volume II.
8. Essentials of Carbohydrate Chemistry and Biology: Thisbe K. Lindhorst, WILEY-VCH, 2000, Chapter 3.
9. Monosaccharide's: Their Chemistry and their Roles in Natural Products: Peter M. Collins, Robert J. Ferrier: John Wiley & Sons, 1995.
10. Carbohydrate in Chemistry and Biology: Part 1 Chemistry of Saccharides Vol.1. WILEY-VCH, 2000.
11. The Organic Chemistry of Sugars; By: Daniel E. Levy Peter Fugedi Publication: Taylor & Francis, Published on 2006
12. Handbook of Chemical Glycosylation by Alexei V. Demchenko, Wiley VCH, 2008

CBOP-3, CHO-353(B): Designing Organic Syntheses and Heterocyclic Chemistry

[48 L + 12 T]

Section I: Designing Organic Syntheses [24 L + 6 T]

1. Concepts of Retrosynthesis: Retrosynthetic analysis, disconnection approach, Synthons, multiple step synthesis, functional group intercoversion, Illogical two group intercoversion, C-C disconnection, Donor and acceptor Synthons, two group disconnection, 1,5 related functional group disconnection, Umpolung, convergent synthesis, special methods for small rings, Heteroatom and Heterocyclic compounds, problems, (***Ref***.-1, 2, 4). **[12 L]**

2. Application of Retrosynthetic Approach: Retrosynthesis and synthesis of following Molecules: Strychnine, Reserpine, Thienamycin, Asteltoxin, Indolizomycin, Erythronolide B**. Ref**-3 **[12 L]**

References:

1. Designing Organic Syntheses by Stuart Warren
2. Organic Chemistry from Retrosynthesis to Asymmetric Synthesis, by Vitomir Sunjic, Springer; 1st ed. 2016 edition
3. Classics in Total Synthesis by K.C. Nicolaou and E.J.Sorensen

Additional Study material: NPTEL Lecture:

A Study Guide in Organic Retrosynthesis: Problem Solving Approach (https://nptel.ac.in/content/syllabus_pdf/104105087.pdf)

Section II: Advanced Heterocyclic Chemistry [24 L + 6 T]

1. Systematic nomenclature (Hantzsch-Widman System) for monocyclic, fused and bridged heterocycles. Tautomerism in aromatic heterocycles. Strain-bond angle, torsional strains and their consequences in small ring heterocycles. **[4 L]**

2. General chemical behaviour of heterocyclic compounds and their applications in: Biological systems (Anthocyanins, Flavones, Neurotransmitters), Natural Products (Alkaloids: Nicotin, Quinine), Drugs and Medicines (Omeprazole, Amlodipine, Cilostazol) **[4 L]**

3. Synthesis, reactions and structural effects of heterocyclic rings [16 L]

a) Common Methods in Ring Synthesis of Aromatic Heterocyclic Systems**:** Typical ring synthesis involving C – Heteroatom, C – C bond formations, Electrocyclic processes in heterocyclic Synthesis: 1,3 -dipolar cycloadditions producing five - membered heterocycles, Nitrenes in heterocyclic synthesis, Palladium catalysis in the synthesis of Benzo - Fused heterocycles, Fischer synthesis, Epoxidation, Use of Sulphur Ylides, Azides for small rings

b) Three and four membered heterocylces: Aziridines, Oxiranes, Thirienes, Azetidines, Oxitanes and Thietanes

c) Five-membered and benzo-fused five memberedheterocycles:Oxazole, Isoxazole, Thiazole, Pyrazole, Imidazole, Benzothiazole and Benzimidazole

d) Six membered and benzo-fused six membered heterocycles:Pyrazine, Pyridazine, Pyrimidine, Quinazoline, Quinoxaline, Aziridines, Quinoline

Self Learning: Isoquinoline, Indoles

References

1. Heterocyclic Chemistry by T. Gilchrist.
2. An Introduction to the Chemistry of Heterocyclic Compounds by RM Acheson.
3. Heterocyclic Chemistry by J A Joule and K. Mills.
4. Principles of Modern Heterocyclic Chemistry by A Paquette.

5. Heterocyclic Chemistry by J A Joule and Smith.
6. Handbook of Heterocyclic Chemistry by A R Katritzky

Additional Study Material: Heterocyclic Chemistry

https://nptel.ac.in/content/syllabus_pdf/104105034.pdf

https://nptel.ac.in/courses/104/105/104105034/

CCPP-3, CHO-354: Practical-I Solvent Free Organic Synthesis

[96L +24T]

Note:

The students should perform any 24 Syntheses from the following list. Students should acquire **pre-experiment** (Reading MSDS, purification of reactants and reagents, mechanism, stoichiometry etc) and **post-experiment** skills (work-up, isolation and purification of products, physical constants characterization using any spectroscopic methods etc.)

A) Solvent Free Carbon–Carbon Bond Formation

1. Pinacol coupling reaction (Page 36)
2. Reformatsky reaction/Luche reaction (Page 36)
3. Knoevenagel condensation (Page 40)
4. Dieckmann condensation (Page 42)
5. Corrole Synthesis (Page 42)
6. Knoevenagel condensation, 3-carboxycoumarin (Page 45)
7. 3-(ethoxycarbonyl)-4-hydroxy-5-(1-hydroxyalkyl)-2-isoxazoline-2-oxide (Page 46)
8. Biginelli reaction (Page 46)
9. Claisen reaction(Page 47)
10. Pechmann reaction (Page 50)
11. calix[4]resorcinarene (Page 50)

B) **Solvent-Free C–N Bond Formation**

1. terephthalic acid dihydrazide (Page 205)
2. azomethine synthesis (Page 213)
3. diazepinone synthesis (Page 218)
4. dibenzyl sulfone Synthesis (Page 297)

C) **Solvent-Free C–S Bond Formation**

1. 1,3-dithiolane synthesis (Page 299/300)

D) **Solvent-Free C–X Bond Formation**

1. Cinnamic acid/ stilbene halogenations (Page 319)
2. Phenol bromination using , *N*-bromosuccinimide (Page 320)

E) **Solvent-Free N–N Bond Formation**

1. Triazenes Synthesis (Page 335)
2. Beckmann rearrangement (Page 346)

F) **Other Solvent-Free Reactions**

1. D-mannitol protection using phenylboronic acid (Page 388)
2. Baeyer-Villiger reaction
3. 2-Hydroxybenzaldehyde oxidation using urea-hydrogen peroxideComplex (Page 13)
4. Alumina-supported permanganate oxidation (Page 15)
5. Sulfide oxidation using MnO_2 (Page 21)
6. Oxidative coupling of thiol using MnO_2 (Page 22)
7. Iodine catalysed S-S bond formation of Cystine (Page 28)

G) Solvent free supramolecular assembly formation

1. Caffeine and oxalic acid (Page 420)
2. *rac-Bis*-beta-naphthol and benzoquinone
3. Isovaleraldehyde and pyrogallol

Reference:

Solvent-free Organic Synthesis by Koichi Tanaka (Copyright © 2009 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 978-3-527-32264-)

Additional Study Material: https://nptel.ac.in/courses/104/106/104106108/

Semester IV

CCTP- 10, CHO-450: Chemistry of Natural Products [48L +12T]

Section I: [24 L + 6 T]

1. Understanding and planning of total synthesis while maintaining the stereochemistry. A case study: **Longifolene** – (All Nine syntheses from Advanced Organic Chemistry Carey, Sundberg; Part B). **[12 L]**

2. Total Synthesis of

i. Hirsutellone B (Angew. Chem. Int. Ed. 2009, 48, 6870 –6874.)

ii. Ribisins A and B : (J. Org. Chem. 2019, 84, 15165−15172)

iii. Subincanadine E : **(*For Self-Learning)** (J. Org. Chem. 2017, 82, 11126-11133) **[12 L]**

Section II : [24 L + 6 T]

A) Vannusals

References:

1.J. Am. Chem. Soc. 2010, 132, 20, 7138-7152.
2.J. Am. Chem. Soc. 2010, 132, 20, 7153-7176.
3.Angew. Chem. Int. Ed. 2009, 48, 5642 –5647.
4.Angew. Chem. Int. Ed. 2009, 48, 5648–5652

B) **Pinnaic acid**

References:

1. Angew. Chem. Int. Ed. 2001, 40 (23), 4450-4452.
2. Angew. Chem. Int. Ed. 2001, 40, (23), 4453-4456.
3. Angew. Chem. Int. Ed. 2007, 46, 5746–5749

CCTP- 11, CHO-451: Organometallic Reagents in Organic Synthesis [48 L + 12T]

1. Transition metal complexes in organic synthesis; Pd, Ni, Ru, Fe, Ir and Cu only (C-C, C-N, C-O bond formation reactions with catalytic cycle, ligand and % mole concepts)**[18 L]**
2. C=C formation reactions: Wittig, Horner-Wordworth-Emmons, Shapiro, Bamford-Stevens, McMurry, Julia-Lythgoe and Peterson olefination reactions. **[6 L]**
3. Multi-component reactions: Ugi, Passerini, Biginelli and Mannich reaction **[3 L]**
4. Ring formation reactions: Pausan-Khand, Bergman and Nazerov cyclization **[3 L]**
5. Click chemistry: criterion for click reaction, Sharpless azides cycloadditions. Click reactions in synthesis of bioconjugates **(sugars and proteins)** **[4 L]**
6. Metathesis: Schrock and Grubbs catalyst, Olefin cross coupling (OCM), ring closing (RCM) and ring opening (ROM) metathesis, application in polymerization and synthesis of small organic molecules**.** **[6 L]**
7. Use of Boron and Silicon reagents in organic synthesis. **[8 L]**
8. Other important reactions: Baylis Hilman, Eschenmoser-Tanabe fragmentation, Mitsunobu reaction**. [*Self Learning]**

References:

1. C–N bond forming cross-coupling reactions: an overview: by Jitender Bariwalab and Erik Van der Eycken *Chem. Soc. Rev.*, 2013, **42**, 9283
2. Iron Catalysis in Organic Synthesis Chem. Rev. 2015, 115, 3170–3387.

3. Recent advances in homogeneous nickel catalysis Nature 2014, Vol 509, Page 299-309.
4. Ruthenium-Catalyzed Reactions for Organic Synthesis *Chem. Rev.* **1998**, *98*, 2599-2660.
5. Organic Synthesis Involving Iridium-Catalyzed Oxidation Chem. Rev. 2011, 111, 1825–1845.
6. Aerobic Copper-Catalyzed Organic Reactions Chem. Rev. 2013, 113, 6234−6458.
7. Transition Metals for Organic Synthesis Volume 1 *Edited by M. Beller and C. Bolm* WILEY-VCH Verlag GmbH & Co. KGaA ISBN: 3-527-30613-7
8. Multicomponent Reactions Edited by Jieping Zhu, Hugues Bienayme WILEY-VCH Verlag GmbH & Co. KGaA
9. Organic chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press),
10. Some modern methods of organic synthesis – W. Carruthers (Cambridge)
11. Organic synthesis – Michael B. Smith
12. Advanced organic chemistry, Part B – F. A Carey and R. J. Sundberg, 5th edition (2007).
13. Strategic Applications of named reactions in organic synthesis-Laszlo Kurti and Barbara Czako
14. Name Reactions Jie Jack Li (Fourth Expanded Edition), Page No: 1-582.
15. Organic Synthesis Using Transition Metals, by Roderick Bates, Second Edition, A John Wiley & Sons, Ltd., Publication.

CBOP-4, CHO-452(A): Concepts and Applications of Medicinal Chemistry
OR
CHO-452(B): Applied Organic Chemistry [48L + 12T]

CBOP-4, CHO-452(A): Concepts and Applications of Medicinal Chemistry [48L + 12T]

Section-I: [24 L + 6 T]

1. Introduction to Peptides and proteins, Proteins as biological catalyst Nucleic acids, Metabolism, Chemistry of cofactors/coenzymes, Chemistry of TPP, PLP, Folic Acid and other vitamins, Principle of drug design, Chemistry of diseases and Drug development, Proton pump inhibitors and Problem solving. **[8 L]**
Additional study material: NPTEL lecture: Organic Chemistry in Biology and Drug Development (full course) https://nptel.ac.in/content/syllabus_pdf/104105120.pdf) https://nptel.ac.in/courses/104/105/104105120/

2. Peptides, sequencing and applications in therapeutics, Solution phase and solid phase peptide synthesis and Modern techniques for biomolecules and disease diagnosis. **[6 L]**
Additional study material: NPTEL lecture (only 3 topics): Essentials of Biomolecules: Nucleic Acids and Peptides https://nptel.ac.in/content/syllabus_pdf/104103121.pdf https://nptel.ac.in/courses/104/103/104103121/

3. Introduction to medicinal Chemistry. History, drug targets, Drug discovery, design and development, Case Study: Design of Oxamniquine. **[4 L]**

4. Pharmacokinetics and Pharmacodynamics of drug: Drug absorption, distribution, metabolism, elimination and toxicity, drug metabolism, biotransformation, Drug receptor interactions, Hansch Equation and significance of terms involved in it. **[6 L]**

Section II: [24 L + 6 T]

1. Structure and activity Relationship: QSAR, Applications of SAR and QSAR in drug design, physio-chemical parameters lipophilicity, partition coefficient, electronic ionization constant, Case Study: Statins **[10 L]**
2. Introduction, Developments, SAR, Mode of action, limitations and adverse effect of Anti-infective Agents, Beta lactam antibacterial agents (Penicillins, Cephalosporins), Tetracyclins, Macrolides, Chloramphenicol, Polyenes, Amphotrecin-B, Azoles, Amantadine,Acyclovir, Quinine, Quinolines, Quinolones, Refamycine, Sulphonamides [**14 L]**

References:

1. Medicinal Chemistry and Drug Discovery by Burger
2. Introduction to Medicinal Chemistry by Grham and Patrick
3. Introduction to Drug Design by J. R. Dimmock and S.S. Pandeya
4. The Organic Chemistry of Drug Design and Drug Action, 3rd Edition, R. B. Silverman, Academic Press, 2014
5. Wilson and Gisvold's Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed Robert F Dorge, 12th Edition, 2010
6. Chemistry of Heterocycles by T. Eicher and S. Hauptmann, Thieme

CBOP-4, CHO-452(B): Applied Organic Chemistry [48 L + 12T]

Section-I: [24 L + 6 T]

1. Covalent Organic Frameworks: Structures, Synthesis, and Applications. [12 L]
(Ref: Review article by Maria S. Lohse and Thomas Bein ***Adv. Funct. Mater***. 2018, 28(33), 1705553.)

2. Organic Electroluminescent Materials, [12 L]
(Ref: Review article by L.S. Hunga and C. H. Chen ***Materials Science and Engineering*** 2002, R 39, 143–222)

Section –II : [24 L + 6 T]

1. Supramolecular Organic Compounds [8 L]

(Ref: Review by Matthew C. T. Fyfe and J. Fraser Stoddart ***Accounts of Chemical*** *Research* 1997, 30 (10), 393-401.)

(Ref: Review article by Wei Chen and et al. ***Chem. Soc. Rev.***, **2015**, *44*, 2998-3022)

2. Single Molecule Switches [8 L]

(Refs: Review article by Wei Chen and et al. ***Chem. Soc. Rev.***, **2015**, *44*, 2998-3022.)

2. Molecular Machines [8 L]
(**References:**

1. Review article by David A. Leigh and et al. *Chem. Rev.* 2015, *115*, 10081−10206.
2. Redox-Gated Tristable Molecular Brakes of Geared Rotation. *J. Org. Chem.*, 2017, 82(10), 5354-5366.
3. Massimo Baroncini, Serena Silvi, Alberto Credi. *Chem. Rev.* 2020, *120* (1), 200-268).

References:

1. The Chemistry of Metal–Organic Frameworks- Wiley Online. Print ISBN: 9783527338740, Online ISBN:9783527693078, DOI:10.1002/9783527693078
2. Covalent Organic Frameworks - 1st Edition - Atsushi Nagai, ISBN 9789814800877, Published January 24, 2020 by Jenny Stanford Publishing.

CBOP-5, CHO-453: Practical-III: Select ANY TWO Section I, II and III [96 L + 24 T]

Section-I: Ternary Mixture Separation [48 L + 12 T]

Separation of minimum 12 mixtures containing three components. The mixtures should also involve separation of nitrophenols, amino acids, low boiling and water soluble and insoluble compounds solids and liquids with **multifunctional groups**. The mixture separation should be carried out on micro-scale using ether or water.

The students should be able to

1. Understand and employ concept of type determination and separation
2. Meticulously record physical constants
3. Perform micro scale chemical elemental analysis
4. Perform qualitative estimation of functional groups
5. Recrystallize /distill the separated compounds
6. Extend these skills to organic synthesis

Section-II: Carbohydrates Synthesis and Isolation Natural Products [48 L + 12 T]

Unit I: Carbohydrate Synthesis (Any 3)

1) Synthesis and structural determination of α- and β-D-glucose penta- acetate.
2) Selective deacylation of α- and β-D-glucose penta-acetate.
3) Benzoylation of D-glucose.to D-glucose penta-benzoate.
4) Selective debenzoylation of D-glucose penta-benzoate
5) Synthesis 1,2:5,6-di-O-isopropylene-D-glucofuranose.
6) Synthesis of 1,2: 5,6 – di-O-isopropylene-3-O-benzyl –D-glucofuranose.

Note:

Carbohydrate (sugar molecules) are highly soluble in water, to derivatives the sugar molecules require special practical skill in order to get product in hand.

i) To understand the meaning of dry condition in reaction.
ii) How to prepare dry solvents.
iii) Workup of reaction in minimum quantity of water.
iv) To acquire skill in handling of carbohydrates reaction.

Unit II: Isolation of pigments from the natural products (Any 3)

1. Orange Marigold
2. Rose
3. Sunflower
4. Hibiscus
5. Any colored flowers/fruits available in the local area **(only one is allowed).**

Note: Students should be able to collect reasonable quantities of color pigments to do the characterization (Physical Constant, Elemental analysis functional group test etc) and should also form the appropriate derivative. They are encouraged to use these pigments for developing food grade natural colors from lesser known plant sources.

Unit III: Isolation of essential oils from the natural products (Any 3)

1. Ginger
2. Lemongrass
3. Garlic
4. Ajwain/ajowan/Trachyspermum ammi
5. Vekhand (achourus calamus) root

6. Any natural products available in the local area **(only one is allowed)**

Note: Students should be able to collect a reasonable quantities of essential oils to do the characterization(Physical Constant, Density, Elemental analysis functional group test) Should form the appropriate derivative. They are encouraged to use these essential oils for the development of the products like soap, perfumes etc.

Unit IV: Isolation of medicinally important component from the natural products (Any 3)

1. Nimbin from Neem leave
2. Amyrin from Apati/Apta bark
3. Eujenol from Tulsi leaves
4. D-Galacturonic Acid from Jeshtamadh
5. Piper from Betel leaf
6. Any medicinally important plants available in the local area **(only one is allowed)**

At least one natural product should be isolated by using column chromatographic techniques (Use micro columns to avoid excess use of solvents)

Note: Students should be able to collect a reasonable quantities natural products to do the characterization (Physical Constant, solubility, Elemental analysis functional group test etc) and should also form the appropriate derivative. They are encouraged to study novel medicinal plants from their local area.

References for Carbohydrates:

1. Essentials of Carbohydrate and Chemistry and Biology: Thisbe K. Lindhorst, WILEY-VCH, 2000.
2. Kawanata , K. P. R. Tretrahedron Lett. 1986, 27, 3415.
3. Bessodes, M., Shamszar, J. Antonakies, K., Synthesis, 1988, 560.

Section-III: Project [48 L + 12 T]

Project/ Industrial Training/Summer Training/ Internships

1. Students should carry out a small research project.
2. This should make them familiar with
   i. Literature survey, research methodologies
   ii. Data Analysis
   iii. Column and TLC chromatographic techniques
   iv. Characterization of the products by analytical and spectral methods.
3. **Project report must be written and submitted in a proper format as follows;**
   i) Certificate (Signed by Project guide and Head of the Department)
   ii) Certificates for Poster/Paper presented in conferences (if any)
   iii) Self declaration certificate for plagiarism
   iv) Introduction (not more than 6 pages)
   v) Results and Discussions
   vi) Experimental Section
   vii) Conclusion
   viii) References (Use ACS format)
   ix) Spectroscopic or other relevant supporting data
   x) Acknowledgement
4. Interdisciplinary projects shall be encouraged; however there **must be some organic chemistry component**.
5. Students should spend enough time for the project works (**at least** 4 hours per week for **15 weeks**)
6. At least 30% students should undertake projects/summer training/Internships etc.
7. If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this

case student has to obtain certificate from both external and internal mentor. ***Systematic record of attendance of project students must be maintained by a mentor.*** Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work, discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.

CCPP-04, CHO-454: Practical-II: Convergent and Divergent Organic Syntheses [96 L + 24T]

Note: Any **3 sets** should be conducted from the following convergent and divergent synthesis sets.

Students should acquire **pre-experiment** (Reading MSDS, purification of reactants and reagents, mechanism, stoichiometry etc) and **post-experiment skills** (work-up, isolation and purification of products, physical constants characterization using any spectroscopic methods etc.)

SET-I

A) Convergent Synthesis 1 (Three Stage Synthesis)

1. Stage I: Anisole to 4-nitro anisole to 4-amino anisole (2 steps)
2. Stage II: Toluene to 4-nitro toluene to 3-acyl nitro toluene (2 steps)
3. Stage III: Synthesis of N-(1-(2-methyl-5-nitrophenyl) ethyl) aniline from 4-amino anisole, 3-acyl nitro toluene and SBH (One pot synthesis: MCR)

B) Divergent Synthesis 1 (5 Single Stage Synthesis from Acetyl acetone):

1. Acetyl acetone to Pyrimidine
2. Acetyl acetone to 2,4-dimethyl-1H-benzo[b][1,4]diazepine
3. Acetyl acetone to Pyrazole
4. Acetyl acetone with 1mmol benzaldehyde to 3-benzylidenepentane-2,4-dione
5. Acetyl acetone with 3 mmol benzaldehyde into 3-benzylidene-6-phenylhex-5-ene-2,4-dione

SET-II

A). Convergent Synthesis 2(Three Stage Synthesis)

1. Stage I: 4-Nitro toluene to 4-amino toluene (Reduction by using Sn/HCl)
2. Stage II: Phenol into 2-hydroxy benzaldehyde (Reimer-Tiemann reaction)
3. Stage III: Synthesis of amidoalkyl-2-naphthols from β-Naphthol,4-amino toluene and of 2-hydroxy benzaldehyde (One pot synthesis: MCR)

B). Divergent Synthesis (5 Single Stage Synthesis from β-Naphthol)

1. β-Naphthol to Synthetic dye (By diazonium coupling)
2. β-Naphthol to 6-Bromo-2-naphthol (Bromination reaction)
3. β-Naphthol to β-Naphthyl methyl ether (Methylation reaction)
4. β-Naphthol to temperature dependent sulfonation (Sulfonation reaction)
5. β-Naphthol to (±) Binol then Resolution of Binol (Resolution technique)

SET-III

A). Convergent Synthesis-3 (Three Stage Synthesis)

1. Stage I: Salicylic acid to 5-Chloro-2-hydroxybenzoic acid
2. Stage II: o- Anisidine to 2-methoxy-4-nitroaniline
3. Stage III: Synthesis of 5-chloro-2-hydroxy-N-(2-methoxy-4-nitrophenyl) benzamide from 5-Chloro-2-hydroxybenzoic acid, -methoxy-4-nitroaniline (One pot synthesis: MCR)

B). Divergent Synthesis-3 (5 Single Stage Synthesis from Salysaldehyde)

1. Salicylaldehyde to Salicylaldehyde phenylhydrazone
2. Salicylaldehyde with melanonitrile to 2-iminochromene by intramolecular cyclization.
3. Salicylaldehyde to 2-hydroxy-3,5-dinitrobenzaldehyde

4. Salicylaldehyde to o-Formylphenoxy acetic acid
5. Salicylaldehyde to catechol

SET-IV

A) Convergent Synthesis- 4 (Three Stage Synthesis)

1. Stage I: Benzene to actophenone (F.C acylation)
2. Stage II: 4-Nitrochlorobenzene into 4-amino chlorobenzene (Reduction by using hydrazine)
3. Stage III: Quinoline synthesis by using acetophenone, 4-amino chloro benzene and styrene (One pot synthesis: [3 + 2 + 1] cycloaddition reaction)

B). Divergent Synthesis-4 (5 Single Stage Synthesis from Acetophenone)

1. Acetophenone to Ethyl benzene by Wolf Kishner reduction
2. Acetophenone to m-Nitro acetophenone by nitration
3. Acetophenone to Chalcone using aromatic aldehyde
4. Acetophenone into Schiff base using aromatic amine
5. Acetophenone to Benzoic acid and Iodoform

References

1. Practical organic chemistry by Mann and Saunders
2. Text book of practical organic chemistry –by Vogel
3. The synthesis, identification of organic compounds –Ralph L. Shriner, Christine K.F.
4. Hermann, Terence C. Morrill and David Y. Curtin

Important Notes for Practical Courses

- All experiments should be carried out on micro-scale and by considering stoichiometric quantities of reactants and reagents with the proper understanding of the mechanism.
- Post graduate departments should arrange at least **one study visit to relevant industry/national research laboratory/premier academic institute**.
- Students must read MSDS and should handle chemicals and reactions accordingly.
- The necessary reactions should be carried out in fume hood and appropriate safety measures should be taken during the laboratory experiments and projects.
- All reactions should be **monitored using alumina coated TLC plates**.
- Certified journals should be presented at the time of final examination.
- Students opting for the projects are encouraged to participate in AVISHKAR, national and international conferences and other project competitions.
- Teachers are encouraged to give the project ideas based on the societal needs.

