M.Sc. CHEMISTRY

PHARMACO INFORMATICS SPECIALISATION

SYLLABUS (2017 – 18) ONWARDS

III and IV SEMESTERS

(2017 - 2018)

FOR STUDENTS ADMITTED IN THE YEAR (2016 – 17)
UNDER INNOVATIVE INTERDISCIPLINARY PROGRAM OF
UGC REVISED AS PER NEW (CB) SYLLABUS
APPROVED IN BOS ON _____

M. Sc. CHEMISTRY (PARMACOINFORMATICS)

Syllabus for III and IV Semesters

(For the batch admitted during the academic year 2016-2017 under the CBCS pattern)

[Under Restructured CBCS Scheme]

(Approved in the P.G. BOS meeting held on _____)

Semester - III

	Instruction Hrs/week	Internal assessment marks	Semester marks*	Total	Total Credits
CH(CPI) 301T	4	20	80	100	4
CH(CPI) 302T	4	20	80	100	4
CH(CPI) 303T (CB)	4	20	80	100	4
CH(CPI) 304T (CB)	4	20	80	100	4
CH(CPI) 351P	9	--	100	100	4
CH(CPI) 352P	9	--	100	100	4
Total				**600**	**24**

*Theory: 3 hours; Practical's: 6 hours

Semester - IV

	Instruction Hrs/week	Internal assessment marks	Semester marks*	Total	Total Credits
CH(CPI) 401T	4	20	80	100	4
CH(CPI) 402T	4	20	80	100	4
CH(CPI) 403T (CB)	4	20	80	100	4
CH(CPI) 404T (CB)	4	20	80	100	4
CH(CPI) 451P	9	--	100	100	4
PROJECT	9	--	100	100	4
Total				**600**	**24**
(**Choice based paper (CB) =** Paper offered by the same Department)					

*Theory: 3 hours; Practical's: 6 hours

Grand total (all 4 semesters) 2400 marks and 96 credits

SEMESTER – III

PAPER- I :CH(CPI)301 T : Database Management, Sources and Scripting Languages
CPI - 09 : Chemical Information Sources and Searches
CPI - 10 : Database Design and Management
CPI - 11 : Data Sequencing and Mining
CPI - 12 : Scripting Languages

PAPER-II: CH(CPI)302 T : Computational Chemistry ,Molecular Modeling & Its Applications.
CPI – 13 : Computational Chemistry -I
CPI – 14 : Computational Chemistry -II
CPI – 15 : Drug Design Methods I - Ligand Based
CPI – 16 : Drug Design Methods II - Structure Based

PAPER-III: CH(CPI)303 T: ELECTIVE 3A: Synthetic Reagents, Advanced NMR, Conformational Analysis and ORD
CPI - 17 : Synthetic Reagents-I
CPI - 18 : Synthetic Reagents-II
CPI - 19 : ^{13}C NMR and 2D NMR spectroscopy
CPI - 20 : Conformational analysis (Cyclic systems) & ORD

PAPER-III: CH(CPI)303 T:ELECTIVE 3B: Advanced Natural Products
CPI-21: Biosynthesis of natural products
CPI-22: Structure determination of natural products by chemical methods.
CPI-23: Structure determination and stereochemistry of natural products by spectral methods.
CPI-24: Total stereo selective synthesis of natural products**.**
PAPER-IV: CH(CPI)304 T:ELECTIVE 4A: Modern Organic Synthesis
CPI - 25 : Asymmetric Synthesis
CPI - 26 : Synthetic strategies
CPI - 27 : New Synthetic reactions
CPI - 28 : Chiral Drug

PAPER-IV : CH(CPI)304 T:ELECTIVE 4B: Intellectual Property Rights
CPI - 29 : Introduction
CPI - 30 : International Organizations & Treaties
CPI - 31 : Patent Search
CPI - 32 : IP Reports Generation

LABORATORY COURSES
PAPER-V :CH(CPI)351 P : Molecular Modeling Lab
PAPER-VI :CH(CPI)352 P : Synthesis, Isolation and Mixture separation of Organic Compounds

SEMESTER – III
PAPER -I

CH(CPI)301T: DATABASE MANAGEMENT, SOURCES AND SCRIPTING LANGUAGES

CPI - 09: Chemical Information Sources and Searches
CPI - 10: Database Design and Management
CPI - 11: Data Sequencing and Mining
CPI - 12: Scripting Languages

CPI – 09 : Chemical Information Sources and Searches

Introduction to information sources and searching strategies, tactics for searches, Advantages and Limitations of computer searching, Keyword based general bibliographic searches, Chemical connectivity and structure searches (2D), Chemical structure, property and shape based searches (3D), Searching for the synthesis (or) reactions of specific compounds or classes of compounds, Searching of chemical abstracts.

Types of Publications: Journals, Technical reports, Patents, Conference Papers, Dissertations, Electronic Publications.

Types of databases: Public databases - NCBI, RCSB, CSD, Expasy, Swiss-Prot and Paid databases - CAT'STN and SciFinder.

Web-based cross platform solutions for Cheminformatics: BLAST, ClustalW, SAVES, ProSA.

CPI – 10 : Database Design and Management

Introduction to Computers and it's components, Operating System (Windows & Linux). Introduction to DBMS, Database concepts, Database models and ER diagrams, Normalization. Introduction to SQL, DDL, DML, DCL, and TCL; Creation of databases, Searching database using SQL, Built-in-functions, String manipulation, improving query performance (where, 'Group By', having Clause), cursors, stored procedures. Introduction to MySQL, configuring and running MySQL on Linux. Data Processing, Information systems and computing, Data presentation for computing, Distributed processing.

CPI – 11: Data Sequencing and Mining

Introduction to Data Mining, working principles of Data Mining, Architecture form of data Mining, Difference between Data Mining and Machine learning techniques, Supervised and unsupervised learning methods and its application to QSAR. Data Visualization: Visualizing Data mining models, Decision Tree. Data warehousing: Data mining and analytic technology, Comparing different Models using visualization.