4. M. Sc. (II) Drug Chemistry
Course Structure

Sr. No.	Paper No.	Course Name	Credit
		Semester – III	
1	CCTP-7 CHD-360	Advanced Analytical Methods	4
2	CCTP-8 CHD-361	Drug Discovery and Development	4
3	CCTP-9 CHD-362	Stereochemical Principles and Applications	4
4	CBOP-3 Theory CHD-363	CHD-363(A) Chemistry of Heterocycles and Biologically active Molecules	4
		CHD-363(B): Any two sections	4
		Sec-I: Microbilogy,Immunogy Sec-II: Bioinformatics, Biostatistics in Drug Discovery Sec-III: Enterpreneurship Development	2 2 2
5	CCPP-3 CHD- 364	**Practical-I**: Two Stage Preparation	4
		Semester-IV	
6	CCTP-10 CHD-460	Advanced Medicinal Chemistry	4
7	CCTP-11 CHD-461	Drug Design	4
8	CBOP-4 Theory CHD-462	CHD-462(A) Advanced Synthetic Methods in Chemistry **OR** CHD-462(B) Supramolecular, Green Chemistry and Forensic chemistry	4 4
9	CBOP-5 Practical CHD-463	**Practical-III: Select any two sections from I, II, III, IV** Section-I: Microbiology, Drug Chemistry Section-II: Practical For Forensic Chemistry Section-III: Ternary Mixture Separation Section-IV: Project / Industrial Training	4
10	CCPP-4 CHD- 464	**Practical-II**: Synthesis of Heterocycles and Drug Molecules	4

Equivalence to Previous Syllabus

New Syllabus 2019 pattern		Old Syllabus 2014 syllabus	
CCTP-7 CHD-360	Advanced Analytical Methods	**CHD-362**	Advanced Analytical Methods
CCTP-8 CHD - 361	Drug Discovery and Development	**CHD-363**	Microbiology, Immunology & Drug Discovery and Development
CCTP-9 CHD -362	Stereochemical Principles and Applications	**CHD-364**	Stereochemistry, Assymetric synthesis and Pericyclic Reactions
CBOP-3 Theory CHD-363	A)Chemistry of Heterocycles and Biologically active Molecules	**CHD-361**	Chemistry of Heterocycles and Drug Synthesis
	B-I) Microbiology, Immunology		No Equivalence
	B-II) Bioinformatics, Biostatistics in Drug Discovery		No Equivalence
	B-III) Entrepreneurship Development,		No Equivalence
CCPP –3 CHD - 364	**Practical-I**: Two Stage Preparation	**CHD- 367**	Practical Course I Organic Synthesis
CCTP –10 CHD - 460	Advanced Medicinal Chemistry	**CHD- 462**	Advanced Medicinal Chemistry
CCTP –11 CHD - 461	Drug Design	**CHD- 463**	Principles and applications in Drug Design
CBOP-4 Theory CHD-462	A) Advanced Synthetic Methods in Chemistry	**CHD- 461**	Advanced Organic Synthesis- Principles and Strategies
	B) Supramolecular, Green Chemistry and Forensic Chemistry		No Equivalence
CBOP-5 Practical CHD-463	**Practical-III:** I) Microbiology, Biochemistry	**CHD- 468**	Practical Course II Microbiology and Biochemistry
	II) Practical on Forensic Chemistry		No Equivalence
	III) Ternary Mixture Separation		No Equivalence
	IV) Project / Industrial Training	**CHD- 469**	Practical Course III Project /Industrial training
CCPP – 4 CHD - 464	**Practical-II:** Synthesis of Heterocycles and Drug Molecules	**CHD- 469**	Practical Course III Project /Industrial training / Advanced practical

The detailed course wise syllabus of M. Sc-II Drug Chemistry is as follows:

Semester-III

CCTP-7, CHD-360: Advanced Analytical Methods [48L + 12T]

SECTION I: Spectroscopy-I [24 L +6 T]

1. ^{1}H NMR Spectroscopy [14 L]

Recapitulation: shielding and deshielding, Chemical shift, factors influencing chemical shift, Chemical and magnetic shift equivalence. **Chemical shift(δ):** correlation for protons bonded to carbons (aliphatic, olefinic, aldehydic, aromatic) and other nuclei (oxygen and nitrogen);

Spin-spin splitting: (n+1) rule, origin of spin-spin splitting, pascal triangle. **Coupling Constant (J):** Mechanism of coupling, Type (Geminal, vicinal coupling, long range and W coupling), factors effecting geminal and vicinal coupling constant; **Spin System:** classification of spin system, spin notations (A_2, AB, AX, AB_2, AX_2, ABC, ABX, AMX, A_2B_2, A_2X_2), complex spin-spin interaction between two, three and four nuclei (First Order Spectra and Second order spectra); **Simplification of complex spectra:** nuclear magnetic double resonance, spin decoupling, contact shift reagents, solvent effects, chiral resolving agent, nuclear overhauser effect (NOE), resonance of other nuclei like ^{31}P, ^{19}F.Problems and Assignment of PMR signal

2. ^{13}C NMR spectroscopy [10 L]

Recapitulation: ^{13}C Nucleus, Chemical Shift and factor affecting ^{13}C NMR, **Types of ^{13}C NMR Spectra:** proton coupled (spin-spin splitting), Proton decoupled, Off resonance, **Pulse sequence:** spin and magnetization vector, DEPT, APT and NOE, **Coupling constants:** Homo nuclear (^{13}C-^{13}C) and Hetero nuclear (^{13}C-^{1}H, ^{13}C-^{19}F, ^{13}C-^{31}P).Problems and Assignment of ^{13}C NMR signal

SECTION II: Spectroscopy-II [24 L +6 T]

3. Correlation Spectrometry; 2D NMR [04 L]

Pulse sequence in 1 D and 2 D spectra, type of 2D (Homo and Hetero nuclear); **2D in structure determination:** ^{1}H- ^{1}H Correlation spectroscopy (COSY), Double Quantum Filtered COSY (^{1}H-^{1}H), Heteronuclear Correlation (HETCOR, HMQC and HMBC); **Applications:** INADEQUATE, Totally correlated spectroscopy (TOCSY), NOESY and ROESY experiments.

4. Mass Spectrometry [10 L]

Instrumentation, various methods of ionization: Gas phase ionization (electron impact and Chemical) Desorption ionization (field desorption, FAB, Plasma, Laser), Evaporative ionization (Thermospray and Electrospray mass spectrometry); Detectors: Quadrupole mass filter, time of flight (TOF). **EI mass spectra interpretation:** intensity of molecular ion peak, base peak, fragment ion peak and isotope peak (M+1, M+2); Nitrogen Rule, Molecular formula determination (Rule of 13). Fragmentation Pattern and McLafferty rearrangement.**Fragmentation of functional groups:** Hydrocarbons, Ether, Aldehyde, Ketone, Carboxylic Acid, Ester, Amide, Sulfur and halogen compound.

5. Problems based on joint application of UV, IR, PMR, CMR, Mass and 2-D NMR. [**10 L]**

References

1. Introduction to Spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 3rd Ed. (Harcourtcollege publishers).
2. Spectrometric identification of organic compounds R. M. Silverstein, F. X. Webster, 7th Ed. John Wiley and Sons.
3. Spectroscopic methods in organic chemistry – D. H. Williams and I. Flemming Mc Graw Hill

4. Absorption spectroscopy of organic molecules – V. M. Parikh
5. Nuclear Magnetic Resonance – Basic Principles- Atta-Ur-Rehman, Springer-Verlag (1986).
6. One- and two-dimensional NMR Spectroscopy – Atta-Ur-Rehman, Elsevier (1989).
7. Organic structure Analysis- Phillip Crews, Rodriguez, Jaspars, Oxford University Press (1998)
8. Organic structural Spectroscopy- Joseph B.Lambert, Shurvell, Lightner, Cooks, Prentice-Hall (1998).
9. Organic structures from spectra –Field L.D., Kalman J.R. and Sternhell S. 4th Ed. John Wiley and sons Ltd.
10. Spectroscopic identification of organic compound- R M Silverstein, G C Bassler and T CMorril, John Wiley
11. Introduction to NMR spectroscopy-R J Abrahm, J Fisher and P loftus Wiley
12. Organic spectroscopy-William kemp, E L B with McMillan
13. Spectroscopy of organic molecule-PS Kalsi,Wiley, Esterna, New Delhi
14. Organic spectroscopy-RT Morrison and RN Boyd
15. Practical NMR spectroscopy-ML Martin, J J Delpench, and D J Martyin
16. Spectroscopic methods in organic chemistry-D H Willson, I Fleming
17. Spectroscopy in organic chemistry- C N R Rao and J R Ferraro
18. NMR –Basic principle and application-H Guntur
19. Interpretation of NMR spectra-Roy H Bible
20. Mass spectrometry organic chemical applications, J H Banyon

Learning Outcome

1. Understand the principle, working and application of Nuclear magnetic resonance spectroscopy.
2. Understand the use of coupling constant values in structure determination.
3. Understand the principle, working and application of Mass spectrometry.
4. Understand the structure elucidation using combined spectroscopic data.

CCTP-8, CHD-361: Drug Discovery and Development [48L + 12T]

SECTION-I: Drug Discovery [24 L +6 T]

1. Introduction to drugs, History and classification, their action and discovery **[2L]**
2. Drug targets- lipids, carbohydrates, proteins, and nucleic acids [**4L]**
3. Sources of drugs, Microbial, Plant, Marine, synthetic, A historical perspective. **[4L]**
4. Introduction to the different systems of medicines-Ayurveda, Allopathy, Unani and Homeopathy **[6L]**
5. Routes of drug administration, formulation of Dosage forms, Types of dosage forms [**8L]**

SECTION-II: Drug Development [24 L +6 T]

1. **Discovery and Development of Drugs [8L]**
   History of drug discovery, Strategies in drug discovery, lead discovery, pharmacophore identification, lead development, Bioassays, screening of compounds.
2. **Toxicological evaluation of new drugs [8L]**
   Pre-Clinical testing, Clinical trials, Bioavailabability of drugs, Bioequivalence
3. **Patents and intellectual property rights [4L]**
4. **Pharmacokinetics and Pharmacodynamics of drug action [4L]**
   From R & D to plant, QA, QC scale up process. GMP, FDA Documentation, Pharmacopeia, Industrial hygiene and safety

References

1. Medicinal Chemistry an Introduction-Gareth Thomas 2nd Ed. Wiley
2. An introduction to medicinal chemistry-Graham L. Patrick 5th Ed. Oxford

3. Introduction to Medicinal Chemistry-Alex Gringauz (Wiley)
4. Comprehensive Medicinal Chemistry Vol-I (Hansch (1990) Pergamon press
5. Principle of Drug action-Goldstein.
6. Bioavailabinty and Bio equivalence-H.P.Tinis.
7. Pharmacoepia of India, British pharmecoepia, US Pharmacoepia
8. Pharmaceutical Dosage forms and Drug Delivery system VIthEdn. .Arnel (Wessl
9. Organic Chemistry of Drug Design and Drug Action. R.B.Silverman (1993) Academic Press

Learning Outcomes:-

1. Student should understand the various systems of medicines.
2. To understand concept of drug and different sources of drugs.
3. Student should able to learn lead discovery and pharmacophore identification.
4. To know about bioassays and toxicological evaluation of new drugs.
5. Student should understand the pre-clinical testing and clinical trials.
6. Student should able to understand the concept of Patents and intellectual property rights.
7. To know about Pharmacokinetics and Pharmacodynamics of drug action.
8. Student should able to understand the different dosage forms of drugs.

CCTP-9, CHD-362: Stereochemical Principles and Applications [48L + 12T]

SECTION - I Stereochemistry [24 L +6 T]

1. Stereochemistry of six membered rings-
Relation to physical properties, conformation and chemical reactivity, conformational effects in six membered rings containing unsaturation. **[8L]**

2. The shapes of rings other than six membered rings: five membered, medium rings, transannular effects, concept of I strain – **[6L]**

3. Fused rings and bridged rings **[6L]**

4. Stereochemistry of Drug molecules
Saquinavir (HIV protease inhibitor), Abiraterone (drug for prostate cancer), ephedrine and pseudoephedrine, *R- and S-enantiomers of* Ibuprofen (non-steroidal anti-inflammatory), *R- and S-enantiomers of thalidomide.* **[4L]**

SECTION II: Principles and Applications of Asymmetric Synthesis [24 L +6 T]

1. Principles and applications of asymmetric synthesis:
Stereoselectivity in cyclic compounds, enantio-selectivity, diastereo-selectivity, enatiomeric and diastereomeric excess, stereoselective aldol reactions. Cram's rule,Felkin Anh rule, Cram's chelate model, Asymmetric synthesis, use of chiral auxiliaries,chiral reagents and catalysts, asymmetric hydrogenation, asymmetric epoxidation andasymmetric dihydroxylation. Synthetic and Industrial applications. **[18L]**

2 Racemization and Resolution methods **[04L]**

3. Stereochemistry of a polymer chain – Types and examples of Tacticity **[02 L]**

References:

1. Stereochemistry of carbon compound-by E.L. Eliel
2. Stereochemistry of organic compound-by Nasipuri
3. Stereochemistry of carbon compounds – E. L. Eliel and S. H. Wilen
4. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers,
5.Topics in Stereochemistry (Volume 2) By Norman L. Allinger and Ernest L. Eliel
6. Stereochemistry of organic compounds-P. S. Kalsi
7. Organic stereochemistry – Jagdamba Singh

Learning Outcome:
On the successful completion of the course, students will be able to:
1. Understand the stereochemistry, reactivity and conformational effects of six membered rings.
2. Understand the stereochemistry, shapes of rings other than six membered rings.
3. Understand the role various resolution methods, stereoselective synthesis and asymmetric synthesis.
4. Understand the stereochemistry of polymer chain.

CBOP-3, CHD-363(A) : Chemistry of Heterocycles and Biologically active Molecules

OR

CBOP-3, CHD-363(B) : Any two section from I, II, III

Section-I : Immunology and Microbiology.
Section-II : Bioinformatics, Biostatistics in Drug Discovery
Section-III: Entrepreneurship Development

CBOP-3, CHD-363(A) - Chemistry of Heterocycles and Biologically active Molecules [48L + 12T]

Section-I: Chemistry of Heterocycles [24 L + 6 T]

1. **Condensed five membered heterocycles**: Indole, Benzofuran and Benzothiophene- Nomenclature, reactivity, synthesis and reactions. **[6L]**
2. **Condensed six membered heterocycles:** Quinoline, Isoquinoline, Coumarines and Chromones- Nomenclature, reactivity, synthesis and reactions. **[6L]**
3. **Five membered, condensed five member**, **six membered and condensed six membered heterocycles with more than one heteroatom-** Oxazole, imidazole, Thiazole, 50ydrazine, pyrazole, isothiazole, triazole (1,2,3-triazole, 1,2,4-triazole), pyrimidine, pyrazine, oxazine, thiazine, benzimidazole, benzoxazole, benzthiazole Nomenclature, reactivity, synthesis and reactions. **[12L]**

Section-II: Chemistry of Biologically Active Natural And Synthetic Molecules [24 L +6 T]

1. Synthesis of biologically active natural products: Prostoglandin PGF_2, Cephalosporin–C, Reserpine, Taxol, Periplanone B, Aspidophytine Penicillin, Griseofulvin. **[12L]**
2. Synthetic Drugs and their derivatives: Nalidixic acid, metronidazole, Ciprofloxacin, Ibuprofen, Atenolol, Captopril, Diazepam, Chloroquine, Barbiturates, pyrazinamide, Miconazole, Omeprazole, Astemizole, Orcanozole,lomustine, carmustine, procarbazine, Ranitidine. **[12L]**

Learning Outcomes
1. Knowledge of name reactions in synthesis
2. Different application of name reactions
3. Drug molecule and their uses in treatment
4. Synthetic strategy involved in preparation
5. Recent drug developments

References
1. John A. Joule, Keith Mills.; Heterocyclic Chemistry, 5thEdition, April 2010, ©2010, WileyBlackwell, ISBN: 978-1-4051-3300-5.
2. Gilchrist, T. L. Heterocyclic chemistry; 3rd ed.; Addison Wesley Longman: Edinburgh Gate
3. Joule, J. A.; Mills, K.; Heterocyclic chemistry; 4th ed.; Blackwell Science: Oxford, 2000.
4. An Introduction to Medicinal chemistry: Graham, Patric third edition
5. Classics in total synthesis- More target, Strategies, methods-Nicolaou- Snyder, (Wiley-VCH)
6. The organic Chemistry of drug synthesis-Daniel Lednicer, Lester A. Mitscher (Wiley and

Sons) vol-3

7. Classics in Total Synthesis- Target, Strategy, methods-Nicolaou- Sorensen, (Wiley-VCH)

CBOP-3, CHD – 363(B): Any two section from I, II, III

Section-I: Immunology and Microbiology.
Section-II: Bioinformatics, Biostatistics in Drug Discovery
Section-III: Entrepreneurship Development

Section-I: Immunology and Microbiology. [24 L +6 T]

1. Microbial Drug Development [12L]

Introduction to Microbiology and classification of Microbes. Screening of Microbes fermentation process, concept of primary and secondary screening, characterization of ideal industrial strains, Microbia1growth, kinetics, Isolation and Improvement of Individual micro- organism, fermenter designing, Media designing, antimicrobial assays; Down Stream process and effluent treatment (Microbial and Chemical)

2. Immunology and Immunopharmacology [12L]

Overview of the immune system and its role, three lines of defence, Types of immunity – active, passive, cell mediated and humoral immunity. Antigen and antibody, organs of immune system (Primary and secondary). Adaptive and innate Immunity. Immune response and the underlying mechanisms, Hypersensitivity, immunodeficiency, Autoimmunnity, Immunzation, Immunosuppresants, Immunomodulators, Immunological techniques – Agglutination reaction (Haemogluttination, bacterial agglutination), Precipitation reaction (single and double Immunodiffusion), Diagnostic techniques – ELISA, RIA, FACS

References:

1. Principles of Medicinal Chemistry including Proteomics S. Rangnathan& Jerad Suresh 2011 CBS press
2. Statistical Methods in Biology-Norman Bailey (1995) Cambridge
3. Molecular Modeling, Principles and applications -Andrew Leach (Longman) 1998.
4. Comprehensive Medicinal Chemistry vol.4 Corwin Hansch (1990) pergaman press.
5. Organic Chemistry of drug design and drug action-RB. Silverman 2nd Ed. (2004) Elsevier
6. Basic and Chemical Immunology-Stites (1987) Prentice Hall.

Learning Outcomes: Students will

1. Understand recent trends in drug development
2. Learn various biological databases and their applications
3. Learn applications of bioinformatics and chemoinformatics
4. Learn applications of biostatistics

SECTION-II: Bioinformatics, Biostatistics [24 L +6 T]

1. Bioinformatics: Introduction to biological databases, types of databases, Information retrevial from biological databases. Gene prediction programs, promoter and regulatory elements prediction programs. Structural bioinformatics, Phylogenetics and structural bioinformatics. Elements of genomics, transcriptomics proteomoics and metabolomics and applications Elements of Cheminformatics: Representation of molecular structure, graphs connection tables, linear notations, canonical representations. Structure and substructure searching algorithms. Reaction databases, representation of patents and patent databases. Relational databases for molecules. Use of Chembioinformatics in drug designing with case studies. **[12 L]**

2. Biostatistics: Fundamentals of statistics, various statistical parameters, statistical tests, use of statistics in drug discovery and development and in clinical trials **[12 L]**

References

1. Principles of Medicinal Chemistry including Proteomics S. Rangnathan& Jerad Suresh 2011 CBS press
2. Statistical Methods in Biology-Norman Bailey(1995) Cambridge
3. Molecular Modeling, Principles and applications -Andrew Leach (Longman) 1998.
4. Comprehensive Medicinal Chemistry vol.4 Corwin Hansch(1990) pergaman press.
5. Organic Chemistry of drug design and drug action-RB. Silverman 2nd Ed. (2004) Elsevier

Learning Outcomes:

Students will learn

1. Understand recent trends in drug development
2. Learn various biological databases and their applications
3. Learn applications of bioinformatics and chemoinformatics
4. Learn applications of biostatistics

SECTION III: Entrepreneurship Development [24 L +6 T]

1. Fundaments of Entrepreneurship Development:

Concept and need of Entrepreneurship, Development and Definition of Entrepreneurship, Entrepreneurship, Innovation, Invention, Creativity, Business, Idea, Opportunities, through change, Concept of Entrepreneurship, Manager, Entrepreneur/ cooperate, Entrepreneur-comparative study-Roles, Responsibilities, Career opportunity, Entrepreneurship as a carrier, Entrepreneurship as style of management, The changing role of Entrepreneur: mid career dilemmas, -Closing the window; Sustaining competitive-Maintaining competitive advantages. **[6L]**

2. Theory of Entrepreneurship:

a. Innovation Theory by Schumpeter & Imitating
b. Theory of High Achievement by McClelland
c. X-Efficiency Theory by Leibenstein
d. Theory of profit by Knight
e. Theory of Social change by Everett Hagen [**6L]**

3. Influence of Entrepreneurship devlopment:

a. Entrepreneur Triaits, b. External influence on Entrepreneurship Development: Socio-cultural , political, Economical, Personel, Entrepreneurial culture with special reference to Entrepreneurship, Corporate Entrepreneurship c. Entrepreneurial Success and failure: Reasons and Remedies **[6L]**

4. Business planning process:

The business plan as Entrepreneurial tool, Element of Business plan, Objectives, market Analysis, Development of product /idea, Marketing Finance, Organization & Management, Ownership, Critical risk, contingencies of the proposal, Scheduling and Milestones. [**6L]**

References

1. Entrepreneurship –Robert D Hisrich, Michael P, Peters, Dean A Shepherd
2. Entrepreneurship as strategy –G, Dale Meyer,kurt A. Heppard
3. Project Manegment: K. Nagarajan
4. The Culture of Entrepreneurship-Brigitte Berger
5. Entrepreneurship: New venture Creation –David H Holt

Learning Outcomes: Students will learn

1. Understand aspects of entrepreneurship development
2. Innovation and creativity
3. Development of an idea in marketing and finance
4. Entrepreneurship success and failure

CCPP-3, CHD – 364: Practical-I: Two Stage Preparation [96L + 24T]

At least eight two stage heterocyclic preparations from the following should be carried out. The preparations should be carried out on micro scale

1. Benzaldehyde → Benzalacetophenone → Epoxide
2. 4-Nitro toluene → 4-nitro benzoic acid → 4-Amino benzoic acid
3. Resorcinol → 4-methyl-7-hydroxy coumarin → 4-Methyl-7-acetoxy coumarin
4. Cyclohexanone → Phenyl 53ydrazine→ 1,2,3,4-tetrahydrocarbazole
5. Hydroquinone → Hydroquinone diacetate → 1,2,4-Triacetoxy benzene
6. Acetanilide → p-Acetamidobenzene sulphonyl chloride → P. acetamidobenzene sulphonamide
7. p-Amino phenol → p-acetyl amino phenol → p-Ethoxy acetanilide
8. Cyclohexanol from cyclohexanone (LAH reduction)
9. p-Cresol → p-Cresyl benzoate → 2-Hydroxy-5-methyl benzophenone
10. Phthalimide → N-benzylphthalimide → benzylamine
11. Grignard Reaction
12. Phthalic acid → phthalimide → Anthranilic acid
13. Benzyl cyanide→ p-Nitrobenzyl cyanide→p-Nitro phenyl acetic acid
14. Hydroquinone → Hydroquinone diacetate → 2,5-dihydroxy acetopheneone
15. Cyclohexanone→ Enamine→2-acetyl cyclohexanone
16. α-Pinene→ Disiamyl borane→Pinanol
17. Benzoin ⟶Desylbenzoate ⟶2,4,5-triphenyl Oxazole
18. Phenylacetate ⟶O-Hydroxyacetophenone⟶Chromone -2-carboxylic acid

References

1. Practical organic chemistry by Mann and Saunders
2. Text book of practical organic chemistry –by Vogel
3. The synthesis, identification of organic compounds –Ralph L. Shriner, Christine K.F. Hermann, Terence C. Morrill and David Y. Curtin

Learning Outcomes: Students will

1. Understand different name reactions
2. Learn monitoring of reactions
3. Be able to purify and characterize the reaction products

Semester-IV

CCTP-10, CHD-460: Advanced Medicinal Chemistry [48L + 12T]

SECTION I : [24 L +6 T]

1. Antimicrobial therapy -Development and mechanism of action for Penicillins, Cephalosporins.and Quinolones. An Overview of Aminoglycosides, Macrolides, Tetracyclines, Sulfa drugs. Peptides and polyene antibiotics. **[10L]**
2. Antifungals, Antiviral, Antimalarial, Antimycobacterials **[8L]**
3. Cancer and its Chemotherapy, including developments in Immunotherapy **[6L]**

SECTION II: [24 L +6 T]

1. Cardiovascular system and its disorders: Hypertension, Heart Failure, AnginaPectoris, Arrythmia, Myocardial Infarction, Ischaemic heart diseases, Stroke. Management ofthese disorders with drugs. **[6L]**
2. Central Nervous System, CNS disorders, A study of antidepresants, Anticonvulsants. **[6L]**
3. Pain, Inflammation, Analgesics, anti- inflammatory agents. **[3L]**
4. Endocrine system and Hormonal therapy. **[4L]**
5. Gastrointestinal tract disorders and Drugs. **[3L]**
6. Diabetis and Management of Diabetis. **[2L]**

References

1. Medicinal Chemistry -Burger vols. I to IV (John Wiley)
2. Principles of Medicinal Chemistry- W.Foye.
3. Comprehensive Medicinal Chemistry -C. Hansch (Pregaman Press).
4. Selective Toxicity –A. Albert (Chapman Hall)
5. Principles of Drug action - A. Goldstein.
6. Organic Chemistry of Drug action and Drug design -LB. Silverman (Elsevier)
7. Physiology and Anatomy- Carolla.
8. Medicinal Chemistry-Biochemical approach, Thomas Nogardy.
9. Essential of pharmacology -K. D. Tripathi.
10. Pharmacology-Hanney
11. Pharmacology-Goodman and Gilman.
12.An introduction to medicinal Chemistry Graham Patrick (Oxford)
13. Introduction to the Principles of Drug design and action. IVth Ed. H.John Smith(Taylor and Francis)2010
14. Introduction to Medicinal chemistry Alex Gringauz (Wiley India)
15.Medicinal Chemistry An introduction II nd Edition. Gareth Thomas (Wiley India)2011
16. Wilson and Gisvolds Textbook of Organic, Medicinal and Pharmaceutical Chemistry 12th Ed. John M beale and John H Block 2011 Lippincott Williams and Wilkins

Learning Outcomes: Students will

1. Understand development of various antibiotics.
2. Understand mode of actions of different antibiotics.
3. Study pharmacokinetics and pharmacodynamics of antibiotics
4. Understand the selective toxicity and side effects of various antibiotics.
5. Will understand diseases caused by various pathogens and their treatment.
6. Will biochemical basis of cancer and different approaches to treat cancer.
7. Will study functioning of systems like CNS, CVS, Gastrointestinal system and endocrine system, coordination among these, systemic diseases and their treatment.

CCTP-11, CHD-461: Drug Design [48 L +12 T]

SECTION I: [24 L +6 T]

1. Membrane and Receptors- Structure, functions and the mechanism of drug action (Receptor Response), Clasifications, types of receptors. GPCR & Ion channels Design of agonist and antagonists as drugs. Receptor theories, Models and their types. Receptors and metabolic disorders imp in drug design. **[10L]**
2. Case studies on drug design from Patricks 5th Ed.2013 [**4L]**
3. Physicochemical principles of Drug action- Drug Receptor interactions, Quantitative 4. Description of physicochemical parameters and their calculation. QSAR, Hanschanalysis, COMFA, COMSIA, Free Wilson Method, Topliss manual and batchwise approach. Craig's models. Current trends. [**5L]**
4. Design of Drugs based on pharmacokinetics, Bio activation and metabolism Pro-drug Design. Design of enzyme inhibitors. [**5L]**

SECTION II: [24 L +6 T]

1. Molecular Biology, Genetic engineering and Biotechnology in production of biological as drugs. Antisense therapeutic agents: design and use of siRNA with examples. An overview of Genomics, Metabolomics, pharmacogenomics and Toxicogenomics etc. [**10L]**
2. Combinatorial Chemistry and high throughput Screening. [**5L]**
3. Computers Aided Drug design: Basic concept of Computational chemistry like Quantum Mechanics, Molecular Mechanics, Force fields, Energy minimization, Conformational

search, Molecular dynamics. Ligand based drug design; Receptor based drug design. Analog approach, pharmacophore mapping. Molecular-modeling, Dock, Autodock and Flexidock etc. Virtual Screening. **[8L]**

4. Current trends in the field of drug discovery and design. **[1L]**

References

1. An Introduction to Medicinal Chemistry- 5th Edn. Patrick(Qxford 2013)
2. Medicinal Chemistry Vol. I Burger.
3. Molecular Modeling, Principles and applications -Andrew Leach (Longman) 1998.
4. Comprehensive Medicinal Chemistry vol.4 Corwin Hansch (1990) Pergaman press.
5. Organic Chemistry of drug design and drug action-RB. Silverman 2nd Ed. (2004) Elsevier
6. A Text book of Drug design and development IInd Edn. Povl.Krogsgaard-Larsen Tommy L. and U Madsen (1996) Harwood Acad. Publishers.
7. Medicinal Chemistry An introduction Gareth Thomas 2nd Edition (Wiley India)
8. Introduction to the Principles of Drug design and action. IVth Ed. H.John Smith (Taylor and Francis)2010

Learning Outcomes:

1. Student should understand the various types of receptors and its superfamilies.
2. To understand concept of Receptor theories.
3. Student should able to understand the Receptors and metabolic disorders important in drug design.
4. To know about signal transduction mechanism of various receptors.
5. Student should understand the physicochemical principles of Drug action.
6. Student should able to understand the concept of Quantitative description of physicochemical parameters and their calculation.
7. To know about Pharmacokinetics and Pharmacodynamics of drug action.
8. Student should able to understand the different dosage forms of drugs.
9. To understand concept of Design of Drugs based on pharmacokinetics.
10. Student should understand the concept of Pro-drug design strategy.
11. Student should know the concept of molecular biology.
12. To know about Computers Aided Drug design.
13. To know about Ligand based drug design and Receptor based drug design.

CBOP-4, CHD-462(A): Advanced Synthetic Methods in Chemistry

OR

CHD-462 (B): Supramolecular, Green Chemistry and Forensic Chemistry

CBOP-4, CHD-462(A): Advanced Synthetic Methods in Chemistry [48L + 12T]

Section-I: Designing of Organic Synthesis [24 L +6 T]

1. Protection and de-protection of hydroxyl, amino, carboxyl, ketone and aldehyde functions as illustrated in the synthesis of polypeptide and polynucleotide **[4L]**
2. Enamines in synthesis **[2L]**
3. Umpolung synthons and reagents in organic synthesis **[4L]**
4. Retrosynthesis **[14L]**

Section-II: Transition metal complexes in synthesis [24 L, 6T]

1. Multi-component reactions: Ugi, Passerini, Biginelli and Mannich reactions **[3L]**
2. Ring formation reactions: Pausan-Khand, Bergman and Nazerov cyclization **[2L]**
3. Transition metal complexes in Organic synthesis. Suzuki, Heck, Sonogashira, Stille, **[3L]**
4. Fukuyama, Kumada, Hiyama, Negishi, Buchwald-Hartwig, Noyori, Reppe, Oxo process **[4L]**
5. Organolithium, Aluminium, Phosphorous and Boranes, Synthetic applications **[6L]**

6. Click chemistry: criterion for click reaction, Sharpless azides cycloadditions [**2L]**
7. Biomimetic synthesis [**2L]**
8. Domino Reactions [**2L]**

References

1. Designing Organic synthesis - S Warren (Wiley Interscience)
2. Organic synthesis through disconnection approach- P. S. Kalsi – 2nd edition
3. Some modern methods of Organic synthesis. W Carruthers (Cambridge)
4. Organic Chemistry -Clayden, Greeves, Warren of wothers (Oxford press)
5. Organic synthesis M. B. Smith.
6. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=5 Paper 14: Organic chemistry IV- Advance organic synthesis, supramolecular chemistry and carbocyclic ring
7. Principles of Organometallic Chemistry- G. E. Coates, Green and K Wade
8. Transition Metal Intermediates in Organic synthesis C W Bird, Logos (1967)
9. Organometallics in Organic synthesis- J. M. Swan and DC Black (Chapman Hall)
10. Modem synthetic Reactions- HO House, Benjamin
11. Domino reactions in organic synthesis- L.F. Tietze, G. Brasche, K. m. Gericke

Learning outcome :

1. Use and applications of protecting and deprotecting reagent
2. Applications of enamine and umpolung in synthesis
3. Retro analysis of one and more functional group
4. Synthons, Convergent and divergent synthesis
5. Applications of multicomponent and Cyclic ring formation reactions in synthesis
6. Different name reactions involving transition metal viz. Pd, Ni, Ru, Co, Fe, Cu etc.
7. Organometal applications and uses of Al, Li, P, B
8. Sharpless azide cycloaddition, Domino and biomimetic synthesis

CBOP-4, CHD-462(B): Supramolecular, Green Chemistry and Forensic Chemistry [48L + 12T]

Section-I: Supramolecular, Green Chemistry [24 L +6 T]

1. Supra-molecular Chemistry [12L]

Properties of covalent bond, bond length, inter-bond angles, force constant, bond and molecular dipole moments, molecular and bond polarizability, bond dissociation enthalpy, entropy, Intermolecular forces, hydrophobic effects, Electrostatics, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, force between microscopic bodies, medium effects, hydrogen bond, Principles of molecular association and organization as exemplified by in biological macromolecules like enzymes, nucleic acids, membrane and model systems like micelles and vesicles, molecular receptors and design principles. Cryptands, cyclophanes, calixeranes, cyclodextrins. Supramolecular reactivity and catalysis. Molecular channels and transport processes. Molecular devices and nontechnology.

2. Green chemistry [12L]

1. Atom Economy and Principles of chemistry Green
2. Solvent free reactions
3. Organic synthesis in solid state: Michael addition, Beckmann rearrangement, solid support organic synthesis, synthesis of aziridine, pyridine, chromans and flavones.
4. Aqueous phase Reactions: Diels –Alder reaction, Heck reaction, epoxidation, dihydroxylation [syn & Anti].
5. Microwave Technology: Microwave solvent free reactions- Deacetylation, deprotection, saponification of ester, alkylation of reactive methylene compounds, synthesis of nitrile from aldehyde, reductions.

6. Microwave assisted reaction in water: Hoffmann elimination, hydrolysis, oxidation, saponification reactions
7. Ultrasound assisted reactions: introduction, substitution reactions, addition, oxidation, reduction reactions.
8. Ionic liquids: Introduction and application in organic synthesis.
9. Use of bio-catalyst in organic synthesis.

References

1. Supramolecular Chemistry- Concepts and perspectives by J.M. Lehn
2. Green Chemistry-Theory and practical, By Paul and Anastas and John C. warner.
3. New trends in greenchemistry-by V.K. Ahuwalia and Kidwai
4. Organic synthesis special techniques. by V.K. Ahuwalia and Renu Agrawal
5. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=5 Paper 14: Organic chemistry IV- Advance organic synthesis, supramolecular chemistry and carbocyclic ring

Learning outcome:

1) Concept of supramolecular chemistry
2) Application of supramolecular chemistry in drug synthesis
3) Concept of green chemistry, various green synthetic strategies
4) Use of microwave and ultrasound techniques in synthetic chemistry

Section-II: Forensic Chemistry [24 L +6 T]

1. General Drugs, Other Chemicals [8L]

Introduction, Pharma drugs [barbiturates, benzodiazepine &other pharma drugs],

Drug abuse in sports & Date rape drugs: Introduction, common prohibited substances, analytical approach, Forensic Pharmacological studies, Ingestion of drugs, absorption, distribution, metabolism, pathways of drug metabolism, drug metabolism and drug toxicity, excretion of drugs, detection of drugs on the basis of their Metabolic studies.

Solvent Abuse [chlorinated hydrocarbons, Aromatic hydrocarbons, alcohols, glycols, fuel and fuel additives]: absorption, distribution, and metabolism, psychological & clinical effects.

Analysis: collection of samples, distillation & extraction, Analysis by GC, HPLC.

2. **Narcotic Drugs and Psychotropic Substances [6L]**

Introduction to narcotic drugs, Analysis of Narcotic Drugs and Psychotropic Substances, Classification of Narcotics and other drugs, Analytical techniques for identification of drugs. Characterization and synthesis of 1) Narcotics- heroin and cocaine. 2) Stimulants- caffeine, amphetamines. 3) Depressants- Barbiturates, Benzodiazepinesanalysis of NDPS evidence by various procedures prescribed by U.N. Manual, DFS manual, spot tests, microcrystal tests, extraction methods, TLC, UV-Vis spectrophotometry, IR spectrophotometry, GC-HPLC, MS, GC-MS, NMR and XRD as exemplified by cocaine, cannabis, amphetamines, opiates and hallucinogens (LSD, psilocybine and mescaline), evidence handling & sampling techniques, clandestine laboratory investigation and designer drugs.

3. Fingerprinting & Other Impressions [10L]

Fingerprint: Nature, Location, Classification, Types, Patterns of Fingerprints, Poroscopy & Edgeoscopy, Classification of Fingerprints: Henry's Classification, Single Digit Classification, Extended Henry's System, Types of Fingerprints [Latent, Patent and Plastic], Invisible Fingermarks development methods [Powder methods, Fuming methods, Chemical Methods, etc.] Recent techniques [Digital Imaging & Enhancement, Laser & other radiation-based techniques, Preservation and photography of fingerprints on various surfaces. Ridge counting, Ridge tracing, Minutiae Identification & Matching [Manual and Automated: AFIS].

Palm Prints: Nature, Location, Types, Classification, Development, Lifting, Evaluation, Analysis, Forensic Significance. Footprints: Importance, Gait pattern analysis, Evaluation and analysis of various casts.Electrostatic lifting of latent footprints and comparison with reference sample. Tyre marks / prints and skid marks and comparison with control samples.

Cheiloscopy: Nature, location, collection and evaluation of lip print. Ear prints: Introduction, growth & development, evaluation and analysis of ear print.

Refrences:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=16 Paper 03: Fingerprint and other impression
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=16 Paper 09: Drug of Abuse
3. Krishnamurthy, R., Introduction to Forensic Science in Crime Investigation, 2011, Selective & Scientific Books, New Delhi.
4. Clark, E.G.C.; Isolation and Identification of Drugs, Vol. I and Vol. II, Academic Press, (1986).
5. Moenssens: Finger Prints Techniques, 1975, Chitton Book Co., Philadelphia, New York.
6. Mehta, M. K. : Identification of Thumb Impression & Cross Examination of Finger Prints, 1980 N. M. Tripathi (P) Ltd. Bombay.
7. Cummins & Midlo : Finger Prints, Palms and Soles, 1943, The Blakiston office London
8. Sharma B. R. : Footprints, Tracks and Trials. 1980. Central Law Agency. Allahabad
9. Iannarelli, A V; Ear Identification, Forensic Identification series, Paramount (1989)
10. Saxena's : Saxena's Law & Techniques Relating to Finger Prints, Foot Prints & Detection of Forgery, Central Law Agency, Allahabd (Ed. A.K. Singla).
11. Menzel, E Roland; Fingerprint detection with lasers, Marcel Dekker, NY (1999)

Learning Outcomes:

1. Identification of Type of Drug
2. Expertise in handling UV, IR, GC and HPLC
3. Interpretation of data and comparative study with literature
4. Crime investigation of drug abuse
5. Methods of development of fingerprint
6. Role of Fingerprinting in investigation

CBOP-5, CHD-463: Practical III

Select any two Sections from sections I to IV [96L + 24T]

Section-I: Microbiology, Biochemistry
Section-II: Practical on Forensic Chemistry
Section-III: Ternary Mixture Separation
Section-IV: Project/ Industrial Training

CHD- 463 Section-I: Microbiology and Biochemistry [48 L + 12T]

1. Microbiology - Differentiation, Gram staining Morphology, Protoplast fusion, Screening of bacterial substances, sterility testing. Microbial assays, Production of penicillin by fermentation, Immunology practicals
2. Biochemistry- Isolation, purification and characterisation of Enzymes, stability studies,Kinetics determination of Km, Vmax, 1-50, Inhibition studies, reversible, irreversible and KCat. Electrophoresis, Isolation and estimation of DNA, DNA-drug interaction studies, Determination of drug in blood and urine.

References

1. Practical Organic Chemistry, Al. Vogel (ELBS).
2. Pharmacological Basis of Therapeutics (Pergman press, New York) Goodman and Gilman.

3. Evaluation of Drug Activities- Pharmacometrics, Lawrence D. R. Bacharach AL. (Academic press London)
4. Screening Methods in Pharmacology, Turner R..A (Academic press London).
5. Physiological Chemistry, Hawk.
6. Clinical Biochemistry, Vol I and II Varley.
7. Fundamentals of Experimental Pharmacology, Ghosh M.N.(Scientific Book Agency, Calcutta)
8. Practical Biochemistry Plummer
9. Practical Microbiology. :
10. Practical Biochemistry, Jayaraman.

Learning Outcomes: Students will

1. Understand the various microbial and biochemical techniques
2. Study drug – DNA interactions
3. Learn Synthesis, characterization and purification of drug molecules
4. Learn analysis of biological matrices

CHD- 463 Section-II: Practicals on Forensic Chemistry [48 L + 12T]

(Six practical's to be perform based on instrumentation.)

1. Systematic identification of Narcotic Drugs and Psychotropic substances (opiates, cannabis, barbiturates, benzodiazepines and amphetamines) by spot colour tests. TLC, UV, IR, GC and HPLC. (min. 2 Nos.)
2. Systematic extraction and identification of acidic and basic drugs from viscera (simulated sample) by wet test & GC. (min. 2 Nos)
3. Detection of pesticides and insecticides from blood
4. Systematic analysis of cosmetic products as per IPC specification by using HPLC
5. Systematic analysis of cosmetic products as per IPC specification by using GC

References for Forensic Practicals

1.Practical Organic Chemistry; J.B. COHEN
2. Spot test in Organic Chemistry; Feigl
3. Practical Organic chemistry; Vogel
4. Quantitative Inorganic Analysis; Vogel
5. The Merck index; Stetchar & others
6. Inorganic Semi micro qualitative analysis; Griffin & Plunky
7. Peerson's Chem. Analysis of food; H.Egan, Kirk
8. Clerk's Analysis of Drugs & Poisons VOL.-I & II; Clerke
9. Development & Validation of Analytical Methods; Christopher, M.Riley, Thomas W
10.Steroid analysis by HPLC; Marie P. Kautsky
11. TLC VOL.-II; Jork, Funk & Others

Learning Outcomes: Students will

1. Expertise in handling UV, IR, GC and HPLC
2. Blood sample pesticide and insecticide detection.
3. Interpretation of data and comparative study with literature

CHD- 463 Section-III: Ternary Mixture Separations [48 L + 12T]

Separation of at least Eight mixtures containing three components. The mixtures should also involve separation of nitro phenols, amino acids, low boiling substances, water soluble substances. Amines, Phenols and acids used should also contain other elements and functional groups. The mixture separation should be carried out on micro-scale using ether.

Learning Outcomes: Student will

1. Determine the type
2. Separation of mixture using ether
3. Microscale workup

CHD – 463 Section-IV: Project / Industrial Training [48L + 12T]

Students should carry out a small research project. This should make them familiar with literature survey, research methodologies, Identification of products by analytical and spectral methods and familiarity with chromatographic techniques. Project report must be written and submitted in format.

1. Students should carry out a small research project separately.
2. This should make them familiar with
   i. Literature survey, research methodologies
   ii. Data Analysis
   iii. Column and TLC chromatographic techniques
   iv. Characterization of the products by analytical and spectral methods.
3. **Project report must be written and submitted in a proper format as follows;**
   i. Certificate (Signed by Project guide and Head of the Department)
   ii. Certificates for Poster/Paper presented in conferences (if any)
   iii. Self declaration certificate for plagiarism
   iv. Introduction (not more than 6 pages)
   v. Results and Discussions
   vi. Experimental Section
   vii. Conclusion
   viii. References (Use ACS format)
   ix. Spectroscopic or other relevant supporting data
   x. Acknowledgement
4. Interdisciplinary projects shall be encouraged; however there **must be some chemistry component**.
5. Students should spend enough time for the project works (**more than** 4 hours per week for **15 weeks**)
6. At least 30% students should undertake projects/summer training/Internships etc.
7. If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. ***Systematic record of attendance of project students must be maintained by a mentor.*** Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.

Learning Outcomes; Students will

1. Learn Referencing
2. know about various scientific databases
3. understand applications of various characterization techniques
4. learn how to write project report
5. learn presentation skills

CCPP-4 CHD – 464, Practical II: Synthesis of Heterocycles and Drug Molecules [96L + 24T]

At least fourteen preparations should be carried out on micro scale.

1. 2-Phenyl indole (Fischer indole synthesis),
2. 7-Hydroxy -3-methyl flavone (Baker-Venkatraman reaction),
3. 7-Hydroxy-4-methyl coumarin (Pechmann Reaction)
4. Acridone
5. Triphenyl or diphenyl methyl carbinol (Grignard reaction)

6. Benzotriazole
7. 1-Phenyl-3-methyl pyrazol-5-one
8. O-nitroaniline ⟶O-phenylene diamine ⟶Benzimidazole
9. 2,4-diethoxycarbonyl-3,4-dimethyl pyrrole from ethyl acetoacetate
10. Quinoline from aniline Skraup synthesis)
11. Benzimidazole from benzyl
12. Glycine⟶2,5-dioxopiperazine
13. 3,5-diacetyl-1,4-dihydro2,6-trimethylpyridine
14. Hippuric acid ⟶Azalactone⟶4-benzylidene 2-phenyl oxazol-5-one
15. Benzocaine
16. Antipyrine
17. Paracetamol
18. Aspirin
19. Ibuprofen
20. Barbiturate

References:

1. Practical Organic Chemistry, Al. Vogel (ELBS).
2. Microscale and Macro scale Preparations Williamson and Williamson.
3. Practical Heterocylic Chemistry, Fitton and Smalley (AP)
4. Organic Synthesis Collective Volumes, Vol I to VIII
5. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Aggarwal
6. Practical Chemistry, Fitton and Smalley

Learning Outcomes: Students will

1. Learn different syntheses of heterocycles
2. Use of various synthetic strategies in drug synthesis

5. M. Sc. (II) Analytical Chemistry

To be Implemented form Academic Year 2020-21

Sr. No.	Paper No. & Code	Course Name	Credit
		Semester - III	
1	**CCTP-7 CHA-390**	Electrochemical and Thermogravimetric Methods of chemical analysis	4
2	**CCTP-8 CHA-391**	Analytical Method Development and Extraction Techniques	4
3	**CCTP-9 CHA-392**	Advanced Chromatographic Methods of Chemical Analysis	4
4	**CBOP-3 Theory CHA-393**	CBOP-3, CHA-393-A: Bioanalytical Chemistry **Or** CBOP-3, CHA-393-B: Analysis of Food and Controlled Substances	4
5	**CCPP-3 CHA-394**	**Practical I:** Basics of Instrumental Methods of Chemical Analysis	4
		Semester-IV	
6	**CCTP-10 CHA-490**	Advanced Analytical Spectroscopic Techniques	4
7	**CCTP-11 CHA-491**	Chemical Methods of Pharmaceuticals Analysis	4
8	**CBOP-4 Theory CHA-492**	CBOP-4, CHA-492-A: Laboratory Automation and Environmental Analytical Chemistry **Or** CBOP-4, CHA-492-B: Analytical Chemistry of agriculture, polymer and Detergents	4
9	**CBOP-5 Practical CHA-493**	**Practical III:** CBOP-5, CHA-493-A: Optional Analytical Chemistry Practical **OR** CBOP-5, CHA-494-B: Project	4
10	**CCPP-4 CHA-494**	**Practical II**: Applied Analytical Chemistry Practical	4

Equivalence to Previous Syllabus

Old Paper (2014 pattern)	New syllabus (2020)
Semester - III	
CHA-390	CCTP-7, CHA-390
CHA-380	CCTP-8, CHA-391
CHA-391	CCTP-11, CHA-491
CHA-392	CBOP-4, CHA-492 (A)
CHA-387-Practical	CCPP-4, Practical, CHA-394
Semester - IV	
CHA-490	CCTP-10, CHA-490
CHA-491	CBOP-4(B), CHA-492 (B)
CHA-492	CBOP-4, CHA-492(A)
CHA-481	CBOP-3(A), CHA-393(A)
CHA-487, Practical	CCPP-4, Practical, CHA-494
CHA-488, Practical / Project	CBOP-5, CHA-493: A) Practical / B) Project

Detailed of Syllabus: Semester and Paper Wise

Semester-III

CCTP-7, CHA-390: Electrochemical and Thermogravimetric Methods of Chemical Analysis [48L + 12T]

Section-I: Electroanalytical Techniques **[24 L +6 T]**

1. Coulometry [6 L]

Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, constant current electrolysis, Electrolysis at constant working electrode potential, Coulometric methods of analysis, Faradays laws of electrolysis, Instrumentations-Constant current and constant voltage instruments, potentiation coulometry-Instrumentation and applications, coulometric titrations - apparatus and applications, problems.***(Ref.-1****:696-712, Ref-2: relevant pages)*

2.Voltammetry and Polarographic Methods of Analysis. [18 L]

a) Polarography (linear scanpolarography): Polarographic principles, Instrumentation (different types of microelectrode such as dropping mercury electrode, the static drop mercury electrode, rotating disc and ring disc electrode, cell for polarography, reference and counter electrode and circuit diagram), polarogram and polarographic currents, charging or capacitive current, role of supporting electrolyte, factors affecting on polarographic wave, Ilkovic Equation, advantages and disadvantages of DME, polarographic maxima and maxima suppresors, interference due to dissolved oxygen, Applications (qualitative analysis, quantitative analysis by calibration curve and standard addition methods), specific examples of analysis – analysis of Cu, Cd, Zn, Pb, etc. from tap water and alloys., problems.***(Ref-1:*** *716-723, Ref-2, Supplementary Ref. 3 and 4)*

b) Hydrodynamic Voltametry: Hydrodynamic voltametry and applications of hydrodynamic voltametry (volatameric detectors in chromatography and flow injection analysis, Voltametric oxygen sensors, amperometric titration. ***(Ref-1:*** *723-735)*

c) Cyclic Voltametry: Principle of cyclic Voltammetry, cyclic voltamogram of $K_3[Fe(CN)_6]$ and parathion (*Fundamental studies*), determination of analytes using CV, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes(***Ref-1****:735-742 Ref-2: Relevant pages, Supplementary* ***Ref.-5****: 27-68)*

d) Pulse Polarography: different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, and Stripping method. Voltammetry with ultra-microelectrode, Applications of these techniques Cu and Zn from tap water by differential pulse polarography and by square wave polarography, Vitamin-C by differential pulse polarography, Determination of Pb in tap water by stripping method. (***Ref-1: 742-753*** *2, Supplementary Ref. 3 and 4)*

References

1. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.
2. Vogel's Text Book of quantitative analysis 6th Ed.
3. Introduction to Instrumental Analysis by R. D. Braun, Pharmamed Press.
4. Analytical Chemistry, A Modern Approach to Analytical Science, Ed. by R. Kellner, J. M. Mermet, O. Otto, M. Valcarcel, H. M. Widmer, Second Ed. Wiley –VCH

5. Cyclic Voltammetery, Simultaneous Analysis and Reaction Mechanism, David K Gosser, VCH, 1994.

Section-II: Thermal Methods of Analysis [24 L +6 T]

1. Introduction to Thermal Methods [2 L]

Introduction, Historical development, Definitions: *Thermal analysis, Equilibrium -A Kinetic Diversion, General apparatus,* Factors affecting thermal analysis results, *The sample, The crucible, The rate of heating, The atmosphere, The mass of the sample,* Simultaneous and complementary techniques ***(Ref-1:** 1-21)*

2. Thermogravimetry [5 L]

Introduction, Historical, Definition ofthermogravimetry, Apparatus, *The balance, Furnace, Programmer, Samples, Temperature calibration, Atmosphere, Kinetics of reactions,* Kinetics of Reactions, *Measurement of α and dα/dt, Constant rate methods,* Thermogravimetric curves: *Decomposition Of Magnesium Hydroxide,Calcium oxalate monohydrate, Copper sulphate pentahydrate, Degradation of polymers,* Analysis of mixtures: *mixtures of alkaline earth oxalates, polymer blends, soils,* Oxidation studies, Reduction studies, Controlled rate thermogravimetry and Hi-Res ™ TGA, *Polymer blends, Drugs. **(Ref-1:**22 to 62)*

3. Differential Thermal Analysis and Differential Scanning Calorimetry [7 L]

Introduction, Historical, Definitions: *Differential thermal analysis (DTA), Differential scanning calorimetry (DSC),* Apparatus: *The sensors, The furnace and controller, The computer and display, The reference material,* Theory of DT A and DSC, Heat flux DSC, Power-compensated DSC, *The effect of higher temperatures, Sample size,* Calibration, Applications: *Physical changes and measurements (crystalline phase transitions, potassium nitrate, liquid crystalline transitions, thermoplastic polymer phase changes, heat capacity measurements, glass transition temperatures), Chemical reactions, Inorganic compounds and complexes (calcium oxalate monohydrate, metal complexes, high alumina cements, clays and other minerals), Organic compounds (oxidative degradation, protein denaturation, polymer degradation). **(Ref-1:** 63-113)*

4. Thermomechanical and Dynamic Mechanical Analysis [4 L]

Introduction, Definitions: *Thermomechanical analysis, Dynamic mechanical analysis, Mechanical moduli,* Thermomechanical analysis: *Apparatus (probes, calibration),*Applications:*coefficients of expansion, solvent swelling of polymers, phase transitions, sintering), Chemical reactions (inorganic hydrates, polymer cure),* Dynamic Mechanical Analysis: *Apparatus* (DMA configurations, calibration) Applications: *glass transition temperatures,beta and other transitions, relaxation kinetics, polymer miscibility, characterising cross-linking, studying 'problem samples, characterising film formation **(Ref-1:** 123-151)*

5. Simultaneous Techniques and Product Analysis [4 L]

Introduction, Simultaneous Thermal Analysis: *Simultaneous TG-DTA and TG-DSC applications, (sodium tungstate dihydrate, fire-retarded wood, poly(vinyl chloride), pharmaceuticals, reactive atmosphere effects,* Evolved gas analysis, Instrumentation: Apparatus, Detection and identification of evolved gases: *Physical methods,* Chemical

methods, Spectroscopic methods (mass spectrometry (MS) and simultaneous TG-MS, calcium oxalate monohydrate, poly (ethylene oxide), brick clays), Infrared and simultaneous TA-infrared, *Apparatus, Applications, Gas chromatography and pyrolysis GC-FTIR.**(Ref-1:** 163-184)*

6. Problem Solving and Applications of Thermal Methods [2 L]

Introduction, List of examples, Problems: *Inorganic materials, Polymeric materials, Fine chemicals andpharmaceuticals, Other materials,* Solutions to problems.

(Ref-1: *206-270)*

(This topic is for student's self-preparation)

References

1. Thermal Methods of analysis, principles, applications and problems, P. J. Haines, Springer-Science Business Media B.V. 1st Ed.
2. Principles of Thermal Analysis and Calorimetry, P. J. Haines, Royal Society of Chemistry
3. Principles and Applications of Thermal Analysis, Paul Gabbott, Blackwell Publishing Ltd. (2008).
4. Thermal Analysis in Practice, Fundamental Aspects, Matthias Wagner, Hanser Publications, 2018.

Learning Objective: At the end of course, students should able to-

1. Define various terms in electrochemistry and thermogravimetry.
2. Explain instrumentation in electrochemistry and thermogravimetry.
3. describe basic principles of electrochemistry and thermogravimetry.
4. Explain /Describe applications of electrochemistry and thermogravimetry in industry and in analytical laboratory.
5. Apply / select particular method of analysis for sample to be analysed.
6. Solve numerical problems on electrochemistry and thermogravimetry.
7. Interpret polarogram, cyclic voltammogram, pulse polarogram, thermogram, differential thermogram and DSC thermogram.
8. Differentiate among the various methods of electrochemistry and thermogravimetry.

CCTP-8, CHA-391: Analytical Method Development and Extraction Techniques [48L + 12T]

Sec-I: Analytical Extraction Techniques [24 L +6 T]

1. Assay Validation and Inter Laboratory Transfer [2 L]

Introduction, fundamental definitions, Essential principles of method transfer, method validation report, the interlaboratory qualification (ILQ) process. *(**Ref-1:**pp 3 to 14)*

2. Statistical Analysis and analytical Figure of Merit [14 L]

Introduction, Errors (gross errors, systematic errors, random errors), accuracy, validation parameters: Accuracy, precision, mean and standard deviation, calibration, (linear response functions (linear regression-errors in slope and the intercept, error in the estimate of concentration, standard additions), non-linear response functions and weighted

regression analysis, internal standards), selectivity and specificity (chromatographic methods), limits of detections (spectrophotometric methods, chromatographic methods and related techniques, receptor binding assay), limit of quantification, sensitivity, ruggedness and robustness, analyte stability in the sample matrix, how to reduce systematic errors, mean and standard deviation, reliability of results, confidence interval, comparison of results, comparison of two means of two samples, experimental design.***(Ref-1:****15 to 68, Ref-2, p145-197)*

3. Overview of World Wide Regulations (2 L), ***Ref-1:*** *75 to 98)*

4. Specific methods and Applications: Dissolution Studies [4 L]

Introduction, Dissolution test, Apparatus – USP type –I and II, Sampling and analytical instrumentation, Single point test Vs. Dissolution profile, Calibration, regulatory guidelines, analytical validation, linearity, accuracy, precision, specificity.***(Ref-1:*** *169 to 182)*

5. Specific Examples [2 L]

Explain these method w.r.t. method development and validation of specified analyte from the research papers.(***Ref****-4 to 7****)***

References

1. Development and validiation of Analytical Methods, Progress Pharmaceutical and Biomedical Analysis, Vol-3, Edited by Chitofer M. Riley and Tomas W. Rosanske (Elvier).
2. Vogel's Textbook of quantitative Chemical Analysis, Sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.
3. Development and validation of a colorimetric method for the quantitative analysis of thioamide derivatives, R.B. Ali et al., Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 220 (2019) 117154.
4. HPLC Method Development and Validation for Formaldehyde in Enteric Coating of ard Gelatine Capsules, Journal of Liquid Chromatography, 18(13), 2683-2693 (1995).
5. Development and Validation of Stability Indicating Rp-HPLC Method for Analysis Of Lercanidipine In Bulk Drug And Microemulsion Formulation, Journal of Liquid Chromatography & Related Technologies, 36:143–154, 2013.
6. Development and validation of an LC-MS/MS method for simultaneous quantification of voriconazole and its main metabolite voriconazole N-oxide in human plasma and its clinical application, Journal of Liquid Chromatography & Related Technologies, 40:20, 1047-1053.
7. Development and validation of the spectrophotometric method of butaphosphan determination in veterinary preparations, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 233 (2020) 118171.