CPI – 12 : Scripting Languages

Introduction to Shell scripting, Common Linux commands (Bash), Basic shell Programming: addition, subtraction, loops, conditional-loops, un-conditional loops, Linux text editors (Vi).

Perl: Introduction, basics, sequences, uses, implementation issues, changes from other languages, advantages, and disadvantages. Strings: operations, support with Perl, advantages, accessing MySQL database using Perl, getting id, Sequence from a Database Object, matching a sequence in a Database Object, Subroutines. Introduction to Bio-Perl, Perl for Cheminformatics / Bioinformatics.

References

1. MySQL (TM): The Complete Reference by Jeremy D. Zawodny and Derek J. Balling. O'Reilly & Associates, April 2004.
2. Data Mining: Concepts and Techniques by Jiawei Han and Micheline Kamber, Third Edition, 2012, Elsevier Inc.

3. Mastering UNIX Shell Scripting by Randal K. Micheal Wiley Publisher, Inc, Indianapolis, Indiana.
4. Upgrading and Repairing PC's by SCOTT MUELLER's.
5. Data Mining Techniques by Arun K. Pujari.
6. Perl Tutorial by Chan Bernard Ki Hong
7. Bio-Perl Course by Catherine Letondal and Katja Schuerer.
8. Quick, Painless Introduction to the Perl Scripting Language. Norman Matloff. University of California, Davis c 2002 - 2007.

PAPER-II

PAPER-II: CH(CPI)302 T : Computational Chemistry ,Molecular Modeling &Its Applications.

CPI – 13 : Computational Chemistry -I
CPI – 14 : Computational Chemistry -II
CPI – 15 : Drug Design Methods I - Ligand Based
CPI – 16 : Drug Design Methods II - Structure Based

CPI – 13: Computational Chemistry – I

Introduction to Molecular Modeling, Single molecule calculations, assemblies of molecules and reactions of molecules - Co-ordinate systems: Cartesian and Internal Co-ordinates, Z-matrix - Potential energy surface - Conformational search; Global minimum, Local minimum, Conformational analysis of ethane - Force field ; Features of Molecular Mechanics, Bonded and Non-bonded interactions, Bond Stretching, Angle Bending, Torsional Terms (Improper Torsions, out of Plane Bending Motions, Cross Terms), Non Bonded Interactions (Electrostatic Interactions, Van-der Waals interactions), Hydrogen Bonding Interactions.

CPI – 14: Computational Chemistry - II

Force Field Equation in Energy minimization (Energy as function of r, θ, ω) - Introduction to Derivative Minimization Methods (First Order Minimization), Types of energy minimization Methods; Steepest Descent, Conjugate Gradient, Conformational Search procedures - Geometry optimization procedures - Molecular Dynamics: Introduction, description of Molecular Dynamics, basic elements of Monte-Carlo method, differences between Molecular Dynamics and Monte-Carlo method, Qualitative exposure to Molecular Dynamics Simulations.

CPI – 15: Drug Design Methods I - Ligand Based

Lead Molecule - Structure Activity Relationship (SAR), Quantitative Structure Activity Relationship (QSAR), Distinguish between SAR and QSAR - Physicochemical parameters ; Electronic effects, Hydrophobicity, Steric Factors Taft's Steric function, Molar Refractivity, Verloop Steric factor - Molecular Descriptor analysis: Craig plot, Topliss scheme, Bioisosteres - Hansch model, Free-Wilson model for QSAR equations - Regression analysis: Multi Linear Regression and Partial Least Square (terms: n, SD, r, r^2, r^2%, F) - Examples for linear and non-linear equations - 3D QSAR: CoMFA and CoMSIA - Differences between 2D and 3D QSAR.

CPI – 16: Drug Design Methods II - Structure Based.

Database similarity searches - Pair-wise alignment: Global sequence analysis (Needleman-Wunsch), Local Sequence Alignment (Smith Waterman), Multiple Sequence Alignment -

Homology Modeling: Query sequence, Template selection, Alignment, Backbone Modeling, Loop Modeling, Side chain Modeling, Model optimization, Energy minimization - Model Evaluation: Ramachandran Plot, Verify 3D, Errata and ProSA - Active site Identification - Docking, Docking Algorithms: Genetic Algorithm, Incremental construction - Molecular Interactions, Scoring functions - Virtual Screening: Ligand Based and Structure Based. De novo ligand design and its limitations.

References:

1. Molecular Modelling: Principles and Applications, by Andrew Leach, Longman Publications.
2. Computational Chemistry, Guy H. Grant & W. Graham Richards, Oxford University Press.
3. Computational Chemistry: Introduction to the theory and Applications of Molecular and Quantum Mechanics, Errol Lewars, Springer Publications.
4. Recent advances in Bioinformatics by I. A. Khan and A Khanum Ukaaz publications, 2003.
5. Molecular modelling – Basic Principles and Applications by Hans Dieter Holtje and Gerd Folkers, Wiley-VCH, 1996
6. Introduction to Computational Chemistry by Jensen, Wiley Publishers, second edition
7. Bioinformatics – A Primer by P. Narayanan, New Age International, (P) Ltd, 2005.
8. Introduction to Bioinformatics by Arthur M. Lesk, Oxford University Press (Indian. Edition), 2002
9. Principles of Medicinal Chemistry Vol. II by Dr. SS Kadam Pragati books Pvt. Ltd; 2007
10. Principles of Medicinal Chemistry, by Patrick.
11. Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery. S.C. Rastog, Namita Mendiratta, Parag Rastogi, PHI Larning Pvt. Ltd; 2006
12. Pharmacy Practice Vol.I and II by Remington.
13. Burger's Medicinal Chemistry and Drug Discovery, 5th Edition.
14. Text book of Drug design and Vol.1 discovery 3rd Edition by POVL krogsgaard- larsen tommy liljefors and ULF madsen.