Section-II: Analytical Extraction Techniques [24 L +6 T]

1. Pre and Post Extraction Consideration [1 L]

Organic compounds of interest, pre-sampling issues, sampling strategies-solid, aqueous and air samples, chromatographic method of analysis, sample preconcentration methods. ***(Ref-1:*** *1-29)*

2. Classical Approach for Aqueous Extraction [6 L]

Introduction, Liquid-Liquid extraction (LLE), Theory of LLE: distribution ratio and coefficient, solute remaining unextracted, percent extraction, separation factor, factors favouring solvent extraction, quantitative treatment to solvent extraction equilibria, synergic extraction, extraction reagents for metals, selection of solvents, solvent extraction,

problems with LLE process), purge and trap for volatile organics in aqueous samples, Examples of Solvent Extraction- estimation individual metal ions Be, B, Cu, Fe and Pb by solvent extraction. Problems. ***(Ref-2:** relevant pages and **Ref.-1:** 39-45)*

3. Solid Phase extraction (SPE) [6 L]

Introduction, Types of SPE media, SPE formats and apparatus, method for SPE operation, solvent selection, factors affecting SPE, selected methods of analysis for SPE: *application of normal phase SPE, application of reversed phase SPE, application of ion exchange SPE, applications of molecularly impaired polymers,* Automation and On-Line SPE and its applications. ***(Ref-1**: 49-78)*

4. Solid phase micro-extraction [6 L]

Introduction, theoretical considerations, experimental, Methods of analysis: SPME-GC: *direct immersion SPME, headspace SPME, analysis of compounds from solid matrix, other SPME-GC application.* Methods of analysis: SPME-HPLC-MS: *analysis of abitic dehydroabietic acid in food samples, analysis of fungicide in water.* Automation of SPME and its application, New development in micro extraction (Introduction, stirbas sorptive extraction, liquid phase micro-extraction, , membrane micro extraction, micro extraction in packed syringe).***(Ref-1:** 85-110, Ref-3)*

5. Solid -Liquid Extraction, Microwave extraction [6 L]

Classical Approach: Introduction, Soxhlet extraction, Automated Soxhlet extraction, other approaches, **Pressurized Fluid Extraction:** Introduction, theoretical consideration, Instrumentation for PFE, method development and applications. **Microwave assisted extraction:** Introduction, instrumentation, Applications***(Ref-1:** 125-174)*

References

1. Extraction Techniques in Analytical Science, John R. Dean, Wiley
2. Vogel's Textbook of quantitative Chemical Analysis, sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.
3. Solid Phase Microextraction, A Practical Guide, Edited by Sue Ann Scheppers Wercinski, CRC press, Taylor and Francis.

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in analytical extraction and method development and validation.
2. Explain instrumentations and methodology in analytical extraction.
3. Explain / describe basic principles of analytical extraction method development and validation.
4. Explain /Describe applications analytical extraction and method development and validation in industry and in analytical laboratory.
5. Apply / select particular method of analysis for sample to be analysed.
6. Solve numerical problems on analytical extraction and method development and validation.
7. Develop analytical method for analysis of given sample. Apply statistical treatment to the analytical data. Select appropriate parameters for the development of analytical method
8. Differentiate among the methods of analytical extraction.

CCTP-9, CHA-392: Advanced Chromatographic Methods of Analysis

[48L + 12T]

Section-I: Mass spectrometry and Gas Chromatography [24 L +6 T]

1. Mass Spectrometry [6 L]

Fundamentals, Electron ionization, Chemical ionization, Instrumentation:*Quadrupole mass spectrometers, Magnetic sector mass spectrometers, TOF mass analyser, detector;*Interpretation of mass spectra, Types of ions Isotopic abundances and characteristic ion clusters, Nitrogen rule and rings-plus-double-bonds, steps in interpretation, Examples***(Ref-1:** *39-72, Supplementary Ref.- 4)*

2. Fundamentals of Chromatographic Methods of Analysis [4 L]

Fundamentals of Chromatographic Separation (overview, the development of chromatogram), Characteristics value in chromatogram, Chromatographic theories (plate theory, kinetic theory), R_s as measure of peak separation, qualitative and quantitative analysis. Problems.***(Ref-2,*** *Supplementary Ref-1, 6)*

3. Gas Chromatography [4 L]

Retention data and partition coefficient, separation in the gas phase, Components of gas chromatography:*Carrier gas, sample injection, split injection, spitless injection, cold on column injection, programmable temperature vaporization, head space injection, solvent effects, column, detectors- TCD, FID, ECD,* Stationary phases for GC: *stationary phases for packed column, capillary column, deactivation of surface, different stationary phases*, Applications of GC**,** Problem on quantitative analysis.***(Ref.-2,*** *Supplementary Ref-1, 6)*

4. Gas Chromatography-Mass Spectrometry [8 L]

Vacuum and gas flow, Basic principles, Analysis of vacuum and gas flow, Interfaces, Computerization, Computerized operation, Characteristics, Data analysis, Reconstructed gas chromatogram, Mass chromatogram, Selected ion monitoring, Background subtraction, Biller-Biemann stripping technique, Compound identification using reference spectra matching, Mass spectral compilations, Methods of computerized mass spectral search, Commercial mass spectral computer search systems, Quantitative analysis by selected ion monitoring, Choice of ions: basic considerations, Magnetic sector versus quadrupole analysers, Identification and quantitation procedures, Use of isotopically labelled standards, Precision, accuracy and limit of detection, Automated GC-MS operation, Automated data acquisition, Automated data analysis.***(Ref-1:*** *79-134)*

5. Applications of GC and GC-MS [2 L]

1. Quantitative analysis by GLC-different methods, Elemental Analysis using Gas Chromatography, analysis of Al, analysis of a mixture using the interna1 normalisation method, determination of sucrose as its trimethylsilyl derivative using gas-liquid chromatography, ***Ref-4***
2. Phenols in waste water by LLE-GC method *(sec-6420 phenols),* Organochlorine pesticides in water: LLEGC method-1, LLEGC method-2 *(sec-6630 organochlorine pesticides),* volatile organic compounds – Purge and trap capillary column GC-MS method *(Sec-6200-A,B,C),* Tributyl tin by GC-MS and FID method *(Sec-6710-A,B,C)* ***Ref- 5***

References

1. Basic Gas Chromatography Mass Spectrometry, Principles and Techniques, F.W. Karasekand R.E. Clement, Elsevier, (Elsevier Science B.V.) 1988
2. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VCH
4. Vogels's, Textbook of Quantitative Chemical Analysis 6th Ed.
5. Standard methods for the examination of water and waste wter, 23rd Ed. Rodger Baird, Andrew Eatson, Eugene Rice, jointly published by: Americal Public Health Association, Americal Water Works Association, Water Environment Fedearation,
6. Forensic applications of Gas Chromatography by Michelle Carlin and John Dean, CRC press, 2013)

Section-II: Liquid Chromatography [24 L +6 T]

1. Instrumentation of HPLC [4 L]

Introduction: *HPLC-A powerful separation method, A first HPLC experiment, Liquid chromatographic separation modes, The HPLC instrument*,Pumps: General requirements, The short-stroke piston pump, Preparation of Equipment up to Sample Injection:*Selection of the mobile phase, Preparation of the mobile phase, Gradient systems, Sample injectors, Sample solution and sample volume;* Solvent Properties: *Table of organic solvents, Solvent selectivity, Miscibility, Buffers, Shelf life of mobile phases, The mixing cross;Detectors: General, UV detectors, Refractive index detectors, Fluorescence detectors, Electrochemical (amperometric) detectors, Light-scattering detectors, Multiple detection*; Columns and Stationary Phases: *Columns for HPLC, Precolumn, General properties of stationary phases, Silica, Chemically modified silica, Styrene-divinylbenzene, Column care and regeneration(**Ref-2:** 1-9, 59-136, Ref-1)*

2. HPLC Methods [6 L]

a) Adsorption Chromatography: Normal-Phase Chromatography: What is adsorption?, The eluotropic series, Selectivity properties of the mobile phase,Choice and optimization of the mobile phase, Applications*(**Ref.-2:** 159-168, Ref-1)*

b) Reversed-Phase Chromatography: Principle, Mobile phases in reversed-phase chromatography, Solvent selectivity and strength, Stationary phases, Method development in reversed-phase chromatography, Applications, Hydrophobic interaction chromatography. ***(Ref.-2:** 173-191, Ref-1)*

c) Chromatography with Chemically Bonded Phases: Introduction, Properties of some stationary phases, Hydrophilic interaction chromatography, ***(Ref.-2:** 195-200, Ref-1)*

d) Ion-Exchange Chromatography: Introduction, Principle, Properties of ion exchangers, Influence of the mobile phase, Special possibilities of ion exchange, Practical hints, Applications ***(Ref.-2:** 203-213, Ref-1)*

e) Ion-Pair Chromatography: Introduction, Ion-pair chromatography in practice, Applications ***(Ref.-2:** 217-221, Ref-1)*

f) Ion Chromatography: Principle, Suppression techniques, Phase systems, Applications ***(Ref.-2:** 225-230, Ref-1)*

g) Size-Exclusion Chromatography: Principle, The calibration chromatogram, Molecular mass determination by means of size-exclusion chromatography, Coupled size-exclusion columns, Phase systems, Applications. ***(Ref.-2:*** *231-244, Ref-1)*

h) Affinity Chromatography: Principle, Affinity chromatography as a special case of HPLC, Applications. ***(Ref.-2:*** *249-252)*

3. Analytical HPLC [2 L]

Qualitative analysis, Trace analysis, Quantitative analysis, Recovery, Peak-height and peak-area determination for quantitative analysis, Integration errors, The detection wavelength, Derivatization, Unexpected peaks: Ghost and system peaks. ***(Ref.-2:*** *285-308)*

4. Separation of Enantiomers [2 L]

Introduction, Chiral mobile phases, Chiral liquid stationary phases, Chiral solid stationary phases, Indirect separation of enantiomers. ***(Ref.-2:*** *333-345)*

5. Mass Spectrometry, LCMS Interface and applications [8 L]

Interface Technology: Introduction, Thermo-spray interface, The electron spray interface (mechanism of electron-spray ionization, sample types, the electro-spray spectrum, structural information from electrospray ionization), atmospheric pressure chemical ionization interface and the mechanism of atmospheric pressure chemical ionization. Data acquisition (identification, quantitation-selected ion monitoring), Processing of mass spectra (total ion current trace, qualitative analysis, quantitative analysis). **Applications:** Molecular weight determination of small molecules (Method Development for Structural Studies, The Use of Target-Compound Analysis and LC–MS–MS for the Identification of Drug Metabolites, The Use of High-Accuracy Mass Measurements in Combination with LC–MS for the Structure Determination of Drug Metabolites, The Use of Cone-Voltage Fragmentation in Conjunction with High-Accuracy Mass Measurements and LC–MS for Metabolite Identification, The Use of LC–MS^n for the Identification of Drug Metabolites),Quantitation (requirements, quantitative standardization, matrix effect in LC-MS, the method of standard addition to overcome matrix effect).***(Ref-3:*** *75, 94-123, 189-218****)***

Chapter-6: Super Critical Fluid Chromatography and Extraction [2 L]

Properties of supercritical fluid, Supercritical fluid chromatography: *Instrumentation and operating variables, effect of pressure, stationary phases, mobile phases, detectors, comparison with other types of chromatography, Applications,* supercritical fluid extraction: *Advantages of SFE, instrumentation, of line and on line extraction, applications.****(Ref-4:*** *856-865,supplementary Ref-1)*

1. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VCH
2. Practical High-Performance Liquid Chromatography, Veronika R. Meyer, Fifth Ed. John Wiley and Sons, Ltd.
3. Liquid Chromatography Mass Spectrometry: An Introduction by Bob Ardery, Publisher: Wiley India Pvt. Ltd. (2003). A book from series- Analytical techniques in the Science.
4. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in chromatography (GC and HPLC) and mass spectroscopy.
2. Explain instrumentations in chromatography (GC and HPLC) and mass spectroscopy.
3. Explain / describe i) basic principles of chromatography (GC and HPLC) and mass spectroscopy. ii) separation in GC / HPLC column. iii) Functioning and construction of GC / HPLC/ MS detectors.
4. Explain /Describe applications chromatography (GC and HPLC) in industry and in analytical laboratory.
5. Apply / select particular method / instrumental parameters for analysis for sample GC / HPLC.
6. Solve numerical problems on chromatography (GC and HPLC) and mass spectroscopy.
7. Integrate GC and HPLC chromatogram, Mass spectrum
8. Differentiate among the chromatography (GC and HPLC) methods of analysis.

CBOP-3, CHA-393: A) Bioanalytical Chemistry OR B) Analysis of Food and Controlled Substances

CBOP-3, CHA-393: A) Bioanalytical Chemistry [48L + 12T]

Section-I: Bioanalytical Techniques [24 L +6 T]

1. Introduction to Electrophoresis [6L]

General introduction to Electrophoresis: *Introduction and applications of electrophoresis*; Types of electrophoretic systems: *Moving boundary electrophoresis, Zone electrophoresis, Steady state electrophoresis;* Support media in Zone electrophoresis: *filter paper, cellulose acetate, gel media*; Factors Affecting Electrophoretic Mobility: *Characteristic of charged molecules, Characteristic of the electrophoretic system*; Detection in electrophoresis: optical methods, radiochemical methods, biological assay methods ***(Ref-1:*** 1-70)

2. Capillary Electrophoresis: Basics, Instrumentation and Application [10 L]

a) Basic Principles: Basic Electrophoretic Separation Modes, Zone Electrophoresis, lsotachophoresis, lsoelectric Focusing, Set-up for Capillary Electrophoresis, Theory of Electrophoretic Migration, Determination of Effective Mobility, Electroosmosis, Performance Criteria, Efficiency, Resolution. ***(Ref-2:*** *5-33)*

b)Instrumentation: Injection, Hydrodynamic Injection, Electro-kinetic Injection, General Aspects of Injection, Detection, General Aspects, Evaluation of Detector Performance, UV -VIS Absorbance Detection, Light Sources for UV -VIS Detection, Optical Layout of a UV -VIS Detector for CE, Design of the Detection Cell, Fluorescence Detection: Excitation Sources for Fluorescence Detection, Optical Layout of a Fluorescence Detector, Derivatization with Fluorescent Tags, Pre- and Post-Column Derivatization, Electrochemical Detection, Conductometric Detection, Amperometric Detection, Capillary Column, Sample Collection, Commercial Instruments. ***(Ref-2:*** *103-141, 151-158)*

c) Qualitative and Quantitative Analysis and Applications: General Aspects of Qualitative and Quantitative Analysis, Application: Drugs and Natural Products, Amino Acids, Peptides and Protein ***(Ref-2:*** *243-246, 261-274, 278-303).*

3. HPTLC and Detectors for HPTLC [8 L]

Thin layer chromatography, High performance thin layer chromatography. *(Ref-3)*

Planar Chromatography Detectors, Transmittance Measurements in Thin-Layer Chromatography, The Lambert-Beer Law, Reflectance Measurements in TLC and HPTLC, The Kubelka–Munk Equation, Reflectance Measurements with a Diode-Array Scanner, Spatial Resolution on the Plate, Spectral Distribution on HPTLC Plates, Spectral Evaluation Algorithm, Mass Spectrometric Detection in TLC, Direct Plate Extraction (SSSP), MALDI Techniques (MALDI-MS), Atmospheric Pressure Mass Spectrometry. Applications. ***(Ref-4:** 231-257)*

References:

1. Electrophoresis, Analytical chemistry through open learning Series, Wiley
2. Capillary Electrophoresis: Principles and Practice, R. Kuhn S. Hoffstetter-Kuhn, SpringerLaboratory, Springer-Verlag
3. Vogels's Textbook of Quantitative Chemical Analysis, 6^{th} Ed.
4. Quantitative Thin-Layer Chromatography-A Practical Survey, Bernd Spangenberg, Colin F. Poole, Christel Weins, Published by Springer

Section-II: Clinical Analytical Chemistry [24 L +6 T]

1) Analysis of blood and urine[12 L]

a) Collection of Specimens: Blood: Collection of Blood specimens, storage and preservation, Urine: Collection of Urine, physical characteristics of urea, preservation and storage, Faeces: Collection and preservation. **b) Analysis of Blood and urine**: Determination of blood and plasma glucose by glucose oxidase method, Determination of urine for glucose, Determination of ketone bodies in blood, Oral Glucose tolerance test, Determination of serum creatinine, estimation of serum bilirubin, Estimation of serum cholesterol, determination of blood haemoglobin, Urate: determination of serum urate, Determination of urea in urine by urease method and by direct colorimetry, Estimation of Na, K, Ca by flame photometry, inorganic phosphate by colorimetry.**c) Determination of vitamins in body fluid:** Classification of vitamins with example, Each vitamin must be explained with respect of functions, deficiency diseases, daily requirement, and analytical method i) Retinol (determination of retinol and serum carotene in serum using TFA), Vit D_3 (cholecalciferol), Vitamin E (Tocopherols, Determination of serum tocopherol by spectrophotometry by dipyridyl method), Vitamin B_1 (thiamine determination by flurometry), Vitamin B_2 (riboflavin, Photofluorometric method), Vitamin B_6 (Pyidoxine, Fluorometric determination of Xanthuric acid), Nicotinic acid and Niacin: determination by fluorometry, Ascorbic acid (vitamin –c) Volumetric method using 2,6 dichlorophenol method, colorimetric determination of leucocyte ascorbate. **(Ref.-1,** Relevant pages**)**

2. Immunological methods of analysis [10 L]

a) Basic of immunology: The immune response, Antigen, Adaptive Immunity and Clonal Selection, Antibodies, Antigen (Antibody production in response to antigen stimulus, affinity and avidity, antibody production in response toimmunization vaccination, Antibody production in response to infectious agents, relation between antigen and antibody in vivo, diagnostic usefulness of antigen and antibody in infection disease), Antigenic Commonness, **b) Basic Principles of ELISA:** Reactions scheme, Direct

ELISA, Indirect ELISA, Sandwich ELISA, Competition EILISA, Choice of Assay, **Stages in ELISA:** Solid phase (Immobilization of antigen on solid phase coating, coating time and temperature, coating buffer, desorption, binding capacity, nonspecific binding, covalent antigen attachment), Washing, Addition of reagents, incubation, blocking conditions and non-specific reactions, enzyme conjugates, conjugation with enzymes, Development of label, stopping reactions, reading. **Practical Exercise for Direct ELISA**: Explain with respect to learning principles, reaction scheme, basis of assay, materials and equipment's, practical details, data explained, aspects of assay described, conclusions. The pregnancy test on urine. **(Ref-2, 3)**

3. Radioimmunoassay [2L]

Radioimmunoassay (RIA), Principle, RIA Reagents, RIA Steps, RIA Results Interpretation **(Ref-1, 4)**

References:

1. Varley's Practical Clinical Biochemistry, Gowenlock A. H., 6th Edition, 2006, CBS Publishers, New Delhi.
2. Methods in Molecular Biology, Vol-42, ELISA-Theory and Practice, by John R. Crowther, Humana Press, Totowa, New Jersey.
3. Enzyme-linked Immunosorbent Assay (ELISA) From A to Z, Samira Hosseini, Patricia Vázquez-Villegas, Marco Rito-Palomares, Sergio O. Martinez-Chapa, published by Springer,
4. Basic SerologicalTesting, Rowa Yousef Alhabbab, Published by Springer

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in Electrophoresis, capillary electrophoresis, HPTLC, Body fluid analysis, ELISA, RIA.
2. Explain instrumentations in in Electrophoresis, capillary electrophoresis, HPTLC, Body fluid analysis, ELISA, RIA.
3. Explain / describe i) basic principles of chromatography (GC and HPLC) and mass spectroscopy. ii) Separation in GC / HPLC column. iii) Functioning and construction of GC / HPLC/ MS detectors.
4. Explain /Describe applications chromatography (GC and HPLC) in industry and in analytical laboratory.
5. Apply / select particular method / instrumental parameters for analysis for sample GC / HPLC.
6. Solve numerical problems on chromatography (GC and HPLC) and mass spectroscopy.
7. Integrate GC and HPLC chromatogram, Mass spectrum
8. Differentiate among the chromatography (GC and HPLC) methods of analysis.

CBOP-3, CHA-393: B) Analytical Methods of Food and Controlled Substances [48L + 12T]

Section-I: Analytical methods of Food [24 L +6 T]

1. Introduction to Food Analys *(Ref-1: 1-13)* **[1 L]**

2. Sampling and Sample Preparation [1 L]

Introduction, Selection of Sampling Procedures, Sampling Procedures, Preparation of Samples, Grinding, Enzymatic Inactivation, ***(Ref-1:** 71-80)*

3. Moisture and Total solids Analysis [1 L]

Introduction,Importance of Moisture Assay, Moisture Content of Foods, Forms of Water in Foods, Sample Collection and Handling, Oven Drying Methods:*General Information, Removal of Moisture, Decomposition of Other Food, Constituents, Temperature Control, Types of Pans for Oven DryingMethods, Handling and Preparation of Pans, Control of Surface Crust Formation (Sand Pan Technique), Calculations*; Distillation Procedures, Chemical Method: Karl Fischer Titration. ***(Ref-1** 87-96).*

4. Ash Analysis [1 L]

Introduction: *Definitions, Importance of Ash in Food Analysis, Ash Contents in Foods*; Methods: *Sample Preparation, Plant Materials, Fat and Sugar Products, Dry Ashing, Principles andInstrumentation, Procedures, Special Applications, Wet Ashing, Principle, Materials, andApplications, Procedures, Microwave Ashing, Microwave Wet Ashing, Microwave Dry Ashing, Other Ash Measurements, Comparison of Methods*

5. **Analysis of Lipids [5 L]**

a) Definition, Classification, General Considerations, Solvent Extraction Methods: Sample preparation, Solvent selection, Sample Preparation, Solvent Selection, Continuous Solvent Extraction Method: Goldfish Method, Semicontiguous Solvent Extraction Method: Soxhlet Method, Discontinuous Solvent Extraction Methods, Total Fat by GC for Nutrition Labelling (AOAC Method 996.06), Nonsolvent Wet Extraction Methods, Babcock Method for Milk Fat (AOAC Method 989.04 and 989.10), Gerber Method for Milk Fat, Instrumental Methods, Comparison of Methods. **(Ref.-1:** 119-130) **b) Characterization of Lipids** (bulk such as oils): Estimation of free fatty acids, Saponification value of oils, iodine value, Determination of acid value of oil, determination of peroxide value of oil, p-anisidine Value and Totox Value, Thiobarbituric Acid Reactive SubstancesTest, Conjugated Dienes and Trienes, Lipid Oxidation: Evaluating OxidativeStability, Methods for Lipid Components, Identification and quantification of fatty acids, Problem on quantitative methods. ***(Ref-1:** 241, 246-258, Supplimentory-2, 3).*

6. Proteins [5 L]

a. Protein Analysis: Introduction, Classification and General Considerations, Importance of Analysis, Content in Foods, Methods: Following methods with respect to principle, reactions, procedures and applications a) Kjeldahl's Method b) Dumas (Nitrogen Combustion) Method, c) Infrared Spectroscopy, d) Biuret Method e) Lowry Method f) Dye-Binding Methods g) Bicinchoninic Acid Method h) Ultraviolet 280nm, Comparison of Methods. (**Ref-**135 – 142, Supplimentory-2, 3). **b. Protein Characterization Procedures:** Amino Acid Analysis,Protein Nutritional Quality: Introduction, Protein digestibility, Protein efficiency ratio, and netprotein ratio, Other Protein Nutritional Quality Tests,Assessment of Protein Functional Properties, Determination of net protein utilization, digestibility and biological value, Problem on quantitative methods ***(Ref-1:** 271 - 277, Supplimentory-2, 3)*

7. Carbohydrates: [5 L]

Introduction, Mono- and Oligosaccharides: Extraction, Total Carbohydrate: Phenol-

Sulfuric AcidMethod, total reducing sugars by Nelson Somyogi method, Specific Analysis of Mono- and Oligosaccharides - High-performance Liquid, Gas Chromatography, Enzymic Methods, Chromatography, Mass Spectrometry, Thin-layer Chromatography, Polysaccharides: Starch, Total Starch, Degree of Gelatinization of Starch, Degree of Retrogradation of Starch, Non-starch Polysaccharides, Dietary Fibres: Major Components of Dietary Fibre, General Considerations, Methods. ***(Ref-1**: 149-169 Supplimentory-2, 3).*

8. Determination of food preservatives [5 L]

Definition, SO_2 legistration and determination by Tanners method, Nitrate and nitrites legistration and determination, boric acid legistration and determination, Benzoic acid legistration and determination, 4-hydroxybenzoate legistration and determination, ascorbic acid legistration and determination. Sweeteners: Saccharine identification and determination, Colours: Identification by general methods, Natural colours.Problem on quantitative methods. ***(Ref-4:** Relevant pages)*

References

1. Food Analysis, Edited by S. Suzanne Nielsen, Fourth Edition, Springer
2. Hand Book of Food Analytical Chemistry: Water, Proteins, Enzymes, Lipids, and Carbohydrates by Edited by Ronald E. Wrolstad, Terry E. Acree, Eric A. Decker, Michael H. Penner, David S. Reid, Steven J. Schwartz, Charles F. Shoemaker, Denise Smith, Peter Sporns, Wiley Interscience, a John Wiley &Sons, Inc., Publication.
3. Biochemical Methods, By S Sadashivan, A. Manickam; Third Edition, New Age International Publishers
4. Pearson's Chemical Analysis of Food

Section-II: Analytical Methods of Controlled Substances [24 L +6 T]

1. The narcotic drug and Psychotropic Substances (NDPS) Act-1985 [1 L]

Important Definition: *Drug, Cannabis (Indian Hemp), Cannabis Products, Coca-derivatives, Coca Leaf, Coca Plant, Illicit Traffic, Controlled Substance, Manufactured Drug, Opium, Opium Poppy, Poppy Straw, Poppy Straw Concentrate, Psychotropic Substance,* Prohibition Control and Regulation of NDPS (**Ref.-1**: 122-134, Ref-2)

2. Chemical Screening and Microcrystal Tests [2 L]

a) Chemical tests: Introduction, Chemistry of Color Formation, Limitations of Chemical Color Tests, Chemical Color-Test Methods, Documentation, Chemical Colour Tests: *Chen's Test, Dille–Koppanyi's Test, Mecke's Test , Marquis' Test, Nitric Acid Test, Primary Amine Test, Secondary Amine Test, Tertiary Amine Test, Van-Urk's Test, Duquenois–Levine Test, Froehde's Test, Janovsky Test, Weber Test.* **b)Microcrystal Techniques**: Introduction, Advantages of Microcrystal Techniques, Disadvantages of Microcrystal Techniques, Documentation, Microcrystal Test Techniques, Aqueous Test Technique, Volatility Test Technique, Acid and Anionic Test Technique, Aqueous Test Reagents, **(Ref-3:** 79-95)

3. Analysis of Drugs/Narcotics [21 L]

a) **Amphetamine and Related Compounds:** Introduction, Qualitative Identification of Amphetamines, Sampling and Physical Description of Amphetamines, Presumptive Testing of Amphetamines, Thin Layer Chromatography of Amphetamines, Definitive Identification of Amphetamines, Quantification of Amphetamines, Comparison and Profiling of Amphetamine Samples, The Leuckart Synthesis of Amphetamine, The Reductive Amination of Benzyl Methyl Ketone, The Nitrostyrene Synthesis, Impurity Extraction and Sample Comparison.***(Ref.-4:** 13-34)*

b) **The Analysis of LSD**: Introduction, Qualitative Identification of LSD, Sampling and Physical Description of LSD Blotter Acid, Extraction of LSD Prior to Analysis, Presumptive Testing for LSD, Thin Layer Chromatography of Samples Containing LSD, Confirmatory Tests for the Presence of LSD***(Ref.-4:** 37-43)*

c) Cannabis sativa and **Products**: Introduction, Origins, Sources and Manufacture of Cannabis, Analytical Sequence, Bulk and Trace Sampling Procedures, Qualitative Identification of Cannabis, Identification of Herbal Material, Identification of Other Materials, Comparison of Cannabis Samples. ***(Ref.-4:** 49-65)*

d) **Diamorphine and Heroin:** Introduction, Origins, Sources and Manufacture of Diamorphine, Appearance of Heroin and Associated Paraphernalia, Bulk and Trace Sampling Procedures, Identification, Quantification and Comparison of Heroin Samples, Presumptive Tests for Heroin, Thin Layer Chromatography of Heroin Samples, Gas Chromatographic–Mass SpectroscopicIdentification of Heroin, Quantification of Heroin Samples, Comparison of Heroin Samples***(Ref.-4:** 73-92)*

e) **Cocaine:** Introduction, Origins, Sources and Manufacture of Cocaine, Extraction and Preparation of Coca Paste, Synthesis of Pure Cocaine, Qualitative Identification of Cocaine, Presumptive Tests for Cocaine, Thin Layer Chromatography, Definitive Identification of Cocaine, Quantification of Cocaine, Quantification of Cocaine by GC–MS, Quantification of Cocaine by UV Spectroscopy, Comparison of Cocaine Samples. ***(Ref.-4:** 97-109)*

f) Products from *Catha edulis* and *Lophophora williamsii*: Introduction, Products of Catha edulis, Identification, Quantification and Comparison of Khat Samples, Comparison of Khat Samples, Products of Lophophora williamsii, Physical Description and Sampling of Materials, Presumptive Tests for Mescaline, TLC Analysis of Mescaline, HPLC Analysis of Mescaline, GC–MS Analysis of Mescaline, Comparison of Peyote Samples. ***(Ref.-4:** 113-124)*

g) Analysis Barbiturates and Benzodiazepines: Introduction, Analysis of Barbiturates and Benzodiazepines, Extraction of Barbiturates and Benzodiazepinesfrom Dose Forms, Presumptive Tests for Barbiturates and Benzodiazepines, TLC of Barbiturates and Benzodiazepines, Confirmatory Analysis of Barbituratesand Benzodiazepines, Quantification of Barbiturates and Benzodiazepines, Introduction, Products of *Catha edulis,* Identification, Quantification and Comparison, of Khat Samples, Comparison of Khat Samples, Products of *Lophophora williamsii,* Physical Description and Sampling of Materials, Presumptive Tests for Mescaline, TLC Analysis of Mescaline, HPLC Analysis

of Mescaline, GC–MS Analysis of Mescaline, Comparison of Peyote Samples. ***(Ref.-4: 139-149).***

Reference

1. Textbook of Forensic Pharmacy, C. K. Kokate, S. B. Ghokhale, Pharma Med Press (2008)
2. Textbook of Forensic Pharmacy, B. M. Miital
3. Basic Principles of Forensic Chemistry, Javed I. Khan, Thomas J. Kennedy, Donnell R. Christian, Jr. Humana Press
4. Analysis of Controlled Substances, Michael D. Cole, Wiley (2003)

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in food analysis techniques and methods, forensic science and drug substances.
2. Explain methods and principles of analysis of i) Food - carbohydrates, proteins, preservatives, ii) drug substances.
3. Select appropriate methods of food analysis for its quality.
4. Select appropriate methods for identification of drug and analysis of drug from sample.
5. Select and describe the parameters required for food quality.
6. Solve numerical problems on analysis food and drug substances.
7. Interpret food quality and drug substances from analytical results.
8. Differentiate among the different methods of analysis of food and drug substances.

CCPP-3:Practical I: Basics of Instrumental Methods of Chemical Analysis [96 L+24 T]

Section-1: Analytical method Development and Validation

Expt. No	Name of Experiments
Compulsory experiment	
1	**Demonstration Practical:**a. Calibration of UV-Visible spectrophotometer for control of absorbance as per IP or BP b) Theoretical basis for the choice of solvent for recording UV-Visible spectra of substances c) Theoretical basis for choice proper concentration for recording the UV-Visible spectrum d) Recording the UV-Visible spectrum of any one substance like caffeine, aspirin, paracetamol, $KMnO_4$ or any other substance of interest having characteristic UV-Visible absorbance i) identification of characteristics peaks in spectrum, b) Choice of λ_{max} for quantitative analysis c) Calculation of Molar absorptivity (ε) and d) Sp. absorbance (absorbance of sample solution for 1% solution). Theoretical interpretation of spectra. (Ref-6,7)
2	**Table Work:** a) Theorical basis of method development and validation – Accuracy, precision, noise level, detection limit, quantitation limit, Calibration curve and standard addition method and theoretical basis of choice between two, b) Expression of results: Calculation of mean, standard deviation, error and absolute error, elimination of data, c) Regression analysis of calibration curve and its importance. (Ref-3)
3-7	**Analytical method development and validation (Ref. 1, 6, 7)** Study of visible spectroscopic or colorimetric method for estimation of particular metal ion or non-metal ion or organic substance with respect to: a) Selection of ligand

/ reagent and colour formation method b) Choice of reaction cond. such as concentration of analyte and colour forming reagent, pH for colour formation reaction, etc. c) Determination of λ_{max} for quantitative analysis d) estimation of noise level, detection limit, quantisation limit and linearity range (Calculate R^2 value). Thereby set conc. limits for calibration curve method and standard addition method. e) Estimation of known of metal ion by calibration curve method and by standard addition method in triplicate for the validation of method. f) Estimation of metal ion from sample by calibration curve method and by standard addition method in triplicate (Regression analysis must be performed for both methods and results shall be accepted when R^2 is greater than 0.95) g) Detection of possible interfering metal ion.

Some suggested examples:

i) Colorimetric / visible spectrophotometery Cu(II) or Co(II) – R-nitrososalt and estimation of Cu(II) (Sample - alloy brass or bronze or coin) (Cent. Eur. J. Chem.10(5), 2012, 1617-1623, DOI: 10.2478/s11532-012-0081-7)

ii) Colorimetry / visible spectrophotometery Mn(II)-Formaldoxime or Mn(II)-oxidized to $KMnO_4$ (sample - tea leaves on ashing or plant micronutrient supplement). (Ref.- 1, 7)

iii) Colorimetry / visible spectrophotometery B as borate with curcumin reagent (Sample – Talcum powder can be taken) (Ref-1 and 3)

iv) Colorimetry / visible spectrophotometery Ni(II) or Co(II) by alfa nitroso beta-napthol (Sample - Steel alloy). Ref-1 and Monatshefte Fur Chemic 111, 1413 1425, Springer-Verlag 1980

Note: A student can select any other metal and own synthesized ligand system under the guidance of his mentor.

Some examples of non-metal ions

i. NO_3^- or NO_2^- by colorimtry / visible spectrophotometery (Ref- 1 and 2)

ii. NH_4^+ or NH_3 by colorimetry / visible spectrophotometery (alkaline phenol-perchlorate reagent) (Ref-1 and 2)

iii. SO_4^{2-} by Colorimetry/ visible spectrophotometeryetric (Ref-1)

Examples of Organic substances

i) Analysis of aspirin Colorimetry (Ref. 11)

ii) Assay of Vitamin-C by Colorimetry from lemon or orange juice (Ref- 12)

iii) Colorimetry / visible spectrophotometery phenolic compounds (Salicylic acid, salbutamol sulfate, phenol) by Folin-Ciocalteau reagent (Ref-4)

v) Colorimetry / visible spectrophotometery Analysis of paracetamol (Ref-8)

Note: i)A mentor can practice multiple examples in batch**.** ii)*Student shall prepare systematic report in the form of journal which will contain 1) introduction to UV-Visible spectroscopy, basic terms in absorption spectroscopy, Beer's law, construction and working of colorimeter and spectrophotometer, interpretation of absorbance spectra of organic and inorganic substances, basis of quantitative analysis by UV-Visible spectroscopy, calibration curve method, standard addition*

	method, advantages of graphical methods, basis for simultaneous method analysis of non-interfering substance by spectrophotometry. This part will be followed by experiment 3 to 7.
Any three experiments	
8	Analysis of Riboflavin by visible spectrometry and Photoflurometry. Compare results with respect to sample requirement, detection limit, accuracy of both methods. Give your choice for analysis of i) Riboflavin as raw material in pharmaceutical industry and ii) blood/ urine/vitamin supplement. Explain reason for choice of method. *(Ref-4, 6 and 9).*
9	Comparison of end point redox titration between $K_2Cr_2O_7$ and standard Fe(II) i) by potentiometry and ii) external indicator. Calculate amount of Fe(II) by both methods and compare with standard value. Give critical comment on Fe(II) content by two methods with respect to standard value i.e. accuracy of results and advantages and disadvantages of each method. *(Ref-3)*
10	Determine amount of $NaHCO_3$ from eating soda sample or from mixture of $NaHCO_3$ + Na_2CO_3: Determine amount of $NaHCO_3$ by thermal decomposition method (gravimetry) on burner as well as by volumetric method using standardized 0.05 N HCl. Compare purity or amount of $NaHCO_3$ in sample by both methods. Comment on advantages and disadvantages of each methods. Give your choice of method between two. *(Ref-3)*
11	Perform pH metric titration for estimation of CH_3COOH from vinegar using i) 0.1 M standardized NaOH simultaneously using phenolphthalein indicator and pH meter ii) 0.5 M standardized NaOH using pH meter. Compare the results of three methods and give your comment. *(Ref-3)*
12	Determine aspirin in tablet conventional titration and by potentiometric titration and compare the results of two method. *(Ref-10)*
13	Development of turbidimetric method for estimation of i) PO_4^{3-} at low level using ammonium molybadate reagent or ii) S^{2-} using reaction with suitable metal ion such as Cu(II). iii) estimation of Mg(II) by Nessler's reagent***. (for self development)***
14	**Qualitative and confirmatory test for (minimum four)** Test for aniline / para aminophenol, Test for antimony / mercury (No C.T.), Test for Borate (use talcum powder), Dinitrophenol pesticides, Ethanol / methanol, Formaldehyde, Hypochlorites, Iodates, Nitrate / nitrite, Paracetamol, Phenol, Salicylic acid its derivatives, Thiocynates (**Note:** Aq. Solutions shall be given containing prescribed conc. in monograph of the substance). (Ref-13).
	References: 1. Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier 2. Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, Americal water works association, Water environment federation.

	3. Vogels textbook of Inorganic Quantitative Analysis, 4. Biochemical Methods, Third Edition, By S Sadashivan, A. Manickam; New Age International Publishers 6. Indian Pharmacopeia: 2007, Vol-1, 2, 3. 7. Chemical Analysis and Material Characterization by spectrophotometry, Bhim Prasad Kafle, Elsevier 8. Ultraviolet and Visible Spectrophotometry in Pharmaceutical Analysis, Sandor Gorog, Published by CRC press, Taylor and Fransis. 9. An introduction to Practical Bichemistry, David T. Plummer, Tata McGraw-Hill publishing Company Ltd. 10. Experiments in chemistry, D. V. Jahagirdar, Himalaya Publishing Company 11. Method Development for Analysis of Aspirin Tablets, Journal of Chemical Education, Volume 65 Number 10 October 1988. 12. Vitamin C as a Model for a Novel and Approachable Experimental Framework for Investigating Spectrophotometry, Journal of Chemical Education, DOI:10.1021/acs.jchemed.9b00197. 13. Basic Analytical Toxicology, R. J. Flangan, R. A. Braithwait, S. S. Brrown, B. Viddop, F. A. de Wolff, published by WHO.

Section – II: Introduction to Analytical Techniques (12 experiments)	
Nitrogen Estimation	
1	Estimation organic nitrogen by Kjeldahl's Method or semi-micro Kjedahl's method (example: milk powder, soil sample, cooked food containing pulses, fertilizer etc.). *(Ref-1)*
Solvent Extraction	
2	Extraction of organic substance by Soxhelet or semi micro Soxhelet extraction (such as Essential oils, carotenoids from carrot, Caffeine for tea powder) and their isolation from solvent. Purity by TLC, BP/MP. *(Ref-7)*
3	Isolation of carotenoids from spinach / lycopene from tomato. TLC separation to find out number of carotenoids. *(Ref-6, 15)*
Solid Phase Extraction, Ion exchange chromatography	
4	Determination of Ion exchange capacity of ion exchange resins *(Ref-1).*
5	**Solid Phase Extraction:** Isolation of amino acids from aqueous sample using ion exchange resin and their identification by colorimetric test (very dilute glycine solution can be used as an example of alfa amino acid) *(Ref. 5)* Or Isolation of caffeine using RP C-18 cartridge from cold drinks and quantitative estimation *(Ref-7)* Or Isolation of beta carotene from spinach leaves on silica gel cartridge by solid phase extraction and its quantification visible spectrophotometry. *(Ref-7)*
6	**Pre conc. using solid phase extraction on ion exchange cartridge and estimation.** You can any choose any metal ion which is present below detection limit. You will do preconcentration using ion exchange resin and will estimate by AAS or aqueous

	colorimetry (not solvent extraction). Example: Preconcentration of Cu(II) from brine (one can use aqueous solution of Cu(II) solution with less than 0.5 ppm conc.) and its estimation using R-Nitroso salt *(Ref-1, 4)*
Flame photometry	
7	Flame photometric analysis of water /soil sample for Na^+ and K^+ by calibration curve method (give regression analysis for both curves) *(Ref-1)*
8	Estimation of K^+ from soil/water sample by internal standard and its confirmation by standard addition method (give regression analysis of both curves) *(Ref-1)*
Methods of Trace Analysis of metals: Atomic Absorption Spectroscopy	
9	**Demonstration Practical by Mentor:** Handling of AAS and study on any metal ion estimation by AAS method with respect to 1) Effect of oxidant to fuel ratio on absorbance, ii) detection limit and iii) linearity range for calibration curve method. (give regression analysis) iv) Effect of other metal ion and absorbance of analyte. *(Ref-1, 15)*
10	Estimation of any two-metal ion by atomic absorption spectroscopy from soil or micronutrient supplement or food sample. *(Ref-1, 15)*
Turbidimetry / Nephelometry	
11	Selective estimation of Cl^- from water or saline sample or food sample by calibration curve method using turbidimetry (give regression analysis) and its confirmation by standard addition method. *(Ref-1)*
12	Selective estimation of SO_4^{2-} in presence of chloride from water sample or any other sample by calibration curve and its confirmation by turbidimetric titration method (give regression analysis for both curves).*(Ref-1)*
Photoflurimetry	
13	Estimation of quinine sulphate from tablet by calibration curve and its confirmation by standard addition method. *(Ref-1)*
14	Determination of Zn(II) by Photoflurimetry *(Ref-1)*
Polarimetry	
15	a) Determination of optical rotation thereby calculate specific rotation of dextrose (glucose) and sugar (sucrose). Express purity of glucose and sugar samples on the basis of specific rotation. (Ref-2) b) Determination of glucose in DNS saline and glucose supplement (Glucon-D) sample by polarimeter. *(Ref-2)*
Quantitative TLC	
16	Separation of Colours by TLC / Paper chromatography, their isolation by elution from paper or TLC and quantification by colorimetry. *(Ref-1)*
17	Analysis of the Composition of a Mixture of Nitroanilines by Thin-Layer Chromatography and Ultraviolet/Visible Spectrometry *(Ref.-8)*
HPLC	
17	**Demonstration Practical by Mentor** i. Handling of HPLC equipment, choice of mobile phase and column, sample

	preparation. ii. Record the chromatogram of pure substance and study a) Effect of conc. on peak area and peak height b) from retention time and length of column calculate number theoretical plates from. c) Qualitative analysis – spiking method and by using retention time d) Quantitative analysis by comparing peak height of sample with standard as well as by comparing peak area of sample with standard.*(Ref.-1, 14, 15)*
18	Estimation of APC tablet by HPLC method *(Ref-1, 3, 8)* or HPLC method developed in your laboratory.
Gas Chromatography	
19	**Demonstration Practical by Mentor** Study of GC chromatogram: Record the chromatogram of pure ethanol, acetone, methanol and their mixture. Identify peaks of respective substances in mixture and calculate relative percentage of these three substances by percent area method. Calculate N, resolution of chromatographic column. *(Ref-1)*
20	Analysis of vitamin-A acetate or alfa-tocopherol by GC according to IP method or any other reported method or method developed in your laboratory. *(Ref-2)*
Thermogravimetric Method	
21	**Demonstration Practical by Mentor** Study of GC chromatogram: Record the TGA of pure $NaHCO_3$ (room temp to 300 °C). Explain different characteristics of thermogram and quantitative analysis by TGA. Explain how thermal decomposition reaction can be predicted from wt. loss.
22	TGA analysis of dolomite ore for $CaCO_3$ and $MgCO_3$ content *(Ref-1)*
23	TGA analysis $CuSO_4\,5H_2O$ *(Ref-1)*
Cyclic Voltammetry	
24	Cyclic voltammetric study of Fe(II)/Fe(III) system. Basic principle and calculation of basic parameters from CV. *(Ref-1, 10, 11)*
25	Quantitative analysis using CV of any one -Vit-C / parathion / nitrobenzene / or any other substance for which your department has developed CV method. (Ref.-12,13).
Students Self activity	
1	**a) Compulsory:** Prepare report on construction, working, representation, uses and care of electrodes: Calomel electrode, silver-silver chloride electrode, platinum electrode, conductivity cell, and combine glass electrode. (***Ref-1).*** b) Actual construction of standard silver-silver chloride as reference electrode (Replacement to saturated calomel electrode as it contain highly toxic Hg(II), Hg(I) and Hg metal), salt bridge and their testing. ***(Ref-9).*** c. Construct graphite electrode using graphite rod or used dry pen-cell. Perform redox titration using graphite electrode prepared by you and calomel as reference electrode. Perform same titration using Pt electrode and calomel electrode. Report does Pt can be replaced by graphite or not. Give the reasons.
References: 1. Vogel's Textbook of Quantitative Chemical Analysis, 6^{th} Ed.	

2. Indian Pharmacopeia, 2007
3. Chemical Separations Principle techniques and Experiments, Clifton E Meloan, Wiley Interscience.
4. Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier
5. Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, Americal water works association, Water environment federation.
6. Biochemical Methods, Third Edition, By S Sadashivan, A. Manickam; New Age International Publishers
7. Extraction technique in Analytical Science, John R. Dean, Wiley
8. Experiments in modern analytical chemistry, D. Kealey, Springer Science Business media, 1986.
9. Student Construction of a Gel-Filled Ag/AgCl Reference Electrode for Use in a Potentiometric Titration, Journal of Chemical Education, Vol. 76 No. 1 January 1999
10. https://chem.libretexts.org/Courses/University_of_California_Davis/UCD_Chem_115_Lab_Manual/Lab_1%3A_Cyclic_Voltammetry
11. Cyclic Voltammetry Experiment James J. Van Benschoten. Jane Y. Lewis, and William R. Heineman, Journal of Chemical Education, Volume 60, Number 9, September 1983 (772-776) and Volume 60 Number 9 September 1983 (702-706)
12. Voltammetric analysis of hydroquinone, ascorbic acid, nitrobenzene and benzyl chloride in aqueous, non-aqueous, micellar and microemulsion media, R. Sripriya M. Chandrasekaran M. Noel, Colloid Polym. Sci (2006) 285: 39–48.
13. Electrochemical Determination of Methyl Parathion using a Modified Electrode, Toxicol. and Environ. Chem., 2003, Vol. 85, Nos. 4–6, pp. 233–241.
14. Analysis of Soft Drinks: UV Spectrophotometry, Liquid Chromatography, and Capillary Electrophoresis, Journal of Chemical Education, Vol. 75 No. 5 May 1998
15. Analytical Chemistry for Technicians, John Kenkel, Third Edition, CRC Press LLC, 2003.

Learning Objective –

At the end of course students should able to-

1 Maintain proper record of analytical data in notebook. Observer personal safety in laboratory and able handle all chemicals, instruments, etc safely in laboratory.
2. Define / understand various terms involved practical methods of quantitative analysis.
3. Explain instrumentations of colorimeter, spectrophotometer, photoflurometer, TGA, HPLC, GC, Flame-photometer, CV, AAS, etc.
4. Explain / describe basic principles of chromatography different instrumental methods of analysis. Able to handle particular instrument according to SOP.
5. Design / modify and validate new analytical method for chemical analysis of particular sample.
6. Apply / select particular method / instrumental parameters for analysis of given sample.
7. Give mathematical treatment to analytical data and able to interpret the results accurately.
8. Verify theoretical principle practically or apply theory to explain practical observations.
9. To conclude the results able to take the decision regarding quality of sample.

10. Differentiate among the various analytical methods / techniques of chemical analysis.

Semester-IV

CCTP- 10, CHA-490: Advanced Analytical Spectroscopic Techniques [48L + 12T]

Section-I: Atomic Spectroscopic Methods [24 L +6 T]

1. Sample preparation techniques [2 L]

Introduction, aqueous sample, liquid-liquid extraction, Ion exchange, co-precipitation, solid samples: decomposition techniques, microwave digestion, dry ashing, fusion, Extraction procedures: Single extraction, sequential extraction, enzymatic digestion *(Ref-1: 17-36, Supplementary reference - 2)*

2. Atomic Absorption and emission Spectroscopy [6 L]

Introduction, Atomic spectra, Instrumentation of AAS: Sample introduction system: Nebulizers, Laser Ablation technique, hydride vapour generators, automizers: Flame atomizer - premix burner, fuel gases and oxidants, graphite furnace, hydride generator, cold vapour technique, Hollow cathode lamps, spectrophotometers, detectors, Interferences in AAS (spectral and chemical), Quantitative analysis (calibration curve method, standard addition method, internal standard addition method), Practical applications of AAS from *Ref-3. (**Ref-3**: Relevant pages, Supplementary references4,5)*

3. Inductively Coupled Plasma AES and MS [10 L]

a. Inductively Coupled Plasma AES: Introduction to Atomic emission spectroscopy, inductively coupled plasma, Direct current plasma, microwave induced plasma, glow discharge, plasma spectroscopy, spectrometers, Detectors, interferences.

b. Inductively Coupled Plasma MS: Fundamental of MS, Inorganic mass spectroscopy, Interface, mass spectrometer, quadrupole mass analyser, detectors, interferences, isotope dilution analysis, mass spectral interpretation. ***(Ref-1:**57-117, supplementary Ref- 6)*

c. Applications: Forensic analysis of documents, Clinical analysis of blood and urine, ***(Ref-1:** Relevant pages).* Analysis of metals from waste water sample of ICP-MS method *(Ref-2, sec. 3120, 3125)*

4. Atomic Fluorescence Spectroscopy [6 L]

Atomic fluorescence, Apparatus for AFS, EMR source for AFS, LASERS, Cells for AFS, Plasmas- ICP and DCP, Detectors, theory of AFS, Analysis with AFS, Interferences with AFS, Resonant ionization Spectroscopy, LASER enhanced ionization spectroscopy.*(Ref-5)*

5. Elemental Analysis [2 L]

Particular analyses, Elemental organic microanalysis, Total nitrogen analysers (TN), Total sulphur analysers, Total carbon analysers, problems on empirical and molecular formula on CHONS analysis. ***(Ref. -7:** 441-450)*

Reference

1. Practical Inductively Coupled Plasma spectroscopy, John R. Dean, Wiley India Pvt. Ltd. (AnTs Series book)
2. Standard methods for the examination of water and waste water, 23rd Ed. Jointly published by American Public Health Association, American Water Work Association, Water

Environment Federation. 2017.
3. Vogels, Quantitative Chemical Analysis, 6th Ed.
4. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.
5. Introduction to Instrumental Analysis by R. D. Braun
6. Practical Guide to ICP-MS, Edited by Robert Thomas, CRC press, Francis and Taylor.
7. Chemical Analysis Modern Instrumentation Methods and Techniques, Francis Rouessac and Annick Rouessac, Second Edition, John Wiley & Sons Ltd.

Section-II: Molecular Spectroscopic Methods [24 L +6 T]

1. Molecular Luminescence spectrometry [6 L]

Introduction, theory of fluorescence and phosphorescence: *excited state producing fluorescence and phosphorescence, energy level diagram, rate of absorption and emission, deactivation process, variables affecting fluorescence and phosphorescence, Emission and excitation spectra*; Instruments for measuring fluorescence and phosphorescence: *Components of Fluorometers and Spectrofluorometers, Instrument Design, Correction andCompensation Schemes, Instrument standardization;* Applications of Photoluminescence Methods: *Methods for Organic and Biochemical Species, Phosphorometric method, Fluorescence Detection in Liquid Chromatography, Lifetime measurement, Fluorescence imaging;* **Chemiluminescence:** The Chemiluminescencephenomenon, measurement of chemiluminescence, analytical applications, problems. ***(Ref.-1:****399-426)*

2. Electron Paramagnetic Resonance Spectroscopy [12 L]

Basic Theory: general remarks, electron spin and magnetic moment, ESR transitions, Selection rules, g-factor, presentation of spectra, interaction of magnetic dipole with microwave radiations, Larmor precision, resonance phenomenon, relaxation process, transition probability. **Hyperfine Structure:** Nuclear hyperfine splitting, radical containing one proton, spin Hamiltonian, selection rules, radical containing a set of equivalent protons, radical containing a set of multiple protons, radical containing multiple sets of protons (I = ½), radical containing multiple sets of proton (I > ½), Atomic radicals, Origin of hyperfine interaction, sigma radicals, assignments of spectra using Huckel MOs, alternant hydrocarbons, hyperfine splitting constants, second order splitting, Applications.*(**Ref-3:**Relevant pages, Supplementary Ref-4)*

3. Electron Spectroscopy for Surface Analysis [6 L]

Basic principles, x-ray photoelectron spectroscopy, Auger Electron spectroscopy, Instrumentation: *ultra-high vacuum, source gun, electron gun, Ion gun, electron energy analysers*, Characteristics of Electron spectra: *photoelectron spectra, Auger electron spectra*, Qualitative and quantitative analysis: *qualitative analysis, peak identification, chemical shift, problems with insulating materials, Quantitative analysis: peak and sensitivity factor, composition depth profiling.**(Ref-2:** 221-250).*

References:

1. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.
2. Materials Characterization, introduction to microscopic and spectroscopic techniques, Yang Leng, 2nd Wiley-VCH.
3. Introduction to Magnetic Resonance of Spectroscopy ESR, NMR, NQR, D.N.

Sathyanarayana, I. K. International Publishing House Pvt. Ltd.
4. Structural Methods in Molecular Inorganic Chemistry, DavidW. H. Rankin, NorbertW.Mitzel, Carole A. Morrison, Wiley (JohnWiley & Sons, Ltd.), 2013

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in atomic absorption, atomic emission, fluorescence, ESR and electron spectroscopy.
2. Explain instrumentation of atomic absorption, atomic emission, ICPAES, ICPAES-MS, fluorescence, ESR and electron spectroscopy.
3. To describe basic principles of atomic absorption, atomic emission, ICPAES, ICPAES-MS, fluorescence, ESR and electron spectroscopy.
4. Select appropriate methods for sample treatment in AAS / AES, ICPAES, ICPAES-MS.
5. Explain advantages of ICPAES-MS over AES spectroscopy, fluorescence spectroscopy.
6. Solve numerical problems on analysis all these spectroscopic methods.
7. Interpret ESR spectra, super hyperfine splitting and g value in ESR, and parameters affecting it.
8. Calculate theoretical parameters from ESR data and characterize compound.
9. Solve problems based on atomic absorption, atomic emission, ICPAES, ICPAES-MS, fluorescence, ESR and electron spectroscopy.

CCTP-11, CHA-491: Chemical Methods of Pharmaceuticals Analysis

[48L + 12T]

Section-I: Pharmaceutical Dosage forms and General Methods Analysis [24 L +6 T]

1. Pharmaceutical Dosage Forms [4 L]

Capsules: *Definition, types of capsules, Tests;* Creams: *Definition, tests;* Ear Drops: *Definition, tests;* Eye Drops: *Definition, tests;* Gels: *Definition*, Inhalation Preparations*: Definition, Uniformity of delivered, Number of deliveries per container dose, Uniformity of delivered dose (only);* Nasal preparations: *Definition and tests;*Ointments: *Definition and tests;*Oral Liquids: *Definition, types and tests;* Oral Powders: *Definitionand tests;*Parenteral Preparations: Introduction, Injections: *Definition and tests*, Infusion: *Definitionand tests;*Powder for Injection: *Definitionand tests;* Tablets: *Definition, types of tabletsand their tests.(Ref-2: 14 - 47)*, Shelf life of pharmaceutical preparation.