PAPER-III : CH(CPI)303 T

ELECTIVE 3A

Synthetic Reagents, Advanced NMR, Conformational Analysis and ORD

CPI-17: Synthetic Reagents-I
CPI-18: Synthetic Reagents-II
CPI-19: 13C NMR and 2D NMR spectroscopy
CPI-20: Conformational analysis (Cyclic systems) & ORD

CPI-17: Synthetic Reagents I 15 Hrs

i) Protecting groups: a) Protection of alcohols by ether, silyl ether and ester formation b) Protection of 1,2-diols by acetal, ketal and carbonate formation c) Protection of amines by benzyloxycarbonyl, t-butyloxycarbonyl, fmoc and triphenyl methyl groups. d) Protection of carbonyls by acetal, ketal and thiol acetal (Umpolung) groups. e) Protection of carboxylic acids by ester and ortho ester (OBO) formation.
ii) Organometallic Reagents: Preparation and application of the following in organic synthesis: 1) Organo lithium 2) Organo copper reagents 3) Organo boranes in C-C bond formation 4) Organo silicon reagents: reactions involving β-carbocations and α-carbanions, utility of trimethyl silyl halides, cyanides and triflates.
iii) Carbonyl methylenation: a) Phosphorous ylide mediated olefination 1) Witting reaction, 2) Horner-Wordsworth-Emmons reaction. b) Titanium- Carbene mediated olefination 1) Tebbe reagent, 2) Petasis reagent 3) Nysted reagent.
iv) Carbene insertions: Rh based carbene complexes, cycloprpanations.
v) C-H Activation: Introduction, Rh catalysed C-H activation.

CPI-18: Synthetic Reagents II 15 Hrs

ii) Oxidations: a) Oxidation of active C-H functions: DDQ and SeO2. b) Alkenes to diols: Prevost and Woodward oxidation c) Alcohol to carbonyls: CrVI oxidants (Jones reagent, PCC, PDC) IBX, DMP, CAN, TEMPO, TPAP, Swern oxidation d) Oxidative cleavage of 1,2-diols: Periodic acid and Lead tetra acetate.
iii) Reductions: a) Catalytic hydrogenation: Homogenous (Wilkinsons's catalytic hydrogenation) and heterogeneous catalytic reduction. b) Non-metallic reductions: Diimide reduction c) Dissolving metal reductions: Birch reduction. d) Nucleophilic metal hydrides: LiAlH4, NaBH4, and their modifications. e) Electrophilic metal hydrides: BH3, AlH3 and DIBAL. f) Use of tri-n-butyl tin hydride: Radical reductions.

CPI-19: ^{13}C NMR and 2D NMR spectroscopy 15 Hrs

i) ^{13}C NMR spectroscopy: Introduction, Types of ^{13}C nmr spectra: undecoupled, proton-decoupled and off-resonance decoupled (ORD) spectra. 13C chemical shifts, factors affecting the chemical shifts, chemical shifts of organic compounds. Calculation of chemical shifts of alkanes, alkenes and alkynes. Homonuclear (13C, 13C J) and heteronuclear (13C,1H J and 13C, 2H J) coupling. Applications of 13C-NMR spectroscopy: Structure determination, stereochemistry, reaction mechanisms and dynamic processes in organic molecules. 13C-NMR spectral editing techniques: principle and applications of APT, INEPT and DEPT methods.
ii) 2D-NMR spectroscopy: Principles of 2D NMR, Classification of 2D-experiments. Correlation spectroscopy (COSY) HOMO COSY (1H-1H COSY) , TOCSY (Total Correlation Spectroscopy), Hetero COSY (1H,13C COSY,HMQC), long range 1H,13C COSY (HMBC), Homonuclear and Heteronuclear 2D-J-resolved spectroscopy, NOESY and 2D-INADEQUATE experiments and their applications.

CPI-20: Conformational analysis (Cyclic systems) & ORD 15 Hrs

Study of conformations of cyclohexane, mono, di and tri substituted cyclohexanes, (1,3,5-trimethyl cyclohexanes and Menthols), cyclohexanone (2-alkyl and 3 -alkyl ketone effect), 2-halocyclohexanones, cycloheptane . Stereo chemistry of bicyclo [3,3,0] octanes, hydrindanes, decalins and perhydroanthracenes. Conformational structures of piperidine, N-Methylpiperidine, tropane, tropine, pseudotropine, decahydroquinoline and quinolizidine. Factors governing the reactivity of axial and equatorial substituents in cyclohexanes.
(oxidation, SN2 reaction, rearrangements, Ester hydrolysis) Stereochemistry of addition to the carbonyl group of a rigid cyclohexanone ring.
Optical Rotatory Dispersion (ORD) and CD Spectroscopy: Optical rotation, circular birefringence, circular dichroism and Cotton effect. Plain curves and anomalous curves. Empirical and semiempirical rules-The axial haloketone rule, the octant rule, Helicity rule, Exciton chirality method. Application of the rules to the study of absolute configuration and conformations of organic molecules.

Recommended Books:

1. Some modern methods of organic synthesis by W. Carruthers
2. Guidebook to organic synthesis, by R K Meckie, D M Smith & R A Atken
3. Organic Synthesis by O House
4. Organic synthesis by Micheal B Smith
5. Reagents for organic synthesis, by Fieser & Fieser, Vol 1-11 (1984)
6. Organic synthesis by Robert E Ireland
7. Handbooks of reagents for organic synthesis by Reich and Rigby, Vol-I-IV
8. Organic chemistry by Jonathan Clayden, Nick Greeves and Stuart Warren
9. Organic Reactions and their mechanisms by P.S.Kalsi
10. Organic reaction mechanisms by V.K.Ahulwalia and Rakesh Kumar Parashar
11. Spectroscopic identification of organic compounds by RM Silverstein, G C Bassler and T B Morrill
12. Organic Spectroscopy by William Kemp
13. Spectroscopic methods in Organic chemistry by DH Williams and I Fleming
14. Modern NMR techniques for chemistry research by Andrew B Derome
15. NMR in chemistry - A multinuclear introduction by William Kemp
16. Spectroscopic identification of organic compounds by P S Kalsi
17. Introduction to organic spectroscopy by Pavia
18. Carbon-13 NMR for organic chemists by GC Levy and O L Nelson
19. Nuclear Magnetic Resonance Basic principles by Atta-ur-Rahman
20. Basic one and two-dimensional NMR spectroscopy by Horst Friebolin
21. NMR spectroscopy by H.Gunther
22. Stereochemistry of organic compounds — Principles & Applications by D Nasipuri
23. Stereochemistry of Carbon compounds by Ernest L Eliel & Samuel H. wilen
24. Stereochemistry: Conformation & Mechanism by P S Kalsi
25. The third dimension in organic chemistry, by Alan Bassendale
26. Stereo selectivity in organic synthesis by R S Ward.
27. Advanced organic chemistry. Part A Structure & Mechanism by Francis A. Corey and Richard J. Sundberg
28. Optical rotatory dispersion by C Djerassi
29. Optical rotatory dispersion and circular dichroism by P Crabbe
30. Mechanism and Structure in Organic chemistry by S Mukherjee

PAPER-III: CH(CPI)303 T

ELECTIVE 3B

Advanced Natural Products

CPI - 21 : Biosynthesis of natural products
CPI - 22 : Structure determination and stereochemistry of natural products by chemical methods
CPI - 23 : Structure determination and stereochemistry of natural products by spectral methods
CPI - 24 : Total stereo selective synthesis of natural products

CPI - 21 : Biosynthesis of natural products

Biosynthesis of secondary metabolites: Introduction, Difference between Laboratory synthesis and biosynthesis. Methods for determination of biosynthetic mechanism. Isolation and identification of Biosynthetic precursors, Feeding experiments – use of radioisotopes Measurement of incorporation – absolute incorporation, specific incorporation. Identification of the position of labels in labeled natural products by chemical degradation and spectral methods. Major biosynthetic pathways: 1) Acetate-Malonate pathway: Biosynthesis of aromatic compounds, 2) Shikimic acid pathway ; Biosynthesis of essential amino acids – phenylalanine, tyrosine and tryptophan, carboxylic acid derivatives, flavonoids and morphine alkaloids. 3) Mevalonic acid pathway : Biosynthesis of terpenes – mono, sesqui, di, tri (β-amyrin) and carotenoids, steroids – cholesterol.

CPI - 22 : Structure determination and stereochemistry of natural products by chemical methods

Determination of structure and stereochemistry of morphine, reserpine, abietic acid, cholesterol and rotenone.

CPI - 23 : Structure determination and stereochemistry of natural products by spectral methods

Spectroscopic techniques IR, UV, ^{1}Hnmr, ^{13}Cnmr, COSY, HETEROCOSY, NOESY, 2D-INADEQUATE and MS in the structure elucidations of natural products, Examples, flavones, biflavones, flavanones, isoflavones, coumarins, quinolines, isoquinolines.

Study of the following solved problems: Mass, IR, ^{1}H, ^{13}C NMR, HOMOCOSY, HECTOR, DEPT, 2D-INADEQUATE and NOE of Geraniol, INEPT of menthol, APT of apparicine, Heteronuclear 2D-J resolved spectrum of stricticine, NOESY of buxaquamarine, HETEROCOSY of strictanol, 2D-INADEQUATE of α-picoline and β-methyl tetrahydran furan.

CPI - 24 : Total stereo selective synthesis of natural products

Nicalou's synthesis of Dynemicin A , Corey's synthesis of prostaglandins (E2, F2α) and paeoriflorin, Sharpless synthesis of L-hexoses, Nicolaous synthesis of taxol, Danishefsky synthesis of indolizomycin, Takasago synthesis of menthol, Hoffmann-LaRoche synthesis of Biotin.

Recommended books:

1. Textbook of organic chemistry, Vol II by I L Finar
2. Chemistry of natural products, Vol 12, by Atta-Ur-Rahman
3. An introduction to the chemistry of terpenoids and steroids, by William templeton
4. Systematic identification of flavonoid compounds by Mabry & Markham
5. Steroids by Fieser arid Fieser
6. Alkaloids by Manske
7. Alkaloids by Bentley
8. The chemistry of terpenes by A Pinder

9. The terpenes by Simenson
10. Terpenoids by Mayo
11. Alkaloids by Pelletier
12. Total synthesis of Natural Products by Apsimon Vol 1-5
13. Biosynthesis by Geismann
14. Principles of organic synthesis 3rd Ed.R O C Norman and J M Coxen
15. One and two dimensional nmr spectroscopy by Atta Ur Rahman
16. Classics in total synthesis K C Nicolaou and E J Sorenson
17. Spectrometric identification of organic compounds by Silverstein and Webster

PAPER-IV: CH(CPI)304 T

ELECTIVE-4A

Modern Organic Synthesis

CPI - 25 : Asymmetric Synthesis
CPI - 26 : Synthetic strategies
CPI - 27 : New Synthetic reactions
CPI - 28 : Chiral Drugs

CPI - 25 : Asymmetric Synthesis

Introduction: Brief revision of classification of stereo selective reactions

Prostereoisomerism: Topicity in molecules Homotopic, stereoheterotopic (enantiotopic and diastereotopic) groups and faces- symmetry criteria.

Prochiral nomenclature: Pro chiraility and Pro-R, Pro-S, Re and Si.

Conditions for stereoselectivity: Symmetry and transition state criteria, kinetic and thermodynamic control. Methods of inducing enantioselectivityy.

Analytical methods: % Enantiomeric excess and diastereomeric ratio. Determination of enantiomeric excess: specific rotation, Chiral NMR; Chiralderivatizing agents, Chiral solvent, Chiral shift reagents and Chiral HPLC.