2. Chemical Test, Limit Test and Assay [6 L]

Important Note: Write the chemical reaction and explain theoretical basis of the limit tests and assay though it is not given in reference book.

a) Limit Tests: Aluminium, Aluminium in Adsorbed Vaccines, Arsenic, Calcium in Adsorbed Vaccines, Chlorides, Heavy metals, Iron, Lead, Potassium, Sulphates, Sulphated Ash, Total Ash, Free Formaldehyde, N-N-Dimethylaniline *(Ref-1: 74-80, Ref.-4, 93-149)*

b) Assays: Acetyl Value, Acid Value, Cineole, Ester, Ester Value, Hydroxyl Value, Iodine value, Nitrogen, Methoxyl, Nitrite Titration, Peroxide Value, Saponification Value, Assay of Steroids, Unsaponifiable Matter, Assay of Vitamin A, Assay of Vitamin D, Water-(*Titration method and azeotropic distillation method*), Zinc, Ethanol, Assay of Insulins*(Ref-1: 80-99, Ref-3)*

3. Pharmaceutical Methods of Determination [6L]

Disintegration Test, Dissolution Test, Uniformity of Weight of Single-Dose Preparations,

Uniformity of Content of Single-Dose Preparations, Friability of Uncoated Tablets, Contents of Packaged Dosage Forms, Powder Fineness, Particle Size by Microscopy, Particulate Contamination. *(Ref-1: 175-188*)

4.Microbiological Assay of Pharmaceuticals [8 L]

Biological assay in general, **a) Agar diffusion assay – Quantitative basis:***Introduction, The theory of zone formation, what happens in practice, principles of calculation of potency estimate*; **b) The Theory and Practice of Tube Assay- Growth promoting substances**: *Introduction, the mode of action of growth limited by amino acids, growth limited by vitamins, production of acid by lactobacilli, clinical factor in the assay of growth promoting substances*; c) **The Theory and Practice of Tube Assay-Growth Inhibiting Substances:***Introduction, measurement of response, the forms of response line, historical development of the turbidimetric method, linearization of sigmoid curve, the quantitative theory of microbial growth and inhibition, a practical determined log dose – response curve, factor affecting finals cell count, the influence of temperature, the influence of time,* **d) What do we want assay**: *pharmacopeial intension and control of antibiotic bulk materials, control in routine in manufacture, Research and development*; d**) General Practical Aspects of Microbiological Assay:** Introduction, test solutions (weighing – sample of unknown, dilution of primary solution to test level, problem with very dilute solutions, the assay medium), selection of Latin squares and plating routine, Aspects of technique (the test organism, inoculating the medium, assay plate, assay tube, diluents, the sample, test solution and the effect of contamination, application of test solution-agar diffusion assay, application of test solution-turbidimetric assay; Calculation of potency, **e) Standard and reference materials***(Ref-4: 1, 9-18, 23-35, 37-56, 59-64, 65-77, 79-84, Ref-1: 45-52)*

Section-II: Analysis of Raw Materials and Active Ingredients [24 L +6 T]

1. Introduction to Pharmaceutical Analytical Chemistry [1 L]

Introduction, Official European Pharmacopoeia definitions, Pharmaceutical Analytical Chemistry, Manufacture of Pharmaceuticals, Development of New Drugs, Use of Pharmaceuticals ***(Ref-3:** 1-7)*

2. Marketing Authorizations, Pharmaceutical Manufacturing, and International Pharmacopoeias [1 L]

Introduction, Marketing Authorization and Industrial Production, Pharmacopoeias, Life Time of Pharmaceutical Preparations and Ingredients. ***(Ref.3:** 9-14)*

3. Chemical Analysis of Pharmaceutical Ingredients [12 L]

Pharmaceutical Ingredients, Production, and Control, Pharmacopoeia Monographs, Melting point capillary method, (monograph on paracetamol and acepromazine malate tablet, acetaminophen, acetaminophen capsules, caster oil virgin, cefaclor), Impurities in Pharmaceutical Ingredients*: Impurities in Pure Chemical Ingredients, Impurities in Organic Multi-Chemical Ingredients*; Identification of Pharmaceutical Ingredients: IR Spectrophotometry *(identification of ibuprofen, Identification of spironolactone***)** , UV-Vis Spectrophotometry (*Identification of mianserin hydrochloride*), Thin-Layer Chromatography (*Identification of metrifonate***)**, Melting Point, Optical Rotation (*Optical*

*rotation for simvastatin***)**, Liquid Chromatography *(Identification of calcitriol),* Chloride *(Identification of chloride in chlorcyclizine hydrochloride)* and Sulfate, Identification, Impurity Testing of Pharmaceutical Ingredients (Pure Chemical Ingredients): Appearance of Solution (*Appearance of solution for ibuprofen***)**, Absorbance (*Absorbance and color of solution of esomeprazole magnesium***)** pH and Acidity or Alkalinity (*pH of esmolol hydrochloride, Acidity or alkalinity of dopamine hydrochloride***)**, Related Substances (*Related substances according to Ph. Eur. for omeprazole***)**, Residual Solvents (*Limit of acetone in olmesartan medoxomil***)**, Foreign Anions (*Test for foreign chlorides and sulfates in furosemide*), Sulfated Ash (*Residue on ignition for acetaminophen***)**, Elemental Impurities (*Test for foreign zinc in human insulin***)**, Loss on Drying (*Loss on drying for paracetamol***)**, Water (*Determination of water in ephedrine*), Identification and Impurity Testing of Organic Multi-Chemical Ingredients: *Oxidizing Substances,* ***Only importance of the should be explained*** *- Acid Value, Hydroxyl Value, Iodine Value, Peroxide Value, Saponification Value, Unsaponifiable Matter),* Other Tests (*Chromatographic profile for peppermint oil***)**, Assay of Pharmaceutical Ingredients, Aqueous Acid–Base Titration (*Assay of omeprazole, amitriptyline hydrochloride, ephedrine hydrochloride, ephedrine*), Non-Aqueous Acid–Base Titration (*metronidazole benzoate, lidocaine***)**, Redox Titrations (*ferrous fumarate*), Liquid Chromatography (*Assay of simvastatin*), UV-Vis Spectrophotometry (*Assay of hydrocortisone*). *(**Ref-3:** 305-388)*

4. Chemical Analysis of Pharmaceutical Preparations [10 L]

Chemical Analysis of Pharmaceutical Preparations, Monographs and Chemical Analysis (*BP monograph for paracetamol tablets***)**, Identification of the API: Identification by IR Spectrophotometry (*Identification of aspirin, fluoxetine in fluoxetine hydrochloride oral solution, Identification of mupirocin in mupirocin calcium nasal ointment*), Identification by Liquid Chromatography (*Identification of fluoxetine in fluoxetine hydrochloride, droperidol in droperidol injection, Beclomethasone Dipropionate in Beclomethasone Dipropionate Ointment*), Identification by UV-Vis Spectrophotometry (*Identification of Diazepam in Diazepam Tablets, Flupentixol Decanoate in Flupentixol Decanoate Injection, Miconazole in Miconazole Nitrate Cream*), Assay of the Active Pharmaceutical Ingredient, Assays Based on Liquid Chromatography (*Assay of Omeprazole, Fentanyl in Fentanyl Citrate Injection, Assay of Hydrocortisone in Hydrocortisone Ointment*), Assays Based on UV Spectrophotometry (*Assay of Paracetamol in Paracetamol Tablets, Assay of Doxapram in Doxapram Hydrochloride Injection*), Assays Based on Titration (*Assay of Fe^{2+} in Ferrous Fumarate Tablets, Diphenhydramine in Diphenhydramine Hydrochloride Oral Solution*), Chemical Tests for Pharmaceutical Preparations, Test for Related Substances (*Related Substances in Paracetamol Tablets*), Uniformity of Content (*Uniformity of Content for Phenindione Tablets*), Dissolution. ***(Ref-3:** 391-332)*

References

1) Indian Pharmacopeia Volume I, 7th Ed
2) Indian Pharmacopeia Volume II, 7th Ed
3) Introduction to Pharmaceutical Analytical Chemistry, Stig Pedersen-Bjergaard, Bente Gammelgaard, Trine Grønhaug Halvorsen, Second Edition, Wiley (2012).

4. Pharmaceutical Chemical Analysis: Methods for Identification and Limit Tests, Ole Pedersen, CRC press. Taylor & Francis Group, 2006.

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in pharmaceutical raw material and finished product analysis.
2. Explain various pharmaceutical dosage forms and types of raw materials used.
3. To describe basic principles of methods of pharmaceutical analysis according to IP.
4. Explain importance particular test in pharmaceutical raw material and finished product analysis.
5. Perform and explain importance of limit tests, identification tests and micobiological limit test of raw materials and finished products.
6. Solve numerical problems on analysis pharmaceutical raw material and finished product analysis.
7. Interpret IR spectra, HPLC chromatogram, UV-Visible spectra of pharmaceutical materials.
8. To perform total analysis of pharmaceutical raw material and finished product analysis according to IP / BP / USP.
9. Standardize analytical instruments according IP /BP/ USP.
10. Take a decision on the basis of analytical results regarding quality of raw materials so that material can be accepted for production or rejected.

CBOP-4, CHA-492: A) Laboratory Automation and Environmental Analytical Chemistry

OR

CBOP-4, CHA-492: B) Analytical Chemistry of agriculture, Polymer and Detergents

CBOP-4, CHA-492: A) Laboratory Automation and Environmental Analytical Chemistry [48L + 12T]

Sensor-I: Laboratory Automation and Sensor Based Techniques [24 L +6 T]

1. Introduction to laboratory Automation [2 L]

Introduction, automation, miniaturization and simplification, lab automation, flow injection analysis, miniaturized analytical systems, fast response analytical systems, chemical sensors, screening systems, process on-line systems. *(Ref-1: Relevant pages)*

2. Laboratory Automation [4 L]

Definition and concept, objective of automation in analytical chemistry, automation of analytical tools and process, automation of preliminary operations, automation of calibration, automation of measuring and transducing of analytical signals, automation of data acquisition and processing, analysers, automated management system, advantages and shortcomings of automated system. *(Ref-1: Relevant pages)*

3. Flow Injection Analysis [6 L]

Batch and continuous flow analysis, principles, basic FIA instrumentation, dispersion in FIA, FIA for reproducible and precise sample preparation, FIA system with enzymes, flow injection hydride generation scheme, online sample conditioning, and preconcentration, exploiting the physical dispersion process, FIA gradient technique, Process control,

process control analysers. *(Ref-1: Relevant pages)*

4. Miniaturized Analytical systems [4 L]

Introduction, Concept, theory of miniaturization, microfabrication, silicon and glass micro-matching, polymer replication technology, miniaturized analytical components, sampling and sample pre-treatment, system integration, serial integration, parallel integration, commercialization.*(Ref-1: Relevant pages)*

5. Chemical Sensors [4L]

Introduction, definitions, Classification of chemical sensors, descriptions of chemical sensors (electrochemical sensors, potentiometric sensors, Volta-metric chemical sensors, sensors based on conducting properties), Optical sensors (light guides, the evanescent wave, design of fibre optic sensor, indicator mediated sensor), Calorimetric sensors (catalytic gas sensor, thermal conductivity sensor), mass sensor (piezoelectric quartz crystal resonator, surface acoustic wave sensor). *(Ref-1: Relevant pages)*

6. Biosensors in analysis [4L]

Introduction, producing biological surface, methods of immobilization, Achievement of biotransduction (amperometric, potentiometric, optical). *(Ref-1: Relevant pages)*

References:

1. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VCH

Sec-II: Environmental Analytical Chemistry [24 L +6 T]

1. Water Pollution and Measurement of Water Quality [16 L]

a) Water Pollutants: Brief explanation of following with respect to their sources and toxic effects -Inorganic pollutants (Heavy Metals (CD, Hg, Pb), Metalloids, Organotin Compounds, Inorganic Species (CN^-, NH_3 and other species), Asbestos), Organic Pollutants (Soaps, Detergents, and Detergent Builders, Pesticides in Water, Polychlorinated Biphenyls), Emerging Water Pollutants, Pharmaceuticals, and Household Wastes, Radionuclides in the Aquatic Environment).*(**Ref-2:** 159-183*supplementary reference-3 and 4)

b) Analysis: Physical Properties: Colour (Visible Inspection, Spectrophotometric—Multi-Wavelength Method, Turbidity, Odour, Taste, Acidity, Alkalinity, Calcium Carbonate Saturation, (Introduction, Indices Indicating A Water's Tendency To Precipitate Or Dissolve Caco3, Indices Predicting The Quantity Of $CaCO_3$ That Can Be Precipitated Or Dissolved), Hardness, Oxidant Demand/Requirement (Chlorine Demand/Requirement, Ozone Demand/Requirement— Batch Method), Conductivity, Salinity. (**Ref-1:** 2.5, 2.8, 2.12-2.40, 2.48-2.62). **Metal ions:** Introduction, Preliminary Treatment Of Samples *(Introduction, Filtration for Dissolved and Suspended Metals, Treatment for Acid-Extractable Metals, Digestion for Metals, Nitric Acid Digestion, Nitric Acid-Hydrochloric Acid Digestion, Nitric Acid-Sulfuric Acid Digestion, Nitric Acid-Perchloric Acid Digestion, Nitric Acid-Perchloric Acid Hydrofluoric Acid Digestion, Dry Ashing, Microwave-Assisted Digestion*), Quantitative analysis by AAS, FES and ICPAES: *Only general explanation as this part is covered in detail in Analytical spectroscopy* Sec-I. (**Ref-1:** 3.1-3.35, 3.36-3.67, 3.70-3.71, 3.76-3.78, 3.82-3.84, 3.104-3.105). **c) Inorganic**

non-metal: Introduction, Determination of Anions By Ion Chromatography, Inorganic Anions By Capillary Ion Electrophoresis; Bromide (phenol red method), cyanide, Chlorine (DPD colorimetric method), Fluoride (ion selective method, complexone method), ammonia (titrimetric method, ions elective method and phenate method), NO_2^- - colorimetric method, NO_3^- (nitrate electrode and Cd reduction method), Organic nitrogen by MicroKjeldahl method, Dissolved oxygen (iodometric and membrane electrode method), phosphate (molybadate – $SnCl_2$ - colorimetric method), Sulfide (methylene blue and ion selective method), **d) Organic constituents:** Biochemical oxygen demand, Chemical oxygen demand, total organic carbon, phenols (direct photometric method), surfactants. *(**Ref-1:** 4.1-4.14, 4.17, 4.30-4.31, 4.39-4.46, 4.61, 4.72, 4.86-4.90, 4.114-4.120, 4.124 -4.131, 4.139, 4.114, 4.149, 4.156-4.161, 4.181-4.184, 5.5-5.29, 5.49-5.58, supplementary reference-3 and 4)*

2. Air Pollutants and Analysis of the Atmosphere and Air Pollutants [8 L]

a) Air Pollutants: Explanation only with respect to source and health hazards of: CO, SO_2, NO_x, NH_3, Cl_2 and F_2; Organic Pollutants (Aromatic Hydrocarbons, Carbonyl Compounds, Miscellaneous Oxygen-Containing Compounds, Organonitrogen Compounds, Organohalide Compounds, Organosulfur Compounds, Organic Particulate Matter, Hazardous Air Pollutants Organic Compounds)*(Ref-2: 285 to 329 only relevant information from these pages)*

b) Pollutant Analysis: Atmospheric Monitoring, Air Pollutants Measured, Sampling, Methods of Analysis, determination of Sulfur Dioxide, Nitrogen Oxides, Analysis of Oxidants, Contents, Analysis of Carbon Monoxide, Determination of Hydrocarbons and Organics, Determination of Specific Organics in the Atmosphere, Analysis of Particulate Matter**,** Filtration, Collection by Impactors, Particle Analysis, X-Ray Fluorescence, Determination of Lead in Particulate Matter, Direct Spectrophotometric Analysis of Gaseous Air Pollutants. *(**Ref-2:** 707-718).*

Reference

1.Standard methods for the examination of water and waste water, 23rd Ed. Rodger Baird, Andrew Eatson, Eugene Rice, jointly published by: American Public Health Association, American Water Works Association, Water Environment Federation.

2. EnvironmentalChemistry, Stanley E. Manahan, Ninth Edition, CRC press, Taylor and Francis, 2010.

3. Handbook of Environmental Analysis Chemical Pollutants in Air, Water, Soil, and Solid Wastes by Pradyot Patnaik, Third Edition, CRC press, Taylor and Francis, 2018.

4. Environmental Chemistry, A. K. Day, New Age Publication Company

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in – i) Laboratory automation and sensors, ii) environmental pollution, analysis water and air.
2. Explain instrumentation of automated laboratory analysis and sensors.
3. To describe basic principles of automated laboratory analysis and sensors.
4. Explain importance of automated laboratory analysis and sensors.
5. Describe sources of water and air pollution and pollutants.
6. Describe / explain methods / techniques of sampling of water and air and their analysis.

7. Solve numerical problems on analysis water and air.
8. Draw conclusion regarding water and air quality from analytical results.

CBOP-4, CHA-492: B) Analytical Chemistry of agriculture, Polymer and Detergents [48L + 12T]

Section-I: Agricultural Analytical Chemistry [24 L +6 T]

1. Analysis of soil [10 L]

a) Sampling of soil, sample preparation, Pre-treatment of Samples and Contamination, Trace Element Analysis, Sub-sampling, Drying Techniques, Milling, Grinding and homogenization, **b) Weighing and Dispensing:** Weighing Errors, Dispensing Errors, **c) Acid-digestion, Ashing and Extraction Procedure:** Acid-digestion and Washing: *Acid-digestion of soils, Total soil nitrogen; Microwave acid-digestion, Dry ashing, Nitrate and water-soluble carbohydrate;*Extraction Procedures for soils: *pH extractants, Phosphate extractants, Potassium extractants, Trace element extractants, **d)*** **Analysis of Soil:** Soil Analytical Procedures - Determination of extractable boron, Cation exchange capacity, exchangeable bases and base Saturation, Determination of CEC and exchangeable cations, Measurement of calcium and magnesium by AAS, Measurement of potassium and sodium by flame photometry, Determination of cation exchange capacity (CEC), Determination of effective cation exchange capacity (ECEC), Determination of fulvic and humic acids, Discussion - Determination of available nitrogen, Method-a: Determination of nitrate by selective ion electrode, Discussion - Determination of total mineralized nitrogen, Method-b: Determination of extractable ammonium-N, Method-b: Determination of extractable nitrate-N, Discussion, Determination of organic plus ammonium nitrogen, Method-a: Determination of soil nitrogen by autoanalysis, Method-a: Reduction of nitrate before digestion and colorimetric auto analysis, Method-b: Determination of organic plus ammonium-N by digestion and distillation, Discussion, Determination of soil organic matter, Method-a: Determination of soil organic matter by loss on ignition, Method-b: Determination of easily oxidizable organic C by Tinsley's wet combustion, Discussion 5.8. Determination of pH and lime requirement, Method-a: Measurement of pH, Method-b: Determination of lime requirement, Method-c: Determination of pH in soils with soluble salts, Discussion - Determination of extractable phosphorus, Method-a: Determination of extractable phosphorus (manual method), Method-b: Determination of extractable phosphorus (automated method), Method-c: Determination of resin extractable phosphorus (automated method), Determination of extractable magnesium, potassium and Sodium, Determination of extractable trace elements, Discussion-Determination of extractable sulphur, Method-a. Determination of extractable sulphur (manual method), Method-b. Determination of extractable sulphur (automated method*). **(Ref**-1: 17-35, 50-104, Ref.-2: 1-14, 71-331)*

2. Fertilizer Analysis: [6 L]

Discussion -Determination of total nitrogen in presence of nitrate and organic, Method-a: Determination of total nitrogen in presence of nitrate and organic N, with final determination by distillation, Method-b: Determination of total nitrogen in presence

ofnitrate and organic N, with final determination by auto-analysis, Discussion - Determination of phosphorus in fertilizers, Method-a. Determination of water-soluble phosphorus(extraction), Method-a: Determination of water-soluble phosphorus, (auto-analysis), Method-a: Determination of water-soluble phosphorus(manual method), Method-b. Determination of 2% citric acid-soluble phosphorus– method for basic slags (Thomas phosphate), Method-c: Determination of total phosphorus in the aciddigest from Method-b. with final determination by auto-analysis, Discussion-Determination of potassium in fertilizers, Method-a: Determination of water-soluble potassium, Method-b. Determination of ammonium oxalate-solublepotassium, Method-c: Determination of potassium in the acid digest from, Liming Materials, Determination of the moisture and neutralizingvalue of liming materials, Determination of fineness of grinding. ***(Ref.-1:*** *106-123)*

3. Analysis of Pesticide Residues [8 L]

Preparation of Samples, Collection and Preparation of Soil Samples, Collection and Preparation of Water Samples, **Individual Pesticide Residue Analytical Methods:** Aldicarb(GC), Captafol (GC Method), Captafol (HPLC), Captan (HPLC), Chlorothiophos (GC), Ethylene Thiourea (GC), Folpet (HPLC), 1,naphyl acetic acid (GC), Paraquat (photometric); **Multiple Pesticide Residue Analytical Methods:** Substituted Phenyl Urea Herbicides (GC), Organochlorine and OrganophosphorusPesticides (GC and TLC), Dithiocarbamate and Thiuram Disulphide Fungicides (photometric), Phthalimide fungicides (HPLC). ***(Ref-3:*** *17-23, 87-116, 135-148, 167-172, 241-250, 297- 307, 353-359, 401-406).*

References:

1. Methods in Agricultural Chemical Analysis: A Practical Handbook, N.T. Faithfull, CABI Publishing, Typeset by Wyvern 21 Ltd, Bristol (2002).
2. Soil Sampling and Methods of Analysis, Edited by M.R. Carter E.G. Gregorich, Canadian Society of Soil Science, Second Edition (2008)
3. Manual of PesticideResidue AnalysisVolume I, Edited by Hans-Peter Thier and Hans Zeumer, Pesticides Commission, VCH, New York.

Sec-II: Analytical Chemistry of Polymer and Detergents [24 L +6 T]

Section-II: Polymer Analysis and Detergent analysis

1. Polymer analysis

a. Introduction [1 L]

Introduction and Types of polymers. ***(Ref-1: 1-28)***

b. Identification: [4 L]

Introduction, Preliminary Identification Methods: Solubility, Density, Behaviour on Heating; Infrared Spectroscopy, Raman Spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Ultraviolet-Visible Spectroscopy, Differential Scanning Calorimetry, Mass Spectrometry, Chromatography, Emission Spectroscopy. ***(Ref-1:*** *31-64, Supplimentory-2)*

c. Molecular Weight [3 L]

Introduction, Molecular Weight Calculations, Viscometry, Chromatography, Ultracentrifugation, Osmometry, Light Scattering, End-Group Analysis, Turbidimetric

Titration. *(**Ref-1:** 103-119, Supplimentory-2)*

d. Structural Methodology [4 L]

Introduction, Isomerism, Chain Dimensions, Crystallinity, Orientation, Blends, Thermal Behaviour, Dilatometry, Infrared Spectroscopy, Raman Spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Optical Microscopy, Transmission Electron Microscopy, X-Ray Diffraction, Neutron Scattering,*(**Note:** Thermal Analysis and thermal degradation are excluded as explained in TGA);(**Ref-1:** 121-149, 161-170, Supplimentory-2)*

e. Mechanical Properties [4 L]

Introduction, Stress-Strain Behaviour, Viscous Flow, Viscoelasticity: *Creep, Models, Stress Relaxation*; Elasticity, Processing Methods, Tensile Testing, Flexural Testing, Tear-Strength Testing, Fatigue TestingImpact Testing, Hardness Testing, Viscometry, Dynamic Mechanical Analysis. *(**Ref-1**: 209-233).*

2. Analysis of Surfactants [8 L]

a) Surfactant types; classification, identification, separation: Why analyse surfactants, Features peculiar to surfactant analysis, Basic Definitions (surfactant, anionic surfactant, cationic surfactant, non-ionic surfactant, amphoteric surfactant, weakly acidic and basic surfactants), Common types of surfactants of all four classes, b) **Elemental analysis:** Metals, Determination of nitrogen, Determination of sulphur, Determination of phosphorus. c) **Basic techniques:** Extraction of surfactants (Liquid-solid extraction: *Liquid-liquid extraction using separating funnels, Liquid-liquid extraction using extraction columns),*Acid-base titration**:** *(general principles, end point detection, Determination of weak acids and bases and their salts,* Potentiometric titration:*Principle,Applications, Methods for esters, amines, alcohols and unsaturated fatty materials, Two-phase titration of ionic surfactants with surfactants of opposite charge,Introduction, ISO 2271: Principle and procedure, Potentiometric titration with surfactants of opposite charge using a surfactant-sensitive electrode,Advantages of potentiometric titration, Construction and performance of surfactant-sensitive electrodes, Titration procedure,* Open-column chromatography. d**) Analysis of Representative surfactants: i) Analysis of Anionics:** Introduction,general methods- *Para-toluidine precipitation/titration method,* Analysis of Alkane sulphonates:*Determination of total alkane sulphonate, Determination of mean molecular weight of alkane monosulphonates, Separation and determination of alkane mono- and disulphonates,* Carboxylates: *Titration with benzethonium chloride, Solvent extraction, Acid-base titration, Determination of soaps in fatty products,* **ii)Analysis of nonionics:** Analysis of Ethoxylated alcohols, alkylphenols and fatty acids: *Composition, Determination by potentiometric titration, Determination by the cobaltothiocyanate colorimetric method, Determination of total nonionics and polyethylene glycols, Volumetric determination of polyethylene glycols, Determination of oxyethylene groups, Fatty acid ethoxylates: determination of polyethylene glycols, free fatty acid and mono- and diester;* **iii)Analysis of cationics and amphoterics:** Introduction, Analysis of Quaternary ammonium salts:, *Two-phase titration with sodium dodecyl sulphate, Two-phase titration with sodium tetraphenylborate, Determination of free amine and amine hydrochloride,* Amines:*Determination of molecular weight and total, primary, secondary and tertiary amines*

(Ref-3: 1, 8, 17-24, 31-36, 42-75, 105-109, 119-124, 142-143, 149-160, 171-177, 222-226, 264-280, 310-317, Supplementary reference-4)

Reference

1. Polymer analysis, Barbara H. Stuart, Analytical Techniques in the Sciences (AnTS), John Wiley and Sons Ltd.
2. Analytical Methods forPolymer CharacterizationRui Yang, CRC PressTaylor& Francis Group, 2018
3. Introduction to Surfactant Analysis, Edited by D. C. Cullum, Springer-Science + Business Media, B.V, 1994.
4. Handbook of Detergents, Editor-In-ChiefUri Zoller, Part-C, Heinrich Waldhoff, Rüdiger Spilker, Marcel Dekker, New York, 2005.

Learning Objective - At the end of course students should able to-

1. Define / understand various terms in soil analysis, pesticide residue analysis, detergent analysis and polymer analysis.
2. Explain / describe techniques / methods of soil analysis, pesticide residue analysis, detergent analysis and polymer analysis.
3. To describe basic principles techniques / methodssoil analysis, pesticide residue analysis, detergent analysis and polymer analysis.
4. Explain importance of soil analysis, pesticide residue analysis, detergent analysis and polymer analysis.
5. Choose suitable method / techniques to characterize quality of soli polymer and detergent.
6. Describe / explain results of analysis soil, pesticide residue, detergent and polymer.
7. Solve numerical problems on analysis soil, pesticide residue, detergent and polymer.
8. Draw conclusion regarding soil, detergent and polymer quality from analytical results.

CBOP-5, CHA-493: Practical III

CHA-493-A: Optional Analytical Chemistry Practical

OR

CHA-493-B: Project

CBOP-5, CHA-493: A) Optional Analytical Chemistry Practical [96 L +24 T]

Section-I: Any 12 experiments

1	**Table Work:** Characterization of organic compounds by VU-Visible, IR and NMR spectroscopy (any two compounds, Example- paracetamol and aspirin - actual spectra must be given for analysis)

Analytical Chemistry for Self-Employment: (any five experiments from 2 to 9): Preparation / Isolations Analytical Standards or reference material for analytical laboratories **(Imp. Note:** all these materials can be used for further experiments).