Chiral Substrate controlled asymmetric synthesis: Nucleophilic additions to chiral carbonyl compounds. 1, 2- asymmetric induction, Cram's rule and Felkin-Anh model.

Chiral auxiliary controlled asymmetric synthesis: α-Alkylation of chiral enolates, Evan's oxazolidinone, 1, 4-Asymmetric induction and Prelog's rule..

Chiral reagent controlled asymmetric synthesis: Asymmetric reductions using BINAL-H. Asymmetric hydroboration using IPC_2 BH and $IPCBH_2$.

Chiral catalyst controlled asymmetric synthesis: Sharpless epoxidation. Asymmetric hydrogenations using chiral Wilkinson biphosphin catalyst.

Asymmetric aldol reaction: Diastereoselective aldol reaction (achiral enolate & achiral aldehydes) its explanation by Zimmerman-Traxel model.

CPI - 26 : Synthetic strategies

Introduction: Terminology, Target, synthon, synthetic equivalent, functional group interconversion (FGI), functional group addition. Criteria for selection of target. Linear and convergent synthesis. Retrosynthetic analysis and synthesis involving chemoselectivity, regioselectivity, reversal of polarity and cyclizations. .

Order of events : S-Salbutamol, Propoxycaine..

One group C-C and C-X disconnections: Introduction .One group C-C disconnections in alcohols and carbonyl compounds. One group C-X disconnections in Carbonyl compounds, alcohols, ethers and sulphides.

Two group C-C and C-X disconnections : Introduction .Two group C-X disconnections in 1,1-difunctionalised, 1,2-difunctionalised and 1,3-difunctionalised compounds.

Two group C-C disconnections: Diels-Alder reaction, 1,3-difunctionalised compounds, 1,5-difunctionalised compounds, Michael addition and Robinson annulation.

Control in carbonyl condensations: oxanamide and mevalonic acid.

Strategic bond: definition, guidelines for disconnection; disconnection of C-X bonds, disconnect to greatest simplification, using symmetry in disconnection, disconnection corresponding to known reliable reaction, high yielding steps and recognizable starting materials. Retrosynthesis of Retronecene, longifoline.

CPI - 27 : New Synthetic reactions

1. Metal mediated C-C and C-X coupling reactions: Suzuki, Heck, Stille, Sonogishira cross coupling, Buchwald-Hartwig and Negishi-Kumada coupling reactions.

2. C=C Formation Reactions: Shapiro, Bamford-Stevens, McMurrey reactions, Julia-Lythgoe olefination and Peterson's stereoselective olefination.

3. Multicomponent Reactions: Ugi, Passerini, Biginelli, Bergman and Mannich reactions.

4. Ring Formation Reactions: Pausan-Khand reaction, Nazerov cyclisation.

5. Click Chemistry: Click reaction, 1,3-dipolar cycloadditions.

6.Metathesis: Grubb's 1st and 2nd generation catalyst, Olefin cross coupling metathesis (OCM), ring closing metathesis(RCM), ring opening metathesis(ROM), applications.

7. Other important synthetic reactions: Baylis-Hilman reaction, Eschenmoser-Tanabe fragmentation, Mitsunobu reaction, Stork-enamine reaction and Michael reactions.

CPI - 28 : Chiral Drugs

Introduction to chiral drugs. Eutomer, distomer and eudesmic ratio. Pfeiffer's rule, Three point contact model. Synthesis and pharmacological activity of Menthol, S-Naproxen, S-Ibuprofen (anti inflamatory), S-Timolol, oxazolidone, Captopril, Enalapril, Diltiazam (Calcium antagonist), Indinavir sulphate (HIV-1-protease inhibitor), Ethambutal (anti-tubercular). Cloxacillin, Cephalexin (Antibiotic), Oxybutynine hydrochloride (Antispasmodic Agent), Dexormaplatin (Antitumour Agent), indacrinone (Diuretic), Griseofulvin, (Antifungal) Levocitrizine (Antihistamine) and Meteprolal (β1- blocker).

Recommended Books:

1. Asymmetric synthesis by Nogradi
2. Asymmetric organic reactions by J D Morrison and H S Moschcr
3. Principles in Asymmetric synthesis by Robert E. Gawley & Jeffrey aube
4. Stereo differentiating reactions by Izumi
5. Some modern methods of organic synthesis by W Carruthers
6. Guidebook to organic synthesis, by R K Meckie, D M Smith & R A Atken
7. Organic synthesis by Michael B Smith
8. Organic Synthesis-The disconnection approach by S Warren
9. Organic Synthesis by C Willis and M Willis
10. Problems on organic synthesis by Stuart Warren
11. Organic chemistry Jonathan Clayden, Nick Greeves and Stuart Warren

12.The logic of chemical synthesis by Elias James Corey and Xue-Min Cheng
13. Organic Drug synthesis By Ledneiser Vol 1-6
14. Strategies for organic drug synthesis and design By Daniel Ledneiser
15. Top Drugs: Top synthetic routes By John Saunders
16. Chirotecchnology By Roger A. Sheldon

PAPER-IV : CH(CPI)304 T

ELECTIVE-4B

Intellectual Property Rights

CPI - 29 : Introduction
CPI - 30 : International Organizations & Treaties
CPI - 31 : Patent Search
CPI - 32 : IP Reports Generation

CPI - 29 : Introduction

Introduction : Legal Rights and obligations, Concept of Property, Kinds of Property, General concept and Significance of Intellectual Property (IP), Intellectual Property Rights (IPR), Intellectual property, Introduction to IPR, contents of IPR and their protection, Recent Developments, IP Organisations. Introduction to Patents, Trademarks, Copyrights, Trade secrets, Industrial designs and Geographical indications.

CPI - 30 : International Organizations & Treaties

Paris Convention for the Protection of Industrial Property, Berne Convention for the Protection of Literary and Artistic Works, Patent Cooperation Treaty (PCT) which facilitates obtaining of patents in several countries by filing a single application, World Trade Organization (WTO), Trade Related Aspects of Intellectual Property (TRIPS), Madrid system for the international registration of marks, The Hague system for the international deposit of industrial designs, Budapest treaty on the international recognition of the deposit of microorganisms for the purpose of patent procedure, International convention for the protection of new varieties of plants.

CPI - 31 : Patent Search

What is a patent search. Who needs a patent search. Patent Search Types and Methodologies, Novelty Searches, Validity Searches, Infringement Searches, State-of the-art searches. Searching in Patent Databases: Free search databases: USPTO, EPSPACE, WIPO, Free Patents Online, Fresh Patents and JSPTO, Paid search databases: Micropat, Delphion, DialogPro, Patent Optimiser, Aureka and PatentCafe, Structure based search: STN search, SciFinder.

CPI - 32 : IP Reports Generation

Novelty search reports, Infringement search reports, Prior-art search reports, Patent invalidation reports, Competitive search reports, and Business analysis reports, Patent Filing and Drafting, Patent filing procedures, Indian patent act, patent drafting, PCT applications, provisional and complete specifications.

References

1. Fundamentals of Jurisprudence by Dhyani, Allahabad Publication, Central Law.
2. Jurisprudence of Legal Theory by Dwivedi S.P. Allahabad Central Law Agency.
3. Text Book on Jurisprudence by Hilari WC Cobrey, Oxford Publications.

4. Treaties on Intellectual Property Rights by Blackstone
5. W.T.O. by Myneni, Asia Law House.
6. W.T.O. by Vasudeva, Minerva Publications, Delhi.
7. Law of Practice of Intellectual Property in India by Vikas Vashistha, Bharat Law Publications, Delhi.
8. Intellectual property rights by B L Wadhera, Universal Law Publications.
9. Trade Marks Act by Mittal, Eastern Book Company.
10. Patent Law by Narayana P, Eastern Book Company.

SEMESTER -III

LABORATORY COURSES

PAPER-V: CH(CPI) – 351P: Molecular Modeling Lab

1. Dos and Linux commands
2. Shell Scripting : if, if else, for, do while
3. Perl Scripting : if, if else, for, while
4. Creating Database : Creation of tables and Insertion of rows using MySQL
5. Perl scripting for accessing MySQL database objects using DDL, DML, DCL.
6. Perl scripting for Sequence analysis :
    a. Translate DNA sequence into RNA sequence
    b. Finding common Ktup (k = 1, 2, 3) between two sequences
    c. Local and global alignment of two sequences (DNA/RNA/Protein)
    d. Multiple sequence alignment
7. Drawing and minimizing molecules in modeling software, calculating physicochemical parameters.
8. 2D QSAR Studies (COX 1 and 2, DHFR inhibitors).
9. 3D QSAR: Pharmacophore model generation and pharmacophore match searching in database.
10. Homology Modeling: Retrieving Query Sequence, Finding Template, Pair-wise alignment, 3D model generation, energy minimization and structure validation.
11. Molecular Docking of COX 1 and 2, DHFR inhibitors into respective receptors.

PAPER-VI:CH(CPI) – 352P : Synthesis, Isolation and Mixture separation of Organic Compounds

1. Synthesis of Drugs

Benzocaine (Anaesthetic), Antipyrine (Antipyretic), Sulphonamide (antibacterial), Clofibrate(Anti-lipidemic), 2-phenyl-Indole, Quinoxalinone, Isoniazid (Anti-Tubercular), Benzillic acid rearrangement, Beckmann rearrangement and stereo selective reduction of ethyl acetoacetate by bakers yeast.

2. Isolation of Herbal Drugs:

1.Piperine from black Pepper 2. Caffeine from tea leaves 3. Cineole from Eucalyptus leaves

3. Mixture Separation – At least 6 mixtures

Separation of two component mixtures by chemical methods and their identification by chemical reactions — separation by using solvent ether, 5 % aqueous sodium bicarbonate, 5% sodium hydroxide and dil hydrochloric acid, checking the purity of the two components by TLC, identification of the compounds by a systematic study of the physical characteristics (mp/bp), extra elements (nitrogen, halogens and sulfur), solubility, functional groups, preparation of crystalline derivatives and identification by referring to literature.

a) Solid - Solid - 3 mixtures
b) Solid - Liqutd – 3 mixtures
c) Liquid - Liquid – 3 mixtures

SEMESTER – IV

PAPER– I :CH(CPI) 401 T: Pharmacokinetics
CPI - 33 : Biopharmaceutics
CPI - 34 : Drug Absorption and Distribution
CPI - 35 : Drug Metabolism and Excretion
CPI - 36 : Pharmacokinetic Models

PAPER–II:CH(CPI) 402T : Principles of Drug Discovery, Drug Targets and chemistry of Pharmacology
CPI - 37 : Principles of Drug Discovery and SAR Studies
CPI - 38 : General Principles of Pharmacology and drug Targets, drugs acting on ANS and CNS
CPI - 39 : Drugs Acting on Cardio Vascular and Respiratory System
CPI - 40 : Drugs acting on metabolic process, cell wall, genetic material and immune system

PAPER- III : ELECTIVE 3A: Pharmaceutical Analysis
CPI - 41: Spectral Methods in Pharmaceutical Analysis
CPI - 42: Chromatography in Pharmaceutical Analysis-I
CPI - 43:Chromatography in Pharmaceutical Analysis-II
CPI - 44: Titrimetry, Chemical and Extraction methods in Pharmaceutical Analysis

PAPER-III: ELECTIVE 3B: Bio organic Chemistry
CPI - 45: Carbohydrates and Proteins
CPI - 46: Nucleic Acids and Lipids
CPI - 47: Enzymes
CPI - 48: Coenzymes

PAPER-IV: ELECTIVE 4A: Advanced Heterocyclic Chemistry
CPI - 49: Non Aromatic Hetero cyclics & aromacity
CPI - 50: Five and Six membered hetero cyclics with two hetero atoms
CPI - 51: Hetero cyclics with more than two hetero atoms
CPI - 52: Larger ring and other hetero cyclics