2-3	Solvent extraction: Isolation and purification caffeine. Impurity present if any by TLC. Indian Pharmacopeia Tests: identification tests, MP, loss on drying, Total heavy metal and assay. (Spectral characterization may be performed) (Ref-5)
4-5	Synthesis of Paracetamol (or any other medicinal compound) by green chemistry route and recrystallization. Test as per IP: TLC, MP, Identification tests, limit test for chloride, LOD and assay. (spectral characterization may be performed) (Ref-5 and 4)

6-7	Synthesis, recrystallization of ligands used in analytical chemistry: Example- diethyldithiocarbamate (or other dithiocarbamate ligand), salicylaldehyde ethylenediamine, 8-Hydroxyquinoline, or any other, purity by suitable method. (Packaging and labelling - student self-work).
8	Preparation of Analytical Reagent Kit (any one) which will contain all the reagents for determination of specific analyte, labelling and packaging of reagents and writing of standard protocol to use the kit and testing of kit, detection limits should be mentioned. (such kits are used in commercial analytical laboratories) (You cannot adopt procedures from commercialized kits which available in market). Suggested examples: a student can select other example with permission of his mentor. 1) Analysis of creatinine (trinitrophenol method) (Ref-3) 2) Blood cholesterol (ferric chloride method) (Ref-3) 3) Analysis of proteins by Lowry method (Ref-3, 6) 4) Analysis of reducing sugar by colorimetry method. (Ref-3, 6) 5) Regents for qualitative test of carbohydrates and protein for higher secondary laboratories – Fehling solution-A, Fehling solution-B, Iodine solution, Molisch reagent, Barford reagen, Benedicts reagent, Seliwanoff reagent, Bials reagent, biuret reagent. (Ref-6) 5. Preparation of standard solutions required for limit tests of pharmaceuticals as per I. P. **(Note:** These kits should be used for experiments and can be prepared 1 week before the schedule of such an experiment)
9	Synthesis of Methyl red indicator, purification, MP/ TLC and test for colour change with respect to change in pH of indicator, (packaging and forwarding – student self-work) (Ref-8)
	Chromatographic Methods (any three)
10	Identification of amino acids / sugars / or any other mixture by two-dimensional chromatographic method (TLC or paper) (Ref.-3)
11	Sephadex gel separation of proteins (Ref-6)
12	Determination of molecular weight by gel permission column chromatography (Sephacryl S-200 column) (Ref-6)
13	Separation of leaf pigments by adsorption Chromatography (Ref-6)
14	Separation of amino acids by ion exchange chromatography (Ref-6)
15	Separation of proteins by ion exchange (DEAE cellulose) chromatography (Ref-6)
	Part-III (any three)
16	Analysis of phenolics in Aurvedic solution / syrup preparations / black tea – hence determine their antioxidant activity (Ref-3)
17	Estimation of total proteins Lowry method (Ref-3)
18	Estimation of thiamine by photoflurimetry from multivitamin capsule by

	calibration curve and its confirmation by standard addition method. (Ref-3)
19	Determination of total sugars or Glucose content in glucose supplement by (glucon-D) by titration with Fehling solution (FSSAI manual)
Section – II: 12 experiments from 1 to 23	
Part-I: Volumetric and Gravimetric methods for quantitative analysis of complex materials (Any six)	
1-2	Analysis of Cement for: SiO_2, Calcium, Iron, Magnesium and Aluminium (Ref-1)
3-4	Analysis of mixed fertilizer sample for total nitrogen, K and phosphate content. (Ref-1)
5	Analysis of dolomite ore with respect to SiO_2, Ca and Mg (Ref-1)
6	Analysis of brass alloy for Cu and Sn (Ref-1)
7	Determination of total Ash, Ash Insoluble in Hydrochloric acid, Alkalinity of soluble ash in coffee [FSSAI manual]
8	Separation of Chloride and Bromide on anion exchange resin and quantitative estimation (Ref.-1)
9	Electrogravimetry determination of Cu(II) or Ni(II) (Ref-1)
10	Idetification of form of iodine (qualitative test) in table salt and its quantitative estimation by volumetric method. (Ref. 9)
Part-II: Instrumental Methods of selective analysis from complex materials (Any five)	
10-11	Analysis of fertilizer Micronutrient Supplement for Fe, Mn, Cu, and B. **Colorimetry**: Fe with thiocyanate, Mn as $KMnO_4$, B using curcumin reagent, and Cu using diethyldithiocarbamate ligand. (Ref-1, 2) (any two)
12	Analysis of Chloride, Bromide and Iodide from mixture by potentiometry (Ref-1)
13	Use of ion selective electrodes for determination (F, Cl, Ca, NH_4^+ etc. from water)
14	TGA/DTA analysis of polymer for binders, polymer content, etc. (Ref-7)
15	Determination of Ca in milk powder by flame photometry by standard addition or calibration curve method (FSSAI Manual]
16	Estimation of Fe(III) from detergent by solvent extraction (Ref.-1)
17	Selective estimation of Ni(II) from steel alloy or (Ni(II) -Fe(III) synthetic solution) by solvent extraction (Ref.-1).
Part-III: Ane one of the following	
18	Apply Limit test of heavy metals and iron to Aurvedic medicinal preparations (Ref-4)
19	Determination of total cation in water by cation exchange method (Ref-1)
Students self-activity - Compulsory: Review of five research paper on the same research topic must be performed by an individual students and report must be submitted to the mentor. This is evaluative part of internal assessment. **All the papers must be selected from UGC care list for which mentor should help to the students.**	
Refences	
1. Vogel's Textbook of Inorganic Quantitative Analysis, A. I. Vogel, 3rd Ed.	
2. Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z.	

Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier
3. Lab Manual in biochemistry, immunology and biotechnology, Arti Nigam, Archana Ayyagari, Tat-McGraw-Hill Publication.
4. Indian Pharmacopeia, 7th Ed.
5. Green Chemistry Synthesis, Pawia
6. An introduction to Practical Bichemistry, David T. Plummer, Tata McGraw-Hill Publishing Company Ltd.
7. Polymer Synthesis and Characterization, A Laboratory Manual, Stanely R Sandler, Wolf Karo, Jo-Anne Bonesteel, Eli M Pearce, Published by Academic press (Elsevier).
8. https://pubs.acs.org/doi/pdf/10.1021/ie50163a037, *Org. Synth.* **1922**, *2*, 47DOI: 10.15227/orgsyn.002.0047
9. General Chemistry Experiments by Anil J. Elias

Learning Objective / Course Outcomes- At the end of course students should able to-

1. Maintain proper record of analytical data in notebook. Observer personal safety in laboratory and able handle all chemicals, instruments, etc safely in laboratory.
2. Define / understand various terms involved practical methods of quantitative analysis.
2. To analyse organic and inorganic materials using appropriate chemical / instrumental methods
3. Explain / describe basic principles of chemical / instrumental methods used for analysis. Able to handle particular instrument according to SOP.
4. Perform analysis of sample with described procedure. Able to handle analytical instruments.
5. Apply / select particular method / instrumental parameters for analysis of given sample.
6. Maintain appropriate reaction conditions as described in procedures.
7. To perform i) selective analysis of particular component from sample. ii) Analysis at trace level from sample.
8. To conclude the results able to take the decision regarding quality of sample.
9. To perform calculations and interpret the results.

CBOP-5, CHA-493: B) Project [96 L + 24 T]

a) At least 1/3 students of total strength at M. Sc.-II must be allotted projects

b) Each student will perform project separately. Working hours are same as practical of CHA-493(A) project length should be sufficient and should be equivalent to 24 practical. ***Project report must be written systematically and presented in bound form: The project will consist of Title page, certificate, content, summary of project (2-3 page) followed by introduction (4 to 7 pages), literature survey (4-7) pages (recently published about 30 papers must be included), experimental techniques, results, discussion, conclusions, Appendix consisting of 1) references, 2) standard spectra / data if any and 3) safety precautions.*** If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. ***Systematic record of attendance of project students must be maintained by a mentor.*** Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (20 min.) which will be

followed by question-answer session (10 min). It is open type of examination.

Learning Objective / Course Outcomes- At the end of course students should able to-

1. Maintain proper record of analytical data in note book for research purpose.
2. Perform review of literature related to the topic of project work and design the problem for project work.
3. Decide and describe methodology for problem to solve proposed problem in the form of project. Decide and perform application of research work.
4. To design experiment for research work. Collect the resources, design small equipment, etc. for completion of research work.
5. Collect experimental data (raw data) and analyse the data in the perspective of problem. Present data in graphical forms for the conclusive results.
6. Use computer as a tool for result analysis, presentation and writing the project.
7. To obtain concrete conclusion from the results on the basis of reported theory / research work and analytical results.
8. To perform report writing, scientifically.
9. To write research project / paper in scientific manner.

CCPP-4, CHA-494: Practical II: Applied Analytical Chemistry

[96L + 24T]

Sec-I: Analysis of Pharmaceuticals

Sr. No.	Compulsory Practical
1-4	Total analysis of aspirin as raw material as per Indian Pharmacopeia **except** limit test for arsenic (In assay part perform standardization of HCl). Express result as aspirin content ± Standard deviation. (Ref-1)
Any 4 from 5-9	
5	Tablet dissolution test on paracetamol Indian Pharmacopeia (Ref-1) or UV-absorbance based assay of plane paracetamol table using specific absorbance (British Pharmacopeia). (Ref-4)
6	Analysis of Ca-Gluconate or any Ca-supplementary tablet with respect to identification test, average wt. of 20 tablet, and Ca(II) content per tablet as per Indian Pharmacopeia. Express result as Ca-gluconate content ± Standard deviation. (Perform standardization of Na_2EDTA) (Ref-1)
7	Moisture content by i) Loss on drying of caffeine (oven drying method) and water content of dextrose (anhydrous or monohydrate) by Karl Fischer Method. (Ref-1 and 2)
8	Estimation of Benzocaine after extraction in chloroform by non-aqueous titration (Ref-3) or Estimation of Nicotinamide **or** caffeine by non-aqueous titration method according to IP (Ref-3) [standardize perchloric acid with potassium hydrogen phthalate]
9	Limit Tests for Fe, Ba and nitrate on dibasic calcium phosphate.

Table Work (student self-activity): Analysis of IR spectra **for identification** of at least four pharmaceutical compounds from Indian Pharmacopeia or British Pharmacopeia (Spectrum from IP or BP can be used or you can record the IR spectra and analyse. (Ref-1, Ref-4)

Any 4 from 10-14

10	Determination of NaCl (Cl by potentiometric titration or Na by flame photometry) and Dextrose (by polarimetry) in dextrose – sodium chloride type of saline solution.

	(Ref-1, 3).
11	a) Determination of refractive index of four liquids as per IP. b) Viscosity of ethyl cellulose by Oswald viscometer using viscometer which comply specification of IP.
12	The Determination of Aspirin and caffeine in a Proprietary Analgesic or given mixture by Ultraviolet (UV) Spectrometry. (Ref. – 8)
13	Analysis of Caffeine and benzoic acid from cold drink by HPLC (Ref-6, 9) **Or** HPLC Analysis of an Asthma Medication (Ref-7) **Or** Assay of Omeprazole in Gastro-Resistant Omeprazole Tablets (Solid Preparation) by LC (Ref.-6) **Or** Quantitative Determination of Methyl Parabenin a Prepared Sample by HPLC (Ref-9)
14	Kit method (any two): a) Analysis of glucose from blood or hydrolysed food sample and b) urea from urine, c) Cholesterol from blood or fatty material. d) Creatinine (Ref: Perform experiment as per the instructions of manufacturer of kit).
15	Visit to waste water treatment plant (industry or municipal corporation) and writing a detailed report on methods and parameters used for treatment process. Or Visit to Pharmaceutical Industry and report on function of QC department in pharmaceutical industry

Reference

1) Indian Pharmacopeia Volume I, 7th Ed
2) Indian Pharmacopeia Volume II, 7th Ed
3) Indian Pharmacopeia Vol-III, 7th Ed.
4) Introduction to Pharmaceutical Analytical Chemistry, Stig Pedersen-Bjergaard, Bente Gammelgaard, Trine Grønhaug Halvorsen, Second Edition, Wiley (2012).
5. Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed.
6. Analysis of Soft Drinks: UV Spectrophotometry, Liquid Chromatography, and Capillary Electrophoresis, Journal of Chemical Education, Vol. 75 No. 5 May 1998
7. HPLC Analysis of an Asthma Medication, Man L. Muellerl and Lawrence W. Pott,Journal of Chemical Education, Volume 85 Number 10 October 1988.
8. Experiments in modern analytical chemistry, D. Kealey, Springer Science Business media, 1986.
9. Analytical Chemistry for Technicians, John Kenkel, Third Edition, CRC Press LLC, 2003.

	Section-II
Any four from 1-6	
1	Analysis of waste water /natural water sample for pH, dissolved oxygen, total dissolved salts (conductometry) (Ref-1)
2	Analysis of waste water sample: turbidity, colour, total hardness (Ref-1 and 2)
3	Alkalinity and Buffering capacity of water (Ref-1)
4	COD of waste water sample (Ref-3) (Note: small scale experiment is possible where visible spectrometric method can be used for determination of Cr(VI) (Ref.-2)
5	Aqueous carbonate equilibria and corrosiveness (calcium carbonate saturation) (Ref-1, 2)

6	Biological oxygen demand (Ref-2)
Any two from 7-10	
7	Qualitative test for phosphate in hard water / soil sample /food / detergent and its estimation by colorimetry. (Ref-2, 3, 10)
8	Pre-treatment to sulphide containing water (municipal waste water sample or artificially prepared water containing sulphide) its analysis for sulphide (Ref-2)
9	Determination of Cr(VI) by diphenyl carbazide method.
10	Demonstrating the Presence of Cyanide in Bitter Seeds while Helping **s**tudents Visualize Metal–Cyanide Reduction and Formation in a Copper Complex Reaction. (Ref.: 12,13)
11	Determination anionic detergents from waste water (artificially prepared water sample containing detergent or shampoo which contain sodium lauryl sulphate or ammonium lauryl sulphate) (Ref-1, 2, 3)
Any two from 12-14	
12	Electrochemical treatment to liquid waste (water soluble organics) (Ref-1, 4)
13	Photochemical remediation of pollutants (Ref-1)
14	Chemical mineralization of pollutants by Fenton's Process (Ref-1)
Any two from 15-18	
15	Vit-C in food / Lemon juice / or related juice by titration with 2-6 dichlorophenol indophenol (Ref-6, 7) **or** Estimation of Vitamin-C by reaction with Fe(III) and estimation of Fe(II) colorimetrically. (Ref-5)
16	Determination of total casein and lactose in milk [FSSAI Manual] (Ref.-8)
17	Saponification and iodine value of edible oil (Ref-6)
18	Adulteration Test for Milk and Milk product (Ref-8, 9)
Any two from 19-24	
19	Determination of molecular wt. of anionic detergent (Ref-10: 107-108, 120-121)
20	Determination Critical Micelle Concentration of detergent powder or pure detergent by conductometry / viscometry (Ref.-14)
21	a) Molecular weight of polystyrene by viscometer b) Determination of water absorption by polymer (Ref-11)
22	Determination of chlorine content in PVC (Ref-12)
23	a) Determination of carbon black content in polymer b) Determination of swelling network in polymers (Ref-11)
Students activity	
	Estimation of Glucose – Glucose in different samples can be analysed by i) titration with Fehling solution b) Titration with Iodine c) Colorimetry Folin-Wu method or DNSA method d) Colorimetry-Glucose by oxidase peroxidase method. Samples are – a) glucose in saline (DNS), b) glucose in urine / blood sample c) glucose in glucose supplement d) glucose in food. Give your choice of method for sample assigned to you by your mentor and analyse the sample. **Note:** Such many experiments can be designed by a mentor for internal evaluation of

	a student.

References

1. Environmental Chemistry, Microscale Laboratory Experiments, Jorge G. Ibanez, Margarita Hernandez-Esparza, Carmen Doria-Serrano, Arturo Fregoso-Infante, Mono Mohan Singh, published by Springer.
2. Standard methods for the examination of water and waste water, 23rd Ed. Jointly published by American Public Health Association, American Water Work Association, Water Environment Federation. 2017.
3. Vogel's Textbook Quantitative Chemical Analysis, 6th Ed.
4. Laboratory Experiments on Electrochemical Remediation of the Environment. Part 4: Color Removal of Simulated Wastewater by Electrocoagulation–Electroflotation, Journal of Chemical Education, Vol. 75, No. 8, August 1998.
5. Vitamin C as a Model for a Novel and Approachable Experimental Framework for Investigating Spectrophotometry, Journal of Chemical Education, DOI:10.1021/acs.jchemed.9b00197
6. Biochemical Methods, Third Edition, By S Sadashivan, A. Manickam; New Age International publishers.
7. Lab. Manual: Manual of Methods of Analysis of Foods, Vegatables: Fruit and vegetable products: https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals /FRUITS_AND_VEGETABLE.pdf
8. Manual Of Methods Of Analysis Of Foods Food Safety And Standards Authority Of India Ministry Of Health And Family Welfare Government Of India New Delhi 2015 Milk And Milk Products: https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/MILK_AND_MILK_PRODUCTS.pdf
9. Common milk adulteration and their detection techniques, Azad and Ahmed International Journal of Food Contamination (2016) 3:22 DOI 10.1186/s40550-016-0045-3
10. Introduction to Surfactant Analysis, Edited by D. C. Cullum, Springer-Science + Business Media, B.V, 1994.
11. Experiments in polymer science, D. G. Hundawale, V. D. Athawale, V.R. Kapadi, V.V. Gite, New Age International Publishers.
12. Improved ninhydrin-based reagent for spectrophotometric determination of ppb levels of cyanide, Environmental Forensics, Volume 17, 2016 - **Issue 1**, **https://doi.org/10.1080/15275922.2015.1091404.**
13) Demonstrating the Presence of Cyanide in Bitter Seeds while Helping students Visualize Metal–Cyanide Reduction and Formation in a Copper Complex Reaction, *J. Chem. Educ.* 2016, 93, 5, 891-897.
14. Practical Physical Chemistry, Viswanathan B., Raghawan, Viva Books

Learning Objective –

At the end of course students should able to-

1. Maintain proper record of analytical data in notebook. Observer personal safety in laboratory and able handle all chemicals, instruments, etc safely in laboratory.

2. Define / understand various terms involved practical methods of quantitative analysis.
3. To analyse organic and inorganic materials using appropriate chemical / instrumental methods
4. Explain / describe basic principles of chemical / instrumental methods used for analysis. Able to handle particular instrument according to SOP.
5. Perform analysis of sample with described procedure. Able to handle analytical instruments.
6. Apply / select particular method / instrumental parameters for analysis of given sample.
7. Maintain appropriate reaction conditions as described in procedures.
8. To perform i) selective analysis of particular component from sample. ii) Analysis at trace level from sample.
9. To conclude the results able to take the decision regarding quality of sample.
10. To perform calculations and interpret the results.

Important Notes for Practical Courses of all Subjects

1. For all three practical papers - ***Journal should be completed by the candidate on the same day before leaving of the lab***. *This is to i) avid manipulation of data by a student ii) make habitual of writing the experimental data and calculations systematically.* Chance should not be given to manipulate original data to the candidate. In fact, many students adjust or manipulate data from their lab work very close to expected or theoretical values. If journal is completed before leaving the lab it will not encourage students to "adjust" the facts from their lab work. (**Ref-Journal of Chemical Education, Min J. Yang and George F. Atkinson, Designing New Undergraduate Experiments, Vol. 75, No. 7, July 1998**). Higher marks should be given in internal evaluation to the systematic working and accuracy of the results and not to the journal writing.
2. Laboratory safety rules must be followed by all the students and Chemistry Department should take care of safety laboratory. Wherever required personal protective equipments must be used. A student without laboratory coat and foot wares should not be allowed in laboratory.
3. Chemistry Department should make appropriate arrangement of waste chemical treatment and management.
4. Reference books / experimental procedure should be made available to the students before laboratory hours. Before each practical, mentor must discuss procedure, precautions and safety guidelines with students.
6. During start of the practical course students should be discussed with methodology of internal evaluation. Internal evaluation is continuous type (CA). Hence during each practical, internal evaluation must be done with different tools. **Guideline for internal evaluation:** To each practical 30 marks can be assigned which can be distributed as follows:

Overall performance	Discussions during practical	Accuracy of results	Lab report / Journal	Post laboratory quiz / assignment / oral
6	4	8	6	6

At the end of semester, average marks of 24 experiments are assigned as marks of internal

evaluation i.e. out of 30. Systematic record of internal evaluation must be maintained which is duly sign by mentor and student.

For absentee of a student in regular practical zero marks will be assigned. However, pre-intimation absentee will be allowed but student have to complete the experiment in the same week with the permission of your mentor.

5. Printed journal *is allowed. It should consist of Name of the student, Roll No.(first page of each experiment), date, name of experiment, principle, special instructions regarding the safety precautions and special care to be taken (if any), chemicals, apparatus, brief procedure and blank tables is allowed. It should* ***not contain*** *any details of calculations, dilutions factors, calculated amounts, reactions, and structures. At the end 5 to 7 tricky questions on experiment should be given for solving and it is compulsory activity.*

6. Wherever possible use / prepare minimum amounts / required amounts of solutions. Use micro burette for titrations involving instrumental methods. Micropipettes shall be used for measuring small volumes accurately which helpful to prepare small volumes of solutions for instrumental analysis. For flame photometry / AAS typically 10 ml solution is sufficient, HPLC – 1-5 ml, colorimetry / spectrophotometry 5 ml, etc.

7. Similar strategy can be used for internal evaluation of a candidate performing project.

8. In colorimetric estimation ***do not prepare more than 5 ml solution*** for measurement of absorbance. Add all of the reagent with micro-burette or 1 / 2 ml graduated pipette so that student will ***not require volumetric flask***. If possible, use **1 ml cuvette** with spectrophotometers (It is available in market). Solvent extraction procedure can be typically performed with total 5-ml organic solvents to decrease toxic waste.

9. Wherever feasible develop and practice micro or semi-micro methods form known / recommended procedures from the reference books. This is to i) minimization cost of experiment ii) decreases wastage of chemicals iii) decrease environmental pollution.

10. Avoid use of toxic chemicals and reagents. If possible, replace toxic reagent by non-toxic or less toxic reagent. Example: in volumetric estimation of Fe (III) $SnCl_2$ and then $HgCl_2$ is used to convert Fe (III) to Fe(II). Sn (IV) and Hg(I) produced in reaction are toxic. This can be done by using Zn metal powder. Avoid use of $K_2Cr_2O_7$, and no alternative prepare minimum /required amount of it.

11. Wherever required, s***tandardize $Na_2S_2O_3$ with oven dried KIO_3 in place of $K_2Cr_2O_7$ as Cr(VI) is carcinogenic and mutagenic.***

12. By trial replace $CHCl_3$ by other extracting solvents as chlorinated solvents are highly toxic.

13. Metal like Ag can be recovered after experiment. Device suitable method.

14. Wherever possible replace calomel electrode by Ag/AgCl reference electrode as Calomel consists of toxic element Hg and Hg(I). (**Ref-Student Construction of a Gel-Filled Ag/AgCl Reference Electrode for Use in a Potentiometric Titration, Journal of Chemical Education, Vol. 76, No. 1, January 1999).**

15. College / Chemistry Department of the respective college must follow all the rules of EPA / WHO regarding the toxic waste management of the chemistry laboratory produced during practical.

16. In each practical course a mentor can introduce one or two Novel experiment of

analytical chemistry. Experiment should be equivalent to one practical session (4 h duration) or two practical sessions (long experiment). For such replacement students can be exempted one or two regular experiment respectively. A teacher can promote to a student for such Novel analytical chemistry experiments provided that department is ready to support such experiment. The newly introduced experiment will be the inherent part of **external** evaluation. Example-identification and estimation of melamine from milk powder, pesticide residue from vegetables, estimation of As(III) from bore well water, synthesis / extraction of novel organic compound and its total spectral characterization, etc.

6. M. Sc.(II) Biochemistry

Outline for Semester III and IV – Biochemistry

Paper No.	Course name	Credits
	Semester III	
CCTP-7, BCH-311	Molecular Biology	4
CCTP-8, BCH-312	Immunology	4
CCTP-9, BCH-313	Recombinant DNA Technology	4
CBOP-3, BCH-314 (any one)	**CHB-314(A):** Bio-processing and Industrial Biochemistry	4
	CHB-314(B): Pharmacology and Forensic Biochemistry	4
CCPP-3, BCH-315 Practical I	Practical I: Molecular Biology and Immunological techniques	4
	Semester IV	
CCTP-10, BCH-411	Neurochemistry & Endocrinology	4
CCTP-11, BCH-412	Medical and Physiological Biochemistry	4
CBOP-4, BCH-413 (any one)	**CHB-413(A):** Evolution and developmental biology	4
	CHB-413(B): Clinical Nutrition and Food Technology	4
CBOP-4, BCH-414 (any one) Practical III	**CHB-414(**A): Principles Of Downstream Techniques In Bioprocess	4
	CHB-414(B): Clinical Biochemistry and Research Methodology (Presentation of research paper/Preparation of research project) Data interpretation	4
CCPP-4, BCH-415 Practical II	Project	4

Detailed course-wise Syllabus of M. Sc-II, Biochemistry

SEMESTER III

CCTP-7, BCH-311: Molecular Biology [48L + 12T]

Section I: [24L + 6T]

1. DNA Replication: Enzymes involved in DNA synthesis e.g. topoisomerase, helicase,ligase and others. DNA polymerase I, II, III, origin of locus, Okazaki fragments,replication fork. Mechanism in Prokaryotes and Eukaryotes.
2. DNA Repair: DNA damages, detection and repair systems. Pyrimidine dimer formationand its repair. DNA damage and repair mechanisms : Introduction, DNA damage, types of DNA repair and their mechanisms – Direct repair, Base excision repair, Nucleotide excision repair, mismatch repair, recombinational repair, SOS repair; DNA repair genes, role of P53 gene in DNA repair and apoptosis
3. Gene rearrangements: Recombination pathways, Holliday structures, rec A,B,C,D. SOS response, mobile genetic elements, Transposable Elements.
4. Transcription and splicing: RNA polymerases, promoters, sigma and Rho factors,initiation,

elongation and termination of transcription (Prokaryotes), Inhibitors oftranscription. Transcription in Eukaryotes, RNA pol I,II,III, enhancers. Posttranscriptional modifications of t,r and m-RNA, 5' capping, 3' poly A tailing, RNAediting, Transcription factors.
5. Splicing: Splicing phenomenon. Mechanism, spliceosomes, alternative splicing, selfsplicing, ribozyme (catalytic RNA).

Section: II [24L + 6T]

1. Translation: Role of t-RNA and Ribosome in protein synthesis. Mechanism inProkaryotes and Eukaryotes. Epigenetic modification.
2. Protein targeting
3. Protein trafficking
4. Proteasomal degradation
5. Genome protection (RNAi, CRISPR-Cas9) Bacterial Defence Mechanism

Reference Books

1. Biochemistry (III/IV/V/VI edition, 2008) L. Stryer, WH Freeman and Co.
2. Molecular biology of the gene (V edition, 2004) J D Watson, Person education Inc.
3. Molecular Cell Biology (7th edition.2013) by Harvey Lodish et al.
4. Molecular biology of the cell (2008) B. Alberts, Garland Pub. In., NY
5. Genes X (2010), B. Lewin, John Wiley and sons, NY.
6. CRISPR-Cas: Converting A Bacterial Defence Mechanism into A State-of-the-Art Genetic Manipulation Tool, Antibiotics (Basel). 2019 Mar; 8(1): 18.

CCTP-8, BCH-312: Immunology [48L + 12T]

Section I: **[24L + 6T]**

1. Cellular basis of immunity: immunological memory, specificity, diversity, discrimination between self and non self, primary and secondary lymphoid organs, T and B lymphocytes, T cell subpopulation,
2. Innate Immunity, mechanism barriers against infection, PRRs,TLR, innate versus adaptive immunity, cells of the immune system, phagocytic cells engulf and kill microorganisms, complement facilitates phagocytosis, complement mediated acute inflammatory reaction, humoral mechanism provide an additional defensive strategy, extracellular killing , cytokines, cell mediated and humoral immune responses, Clonal selection theory of antibody production, monoclonal and polyclonal antibodies, catalytic antibodies (abzymes)

3. Antigen: Antigen, antigenic determinant, Blood antigens: blood group substances and Rh factor, super antigens, Lipopolysaccharides, Adjuvant complete and incomplete antigen

4. Ig super family: Tcell receptor, B cell receptor, MHC I & II structure, CD receptors. Antibody: structure of antibody, constant and variable regions, Fab, F(ab2) and Fc fragments, different classes of antibodies and their functions, fine structures of antibodies, X ray diffraction studies, isotypes, allotypes and idiotypes,

5. Organization and Expression of Immunoglobulin Genes. Genetic Model Compatible with Ig Structure, Multi-gene Organization of Ig Genes: variable gene rearrangement, generation of antibody diversity and class switching among constant region genes. Expression of Ig genes, synthesis, assembly and secretion of immunoglobulins. Regulation of Ig-Gene transcription, antibody genes and antibody engineering.