PAPER- IV : ELECTIVE 4B: Green chemistry and Organic materials
CPI - 53: Principles of Green chemistry
CPI - 54: Green Synthesis
CPI - 55: Organic nanomaterials
CPI - 56: Supramolecular chemistry

LABORATORY COURSES
PAPER – V :CH(CPI)451 P : Quantitative Analysis of Pharmaceuticals
PAPER – VI :CH(CPI)452 P: Project Work

PAPER– I

CH(CPI) 401 T: Pharmacokinetics

CPI - 33 : Biopharmaceutics
CPI - 34 : Drug Absorption and Distribution
CPI - 35 : Drug Metabolism and Excretion
CPI - 36 : Pharmacokinetic Models

CPI-33: Biopharmaceutics

Introduction, definition of pharmacokinetics, pharmacodynamics, ADME processes. Rate, Rate Constants and order of reactions- zero order kinetics, first order kinetics, mixed order kinetics. Routes of administration: Enteral (oral, sublingual, buccal, rectal) perenteral (intravenous, intramuscular and subcutaneous), topical (dermal, trans dermal, ophthalmic, intranasal), advantages and disadvantages.

Plasma drug concentration *vs* time profile: pharmacokinetic parameters (Peak plasma concentration, time of peak concentration, AUC), pharmacodynamic parameters (MEC, MSC, Therapeutic range, onset of action, onset of time, duration of action, intensity of action).

Dissolution: Definition and theories of drug dissolution, Diffusion layer model, Danckwert's model & interfacial barrier model. Factors influencing dissolution, dissolution tests for tablets and capsules (basket apparatus, paddle apparatus, flow through cell apparatus). In vitro - in vivo correlation of dissolution.

CPI-34: Drug Absorption and Distribution

Absorption: Structure of cell membrane, Mechanism of drug absorption - Passive diffusion, Pore-transport, facilitated diffusion, active transport, ionic or electrochemical diffusion, ion-pair transport, endocytosis. **Factors influencing drug absorption:** Dosage form, pH (pH partition hypothesis), Lipophilicity, Gastric emptying. **Bioavailability:** Objectives of bioavailability studies, absolute verses relative bioavailability. Plasma level- time studies (single dose and multiple dose). Concept of steady state concentration. **Distribution:** Volume of distribution, Apparent volume of drug distribution and its determination. Factors affecting drug distribution, Plasma protein binding.

CPI - 35: Drug Metabolism and Excretion

Definition of biotransformation, drug metabolizing organs, drug metabolizing enzyme. Chemical pathways of drug biotransformation- Phase-I reactions and Phase-II reactions.

Phase-I reactions:

a) Oxidative reactions, Cytochrome-P450 Oxidation-reduction cycle i)Aromatic hydroxylation (Acetanilide), ii) Aliphatic hydroxylation (Ibuprofen), iii) N-Dealkylation (Diazepam), iv) Oxidative deamination (Amphetamine), v) N-Hydroxylation (Paracetamol), vi) S- oxidation (Phenothiazine). B) Reductive reactions- i) Reduction of carbonyls (Chioral hydrate) ii) N-Compounds (Nitrazepam). c) Hydrolytic reactions (Asprin).

Phase-II reactions: (Real detoxication pathways). i)Conjugation with D-Glucoronic acid (Benzoic acid), ii) Conjugation with Sulfate moieties (Paracetamol), iii) Conjugation with α-Amino acids (Salicylic acid). iv) Acetylation (p-Amino Salicylic acid), v) Methylation (Histamine).

Factors affecting biotransformation of drugs i) physiochemical properties of drugs, ii) chemical factors, iii) biological factors, Bioactivation and tissue toxicity.

Excretion of drugs. Definition of excretion, Types of excretion- (Renal and non-renal excretion). The process of Renal excretion of drugs-Glomerular filteration, Active tubular secretion and active or passive tubular reabsorption, concept of clearance, factors effecting renal excretion, nonrenal routes of excretion, biliary excertion, salivary excretion and pulmonary excretion.

CPI - 36 : Pharmacokinetic Models

Definition, classification of models(mammillary and caternary). One Compartment open model (I.V bolous, IV infusion, Extravascular administration), Two Compartment open model (I.V bolous, IV infusion, Extravascular administration), Application of these models to determine the various pharmacokinetic parameters. Calculations and non- compartmental approaches to pharmaco kinetics. Non-linear pharmaco kinetics: causes of nonlinearity, Michaels-Menten kinetics- characteristics, basic kinetic parameters. Calculations.

Text Books

1. Biopharmaceutics and Pharmacokinetics – An Introduction by Robert E. Notary, 2nd edn. 1975, Marcel Dekkar Inc., New York
2. Applied BioPharmaceutics and Pharmaco Kinetics 5th Edition, McGrawhill Medical Publishing 2005 by Shargel, Wupong, Yu Andrew.
3. Pharacokinetics. By Shobha Rani
4. Elements of Pharmacology. By Gandhi,Desani & Goyal.
5. Goodmann & Gilmann's " The pharmacological basis of therapeutics. By Gilman & Rali.
6. Pharmacology. By Rang.
7. Physical Pharmacy by Martin
8. Biopharmaceutics and pharmacokinetics By Brahmanikar
9. Pharmacology By Lippincot
10. Modern Pharmacology with Clinical Applications. By R.Craig.
11. Compehensive pharmacy review by Leon Shargel
12. Hospital and clinical pharmacy
13. Advanced Pharmaco Kinetics - Venkateswarlu

PAPER–II

CH(CPI) 402T : Principles of Drug Discovery, Drug Targets and chemistry of Pharmacology

CPI - 37 : Principles of Drug Discovery and SAR Studies
CPI - 38 : General Principles of Pharmacology and drug Targets, drugs acting on ANS and CNS
CPI - 39 : Drugs Acting on Cardio Vascular and Respiratory System
CPI - 40 : Drugs acting on metabolic process, cell wall, genetic material and immune system

CPI - 37 : Principles of Drug Discovery and SAR Studies

Introduction to drug discovery. Folklore drugs, stages involved in drug discovery- disease, drug targets, bioassay. Discovery of a lead - screening of natural products and synthetic compound libraries. Natural products as lead structures in drug discovery – Pharmacophore - structure pruning technique e.g. morphine. Discovery of lead structure from natural hormones and neurotransmitters(one example). Principles of design of agonists (Salbutamol), antagonists (cimitidine) and enzyme inhibitors (captopril). Drug discovery without lead – serendipity - Penicillin and Librium as examples. Principles of Prodrug design; Existing drugs as leads (me too drugs). Introduction to drug patents and Clinical trials.