6. Major Histocompatibility Complex: General Organization and Inheritance of the MHC,MHC molecules and genes , Detailed Genomic Map of MHC Genes, Cellular Distribution of MHC molecules , Regulation of MHC Expression , MHC and Immune

Responsiveness

Section II: [24L + 6T]

1. Antigen Processing and Presentation: Self-MHC Restriction of T Cells, Role of Antigen-Presenting Cells , Evidence for Two Processing and Presentation Pathways, Endogenous Antigens: The Cytosolic Pathway, Exogenous Antigens: The Endocytic Pathway , Presentation of Nonpeptide Antigens
2. Immunodeficiency: primary B-cell deficiency, primary T cell deficiency, SCID, AIDS
3. Hypersensitivity: Type I anaphylactic hypersensitivity, Type II antibody dependant cytotoxic hypersensitivity, Type III immunecomplex mediated hypersensitivity, Type IV DTH, Type V Stimulatory Hypersensitivity, Mast cells, eosinophils, basophils.
4. Transplantation: graft rejection, types of grafts,types of rejection, mechanism of graft rejection, graft versus host response.
5. Tumor immunology: classes of tumor antigens,immune response to tumor, approaches to cancer immunotherapy , CAR-T cell therapy.
6. Autoimmune diseases
7. Immunological techniques: immuno-diffusion, immunoelectrophoresis, radioimmunoassay, immunofluorescence, ELISA, Western blotting, FACS, ChIP assay, FISH.
8. Vaccines : Passively acquired immunity,Principles of vaccination, Killed organisms as vaccines,Live attenuated organisms, Subunit vaccines, Newer approaches to vaccine development, Current vaccines,Vaccines under development

Reference:

1. Essential immunology; Ivan Roitt, 13 th edition
2. Kuby-Immunology 8th edition
3. Fundamental Immunology; William E. Paul 7th edition

CCTP-9, BCH-313: Recombinant DNA Technology [48L + 12T]

Section I: [24L + 6T]

1.Isolation and Quantification of DNA
2. Genetic engineering concepts: Early development in genetics, concept of gene cloning and its importance.
3. Promoter analysis. Chip-seq assay, EMSA
4. Manipulation of DNA: Enzymes in genetic engineering, Restriction endonucleases, restriction map, Ligase, polymerase modifying enzymes, ligation; putting sticky ends to blunt ended molecules.
5. Cloning and expression vectors: Vectors for *E. coli*: Plasmids, M 13 bacteriophage vectors, λ bacteriophage,. Eukaryotic cloning vectors: Cloning vectors for yeast, cloning vectors for higher plants, Ti plasmid, cloning vectors for insects, viruses as cloning vectors for mammals.
6. Introduction of DNA in living cells: Transformation/ transfection methods, identification of recombinants. Selection of recombinant DNA.
7. Construction of genomic and cDNA library.
8. Expression of foreign gene: gene expression in *E. coli*, production of recombinant proteins in eukaryotes, fungi, yeast, mammalian and insect cells systems.

Section II: [24L + 6T]

1. Polymerase chain reaction: concept, types, methods and applications.
2. Sequencing genes and genomes: chain termination using ddNTPs, NGS: Oxford Nanopore, PacBio and Illumina technologies, pyrosequencing.
3. Gene Expression analysis: qPCR: delta-delta Ct method, SYBR Green and TaqMan, NGS, Northern bolting,
4. Transgenic animals: Gene transfer strategies, production of recombinant proteins and other

applications.
5. Protein Engineering: In vitro mutagenesis, Oligonucleotide directed, PCR based, applications of protein engineering.
6. Study of genomes: genome annotations, study of transcriptome, proteome.
7. RNA interference: miRNA, siRNA.
8. Genome editing: Meganucleases, talen, Zinc finger nucleases, CRISPR/Cas9
9. Reporter Genes, GUS assay.
10. Human genome project: Project period and accomplishment, Genome mapping approach, Application and proposed benefits, Ethical, Social and legal issues.

Reference Books

1. Gene cloning- An introduction, T.A Brown, 2nd and 3rd ed, Chapman &Hall.
2. Recombinant DNA- genes and genomes a short course JD Watson, R.M.Myers, A.M.Caudy, J.A.Witkowski, WH Freeman &Co. 2007 (II/ III rded)
3. Principles of gene manipulation, SB Primrose.
4. Principles and Techniques of Biochemistry and Molecular Biology, K Wilson and J Walker, 7th edn
5. Molecular Cloning: A Laboratory Manual (Fourth Edition) Michael R. Green & Joseph Sambrook
6. Genetic Engineering, SmitaRastogi, Neelam Pathak, Oxford University press, 2009.

CBOP-3, BCH-314: (Any one subject) ,

BCH-314(A): Bio-processing and Industrial Biochemistry [48L + 12T]

OR BCH-314(B): Pharmacology and Forensic Biochemistry [48L + 12T]

CBOP-3, BCH-314(A): Bio-processing and Industrial Biochemistry [24L + 6T]

Section I: Bio-processing [24L + 6T]

1. Characteristics of industrial microorganisms
2. Strain improvement, use of auxotrophic mutants
3. Methods and parameters of cultivation of microorganisms , media for industrial fermentation
4. Fermenters, design of fermenters, fermentation process, and maintenance of aseptic conditions, aeration and agitation.
5. Downstream processing, recovery and purification of fermentation products, effluent treatment.
6. Applications of fermentation technology.
7. Manufacturing by fermentative process: beer, Citric acid, Glutamic acid, lipase, Penicillin, L-asparginase, cephalosporin.

Reference Books

1. Principles of Fermentation technology, PF Stanbury, A Whitaker, SJ Hall (2008)
2. Molecular biology and biotechnology- edited by JM Walker and FB Gingold, Royal society of chemistry 5th edition (2009)
3. Industrial Microbiology – Casida 2nd edition (2016).
4. General Microbiology Stainer R.Y. et al (1987) 5th Ed., Macmillan Press Ltd. London

Section II: Industrial Biochemistry [24L + 6T]

1. Media requirements: Sterilization and role of growth regulators, Requirements of aplant tissue culture laboratory.
2. PTC Techniques: Callus and cell suspension culture, Micropropogation, Conditioning of tissue culture plants (weaning and hardening),Somatic cell hybridization, Haploid (anther) culture, Embryo culture, Protoplast fusion, Somatic embryogenesis, Somaclonal variations, Cybrids and Allopheny, Agrobacterium mediated hairy root culture
3. Active principles in medicinal plants and phytochemistry of the metabolites of medicinal

importance.

Animal tissue culture

1. Media requirements: preparation of medium and sterilization techniques, Advantages and disadvantages of natural and synthetic media.
2. Cell culture methods: Hanging drop, suspension and monolayer culture, Behavior and characteristics of cells in culture, Primary and established cell lines, characteristics of transformed cells, Methods of cell preservation.
3. ATC techniques: Primary cultures and secondary cultures, cloning, heterocaryons, variant cells, contact inhibitions, Organ culture and cell and tissue banking

Reference Books:

1. Principle and practice of Animal tissue culture by SudhaGangal, 2nd edition (2010).
2. Tissue Culture by John Paul, 4th edition (1970).
3. Plant cell tissue and Organ culture by Gamborg Phillips (1995).
4. Plant tissue culture basic and applied T B JhaandB Gosh (2005).
5. Culture of Animal Cells by Ian Freshney 6th edition (2011)

CBOP-3, BCH-314(B): Pharmacology and Forensic Biochemistry [48L + 12T]

Section I: Pharmacology [24L + 6T]

1. Concept of evidence-based medicine, Importance of Biochemistry and pharmacy: Metabolites and anti-metabolites;
2. Drugs - Classification of drugs, routes of drug administration. Receptor interaction, involvement of binding forces in drug receptor interaction, drug action not mediated by receptors
3. Pharrmacokinetic considerations: drug absorption, distribution, biotransformations and excretion
4. Pharmacokinetic concepts of bioavailability, apparent volume of distribution (aVd), half life (t½), and clearance (CL) that are used to decide the doses and rational dosing during the drug treatment.
5. Pharmacodynamics; site and mechanism of drug action, drug receptors and receptor regulation, concepts of agonists, antagonists, partial agonist and inverse agonist drugs
6. Drug interactions and concept of pharmacogenomics/-genetics in drug action, effects and ADRs
7. Adverse drug reactions (ADRs) and role of pharmacovigilance activity in ADR monitoring
8. Drug Development: Challenges, Discovery, use of genomes for drug discovery, stages of drug development.

Section II: Forensic Biochemistry [24L + 6T]

1. Forensic Toxicology: - Introduction and concept of forensic toxicological. Different areas of toxicology, spectrum of toxic dose, risk and safety. Classification of toxic agents, characteristics of exposure, route and site of exposure. Duration of frequency of exposure. Spectrum of undesired effects: Allergic reactions, Idiosyncratic reactions, Immediate verses delayed toxicity, Reversible verses irreversible toxicity, Local verses systemic toxicity. Interaction of chemicals, Tolerance, Dose response. Selective toxicity.
2. Evaluation of Toxicity: Descriptive Animal toxicity tests: Acute lethality, Sub acute, sub chronic and chronic toxicity testing. Teratology and reproduction, Mutagenecity.
3. Biotransformation of toxicants: Phase I and II biotransformation reactions, Detoxication and toxication. Components of Cytochrome P-450 monooxygenase system. Mechanism of phase I and II reactions. Bioactvation, Toxicity of insecticides/drugs i.e. carbamates, organophosphorous, and chlorinated insecticides metals, animal and plant toxins, solvents and vapors.
4. Applications of toxicology: forensic, clinical and occupational health and industrial

hygeine
5. Enzymes in forensic biochemistry, role of DNA in analysis, role of enzymes to determine the times since death.

Reference books:

1. Haye's principles and methods of Toxicology Ed. A Wallace Hayes, Pub. Raven press, NY, 6th Edition (2014).
2. Casarett and Doull's Toxicology ed. John Doull, Curtio D Kleassen and Mary D Aunder, McMillan publisher Co, NY, 3rd edition (2003).
3. Appraisal of the safety of chemicals in foods, drugs and cosmetics. Ed. The Editorial Committee of Association of Food and Drug Officials of the United States (1959).
4. Toxicology- Mechanisms and analytical methods, Vol I and II, ed Stewart CP and Stolman A, Pub Academic press (1960).
5. Veterinary toxicology by RJ Garner edBeilliere, tindall and Cox London, 3rd edition (2007). 6. The chemistry and microbiology of pollution (1975) IJ Higgins and RG Burns Acad Press, NY 7. Introduction to ecological biochemistry JB HarboneAcad Press, NY 4th edition (2004).

CCPP-3, BCH- 315: Practical, Molecular Biology and Immunological techniques

[96L + 24T]

Molecular Biology

1. Melting Temperature
2. Spectrophotometric analysis of nucleic acids
3. Primer Designing
4. DNA amplification (PCR)
5. Isolation of plasmid DNA
6. Restriction digestion of DNA
7. Ligation
8. Competent cell preparation
9. Transformation
10. Agarose gel electrophoresis of DNA and molecular size determination.

Immunological techniques.

1. Blood group typing, Rh blood typing
2. Ouchterlony double diffusion assay
3. Single Radial immunodiffusion
4. Immunoelectrophoresis
5. Rocket immunoelectrophoresis
6. ELISA
7. WIDAL Test
8. Lateral flow immunodiffisuion assay
9. Separation and purification of Immunoglobulin
10. Western Blotting (Demo Experiment)
11. Quantitative precipitin assay

12. Reverse blood grouping

SEMESTER IV

CCTP-10, BCH-411: Neurochemistry& Endocrinology [48L + 12T]

Section I: Neurochemistry [24L + 6T]

1. Brain and behavior, Nerve cells and behavior
2. Anatomical organization: Central nervous system, spinal cord, different regions of the brain, peripheral and autonomic nervous system afferent and efferent pathways.

3. Neurotransmitters: Synthesis, storage, uptake degradation and action of neurotransmitters. Acetyl choline, GABA, Serotonin, Dopamine, Glutamate Aspartate, Nitrous Oxide etc., Neuropeptides.
4. Receptors: Types of receptors, properties of receptors, sensory modalities and sensory circuits. Sensory perception, cerebrospinal fluid, blood- brain barrier.
5. Learning and memory: Mechanism of short term memory and long term potentiation. NMDA and AMPA glutamate receptors. Retrograde messengers in synaptic transmission. Role of CAM kinase II, Calcium, Protein kinase, CAMP, NO, Calpain and other proteins in memory and learning process.
6. Circadian rhythms.

Reference books

1. Text book of physiology- Guyton, 12th edition (2010)
2. Principles of neural science Kandel ER, Schwartz JH, Elsevier, N.Holland, NY, 5th edition (1991)
3. Neurobiology, Shepherd GM , Oxford Univ. Press (1993).
4. Nerve and muscle excitation Junge D, Sinauerassoc, Sanderland, mass (1976).
5. Biochemistry , L Stryer, Freeman and Co, NY, 8th edition (2015).
6. Biochemistry, Zubay, Addison Wesley and Co.2nd edition (1994)

Section II: Endocrinology [24L + 6T]

1. General characteristics of hormones: chemistry, structure, synthesis, secretion, transport, metabolism & mechanism of action of hormones of the thyroid, hypothalamus, pituitary, pancreas, adrenals, glands, prostaglandins and gastro intestinal hormones, secondary messengers and their mode of action, calcium signaling, zinc fingers.
2. Disorders related to hormones.
3. Cell membranes and intracellular receptors for hormones.
4. Hormonal inter relationship.
5. Biosynthesis of steroid hormones, cholera toxin, adenylate cyclase and TP, hormone overproduction and target cell insensitivity.
6. EGF, NGF, PDGF, Enkephalin.

Reference books:

1. Vertebrate endocrinology- Noris DO 5th ed (2013).
2. Endocrine physiology- Martin, CR (1985(O xfordUniv press (NY)
3. Physiological chemistry –Harper 17ed Lange medical
4. Biochemistry- Zubay (1983) Addison, Wesley publ. Co.
5. Text book of endocrinology –Williams, 13th edition Saundes Co (2016).
6. Biochemical endocrinology E. Frieden (1983)

CCTP-11, BCH-412: Medical and Physiological Biochemistry [48L + 12T]

Section I: Medical Biochemistry: [24L + 6T]

1. Mechanism of action at molecular level of selected antibiotics: inhibitors of cell wall, plasma membrane, nucleic acids and protein synthesis. Mechanism of action of anti metabolites, analgesics, hallucinogens, antiviral, antifungal, antiprotozoal and mechanism of resistance to antibiotics and other drugs.
2. Lysosomes and their physiological role: Structure and function of lysosomes, role in animal and plant cells. Physiological role in various types of digestive phenomenon disturbances to lysosomes (lysosomal pathology), lysosomal storage disease.
3. Molecular basis of hemoglobinopathies: concept of hemoglobinopathies, β and α thalassemia's, sickle cell anemia, pathophysiology, biochemistry, types of mutations.
4. Ischemic heart disease/CHD: myocardial infarction and coronary heart diseases (pathophysiology); laboratory findings, enzymes involved.
5. Cancer: carcinogenesis, microevolution process, molecular genetics of cancer, causative

agents, role of viruses.
6. Biochemistry of diseases: Influenza: life cycle, transmission, biochemical mechanism, Malaria: epidemiology, life cycle, biochemical mechanism; Alzheimer: dementia, biochemical mechanism, formation and tangles and plaques.
7. Apoptosis: extrinsic and intrinsic mechanism, role in diseases and physiology.

Reference Books

1. Biochemistry of antimicrobial action (4th ed) TJ Franklin, Chapman hall (1989)
2. Mechanism of microbial diseases, M Schaechter et al,Williams and Wilkino Int. 5th Ed.(2012)
3. Microbiology an application based approach, M.J Pelczar, ECS Chan, N.R.Krieg (2009).
4. Biochemistry, L Stryer (3rd ed), Freeman and Co, 8th edition (2015).
5. Biochemical aspects of human diseases (1983), RL Elkeles, Slackwell scientific publishers,Oxford
6. Biochemistry and diseases, Robert Cohn Carl S Roth (1996).
7. Molecular biology of the cell, third edition, Bruce Alberts, Dennis Bray, Julian Lewis, Martin Raff, JD Watson, 6th edition (2014).

Section II: Physiological biochemistry [24L + 6T]

1. Liver: anatomy, physiological functions, Liver function tests, Liver disorders:- hepatitis, cirrhosis, Jaundice: etiology and symptoms.
2. Kidney: anatomy, physiological functions, diseases/disorder, diagnostic tests.
3. Respiration: Principles of gaseous exchange during respiration, Bohr effect, transport of oxygen and carbon dioxide in the blood, regulation of respiration.
4. Digestion and Absorption of food: Generalized structure of digestive tract and associated digestive gland. Function of different parts- peristalsis, regulation of saliva, gastric, pancreatic, Intestinal and bile secretion (i.e. digestion), Absorption – (carbohydrate, protein, lipid, minerals and vitamin) transport and excretion of nutrients.
5. Biochemistry of blood clotting ,clotting factors, intrinsic and extrinsic pathways, mechanism of formation of thrombin, fibrin, fibrin clot, role of vitamin K clotting process, lysis of fibrin clot. Conditions that cause excessive bleeding in humans.
6. Regulation of acid-base balance, types and functions of acid-base buffers, clinical abnormalities associated with acid-base imbalance.
7. Water and Mineral metabolism.

Reference Books

1. Biochemistry, L Stryer, Freeman and Co, NY, VI edition (2008).
2. Biochemistry, Zubay, Addison Wesley and Co. (1983).
3. Textbook of Physiology, Guyton, 12th edition (2010).
4. Physiology, Berne and Levy, 7th edition (2017).
5. Harper's Biochemistry- 30th edition (2015).
6. Text book of Biochemistry and Human Biology - Ed. G. P. Talwar (2002).

CBOP-4, BCH-413 (Any one), BCH-413 (A): Evolution and developmental biology
OR BCH-413 (B): Clinical Nutrition and Food Technology

CBOP-4, BCH-413 (A): Evolution and developmental biology [48L + 12T]

Section I: Evolution [24L + 6T]

1. Theories of Evolution.-the time scale and some evolutionary principles. Chemical evolution and origin of life. Prototypes of metabolic pathways.
2. Genesis of oxygen generating photosynthesis and aerobic respiration. Methanogensevolution of prokaryotes
3. Evolution of protists
4. Origin of eukaryotes

5. Theories regarding origin of mitochondria and chloroplast, the five kingdom classification of living organisms, outline of eukaryote evolution- evolution of primates.
6. Construction of phylogenetic trees- molecular data set based on sequences
7. Evolution of proteins and nucleic acid – elastic analysis.
8. Evolution of introns
9. Evolutionary view of exon domain relationships

Section II: DEVELOPMENTAL BIOLOGY [24L + 6T]

1) Basic concepts of development : Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development
2) Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.
3) Morphogenesis and organogenesis in animals : Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick; organogenesis – vulva formation in Caenorhabditis elegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
4) Programmed cell death, aging and senescence
5) Developmental Biology—Cell differentiation, hierarchy of genes, measurement of time during development, nature of differentiation, DNA rearrangements& amplification, genetic control of morphogenesis, plant molecular genetics.

Reference Books:

1. Evolution and Diversity of life, E. Mayer Belknap Press Pub, 1976
2. Population species and evolution (1973), E Mayer Press Pub.
3. Biochemistry ,Lehninger 7th edition, (2012) Worth pub
4. Origin of Eukaryotic cells, Margulis L.(1977)
5. Developmental Biology: Scott F. Gilbert.
6 . Evolution and Diversity of life, E. Mayer Belknap Press Pub, 1976
7. Population species and evolution (1973), E Mayer Press Pub.
8. Origin of Eukaryotic cells, Margulis L.(1977)

CBOP-4 , BCH-413 (B): Clinical Nutrition and Food Technology [48L + 12T]

Section I: Clinical Nutrition: [24L + 6T]

1. Diet and nutrition in India: Assessment of nutritional status
2. Food and Nutritional Security
3. Effects of irradiation, cooking, refining, sprouting and fermentation on nutritional quality of food
4. Food Habits, Food Faddism and Nutrition
5. Interrelationship between dietary lipids and cholesterol metabolism
6. Malnutrition
7. Weight Management and Eating Disorders
8. Nutrition and Anemia
9. Food Allergy
10. Nutrition and metabolic disorders: Diabetic and Obesity
11. Factors affecting digestion and absorption of food

12. Dietary fiber- chemical composition and importance
13. Physiological effects and metabolic adaptation during exercise
14. Nutritional management of inborn errors of metabolism

Reference books:

1. Essentials of food and nutrition M Swaminathan Vol. II, Applied aspects (1974), Ganesh Pub, Madras
2. Human biochemistry – James Orten and Otto Neuhaus, 10th ed , CV Mosby co London
3. Human nutrition and dietetics-Davidson and Passmore

Section II: Food Technology: [24L + 6T]

1. Concepts of food analysis; Rules and regulations of food analysis
2. Monitoring food quality: Hazard Analysis and Critical Control Point, Good manufacturing practices, current good manufacturing practices; Standard operating procedures, good laboratory practices
3. Biochemistry of food spoilage, principles of food preservations , methods of food preservation
4. Proteins from unconventional sources- OCP, SCP etc
5. Starch production, manufacture of natural and synthetic sweeteners and syrups
6. Enzymes in food analysis, alcohol, amino acids, glucose
7. Enzymes in food processing, meat tenderization and fruit juice technology
8. Food additives, starches, sugars, syrups and sweeteners, flavoring agents, colors Food preservatives. Role and mode of action of salts, chelating agents, stabilizers and thickeners; Humectants/polyhydric alcohol, anti-caking agent, firming agent, flour bleaching and maturing agents, antioxidants, nutritional and non-nutritional

sweeteners;

9. Food Laws: FSSAI, AGMARK, BIS, FPO, Weights and Measures Act ,CODEX
10. Genetically modified foods

Reference books:

1. Enzymes and food processing- GG Birch, N Blackbrough (1981)
2. Nutrition and food processing- MG Miller , G Tobin, AVI publishing Co, Creem Holm (1980)
3. Introduction to food sciences and technology –GF Stewart and MA Amerine (1973) Academic Press

CBOP-5, BCH-414 : Practical, Any One Subject

BCH-414 (A): Principles Of Downstream Techniques In Bioprocess **OR**
BCH-414 (B): Clinical Biochemistry and Research Methodology

BCH-414 (A): Industrial Biochemistry [96L + 24T]

1. Ethanol production using bio wastes /raw material [Free cells/ immobilized cells]
2. Microbial production of glutamic acid/citric acid
3. Biotransformation (Enzymatic/Immobilized enzyme)
4. Production of wine from grapes.
5. Extraction, isolation, partial purification (if necessary), calculation of percentage yield and performing a confirmatory test for the following:(Any one)
    1. Carbohydrates:
    a. Cellulose
    b. Glycogen from Liver
    c. Pectin from apples/bananas/oranges
6. Lipids:
    a. Extraction and analysis of lipid.
7. Pigments (Separation of the following pigments on TLC slides):
    a. Oleoresin Extraction
    b. Carotenes from carrots
    c. Chlorophylls from spinach
8. Isolation and Estimation of
    a. Oxalates from spinach/ *Aloe vera*
    b. Lycopene from tomatoes.
9. Demonstration of Bioreactor
10. Isolation and purification of Protein (determination of % yield and purity)
11. Essential oil extraction

CBOP-5, BCH-414(B): Clinical Biochemistry and Research Methodology

Section-I, Clinical Biochemistry(Any 10) [48L + 12T]

1. Estimation of Lipoproteins
2. Estimation of serum amylase
3. Estimation of bilirubin
4. Estimation of blood urea and uric acid
5. Blood sugar determination by Folin-Wu method
6. Estimation of creatine phosphokinase
7. Normal and abnormal constituents of urine
8. Determination of blood cholesterol
9. Determination of glucose by glucose oxidase method
10. Estimation of glycosylated hemoglobin
11. Estimation of LDH and its isozymes
12. Estimation of alkaline and acid phosphatase from serum
13. Estimation of total protein and albumin from serum
14. Determination of SGPT and SGOT

Reference Books:

1. Practical Biochemistry- David Plummer 3rd edition (2015).
2. Practical Biochemistry – J. Jayaraman (2011).
3. Biochemical methods – Sadasivam and Manickam 3rd edition (2007).
4. Biochemistry –Practical Approach – Kieth Wilson and J. Walker 5th edition (2006).
5. Introductory Practical Biochemistry- Randhir Singh and Sawhney (1999).
6. Laboratory handbook on Biochemistry, S Shanmugam, 2010, PHI Pvt Ltd, New Delhi

(2010).

Section-II, Research Methodology [48L + 12T]

1. Preparation of Research Proposal for submitted tothe funding agencies. (Submit it as report)
2. Review of Research work being carried out at any five National/ International Research Centers or Institutes/Research institute visit report
3. Use of Excel for calculation and Graph
   a) Measurement of Central Tendency (Mean, Median, Mode)
   b) Measurement of Dispersion/variability(Mean Deviation, Standard Deviation, Co efficient of variation)
   c) Line Graph, Bar graph. Pie chart
5. Tool plagiarism detection
4. Research Paper analysis
   a) Analysis of data (including graph, table, figure, Method/technique/instrument) (Using MS word of Similar software Brief Report 1 page)
   b) Presentation of Research Paper (15 minute power point presentation)

CCPP-4, BCH-415: (Project) [96L + 24T]

GUIDELINE TO CARRY OUT PROJECTWORK

1. The main purpose of introduction Project Work at MSc Part II is to make the studentsfamiliar with Research Methodology i.e. reference work, experimental work, statisticalanalysis of experimental data, interpretation of results obtained, writing of project workand compilation of bibliography in proper order. This will not only help train the inquisitive minds of the students, but also inspire them to take up research- oriented higher studies and career.

2. **Duration of Project work: -**

Development on the nature of the research problem and the infrastructure available in the respective Biochemistry Departments or Research Institutes or Industries, the duration of Project Work in recommended as follows:-

a. 06 Months (**Equivalent to 96L + 24T**): - The project work will commence immediately after the conclusion of Semester II of M. Sc Part – I.
b. Each student shall complete a small research project during his/ her academic year of M. Sc Part- II. However, the initial reference work can be started in M.Sc Part- I and summer vacation.

4. **Nature of Research Project:-**

The following will be considered as the Research Project.

   a. Experimental based involving laboratory analytical work, or
   b. Industrial training based provided that the candidate has undergone actual hands on training in instrumental analytical techniques.

5. **Schedule for Submission of project Work:-**

a. Experiment work or Industrial training must be completed by October 31.
b. The duration of Diwali Vacation and the part of Sem IV up to December 31 shall be utilized for finalizing the written contents of the project work.
c. The final copy of the project work (3 Copies) will have to submit to the respective HOD by January end of Sem IV.
6. The project containing about 20-30 pages (A4 size paper with normal margins). Should be divided into the following parts: -
   a. Certification of completion of Project Work from the HOD.
   b. Acknowledgement.
   c. Introduction
   d. Review of Related Literature

e. Aims and Objectives
f. Signification of research problems selected
g. Plan of work
h. Material and Methods
i. Results
j. Discussion
k. Bibliography

7. The project should be submitted at the time of University Practical Examination, as the same will be assessed internally.

GUIDELINE FOR THE ASSESMENT OF PROJECT WORK

1. Each student will complete the project (3 copies) and get all the copies certified by the guiding teacher and the Head of Dept.(HOD) by January of Sem IV.
3. One copy of the certified project will be submitted to the HOD; One will be submitted to the guide while the other copy will be retained by the students for his/ her personal record.
4. After the certification of the project, the HOD will invite a PG – Recognized Teacher of Biochemistry Dept of any other College/ Institute/ Research centre for the assessment of **Research Project.**
5. The candidate is required to present the Research Project to the invited examiner followed by Viva- Voce examination based on the project work by the examiner.
6. The following Marking Scheme shall be considered while assessing the project work Particular of Marks Allotment
    a) Project Dissertation (Contents Submitted in the bound form).
    b) Presentation of Project Work before Examiner.
    c) Viva- voce Exam based in Project work.

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