SAR Introduction; 1. Binding role of hydroxy group, Amino group, aromatic ring, double bond, ketones and amides. 2. Variation of substituents- alkyl substituents, aromatic substituents, extension of structure, chain extension, ring expansion/contraction, ring variation, ring fusion. 3. Simplification of the structure, rigidification, conformational blockers, X-ray crystallographic studies. Ex: A case study of Oxaminquine (schistosomiasis), Sulpha drugs (antibacterial), and Benzodiazepines (Hypnotics).

CPI - 38 : General Principles of Pharmacology and drug Targets, drugs acting on ANS and CNS

Introduction - Nature and sources of drugs - Routes of administration of drugs - Concept of absorption – bioavailability - Drug distribution - Biotransformation and excretion drugs - Biological half-life and its significance/toxicity - Mechanism of action including drug receptor - Interactions and factors influencing them - Dose response relationship.

Introduction to molecular targets - lipids, carbohydrates, proteins (catalytic and non-catalytic) and nucleic acids. A brief introduction to the architecture of the Cells - Human Cell structure, Bacterial Cell wall, Cell membrane-membrane lipids, membrane proteins, membrane carbohydrates.

Pharmacology of Drugs Acting on ANS and CNS

Introduction - Transmission - Distribution and Functions of drugs acting on Autonomic Nervous System; Cholinergic agonists (Acetylcholine), Anti-cholinergic agents (Atropine), Anti Cholinesterase (Physostigmine), Local Anaesthetics (Procaine), Adrenergic stimulants (Dopamine), Adrenoreceptor antagonist (Doxazosin). Anti-Histamine agents (Cimetidine).

Distribution and Functions of Drugs acting on Central Nervous System: CNS Neuro-transmitters; CNS Stimulants - Analeptics (Nikethamide), Psychomotor stimulants (Amphetamine), Anti-depressants (Imipramine), Hypnotics and Anxiolytics: Anti-psychotic Agents (Chlorpromazine), Anti-epileptic Agents (Phenytoin), General Anesthetics (Haloethanes (inhalation anasthetic)), Thiopentone (I.V. anasthetic). Neurodegenerative disorders: Alzheimers disease (Donepezil), Parkinson disease (Levodopa).

CPI - 39 : Drugs Acting on Cardio Vascular and Respiratory System

General considerations - Pharmacology of drugs used in the treatment of congestive heart failure - Anti-arrythmics - Classification with examples, Anti-hypertensives, ACE inhibitors (captopril), beta1-blockers (Propranolol), Drugs acting on Ion channels - Ca^{2+}, Na^{+} and Cl^{-} channels and their mode of action. Structural formulae of Tetracaine and synthesis and of Amlodipine, Nifedipine, Diltiazem, Tetracine and 4-Aminopyridine. α-Adrenoreceptor stimulant (Clonidine), α- Adrenoreceptor blocking agent (Prazocin), Anti-hyperlipedemic (Clofibrate).

Pharmacology of Drugs affecting Respiratory System: Drugs used in the treatment of disorders of Respiratory Function and Bronchial Asthma - Broncho dilators - i) β–adrenergic agents (Albuterol) ii) Phosphodiestarase inhibitors (Aminophylline), Anticholinergic agents (Atropine), Corticosteroids (Beclomethasone), Inhibitors of mediator release (Cromolyn Sodium), Anti-tussives (Codeine) and Expectorants (Guaifenesin).

Pharmacology of Drugs affecting Gastro intestinal System - H^{+}/K^{+}-ATPase inhibitors (omeprazole) Pharmacology of purgatives/laxatives (Dulcolax), Anti-diarrhoeals (Lopramide).

CPI - 40 : Drugs acting on metabolic process, cell wall, genetic material and immune system

a) Drugs acting on metabolic process: Antifolates - Discovery and mechanism of action of sulphonamides, Structure of sulfomethoxazole, and dapsone. Diaminopyrimidines - trimethoprim, and drug synergism.

b) Drugs acting on cell wall: β-Lactam antibiotics - mechanism of action of penicillins and cephalosporins. Resistance to pencillins, broad spectrum penicillins - ampicillin and amoxicillin. β-Lactamase inhibitors - Structural formulae and mode of action of clavulanic acid and sulbactum.

Drugs acting on genetic material: Introduction, classification and mechanism of action.

a) DNA-intercalating agents - Anticancer and Antimalarial agents. Structural formulae of Daunomycin, Amsacrine and Chloroquine.

b) DNA- Binding and nicking agents: Antiprotozoal drugs, Metronidazole, and Tinidazole.

c) DNA-Polymerase inhibitors: Antiviral agents - AZT.

d) DNA-Topoisomerase inhibitors: Anti bacterial agents. Structural formulae of Ciprofloxacin and Norfloxacin

e) Inhibitors of transcribing enzymes: Anti-TB and antileprosy agents-structural formulae of Rifamycins.

f) Drugs interfering with translation process: Antibacterial drugs- Structural formulae of Erythromycin, 5-Oxytetracycline and Streptomycin.

Drugs acting on immune system: Introduction to immune system. Immunosupressing agent-structural formula of Cyclosporin. Immunoenhancers-use of vaccines and strucrural formula of levamisol.

Recommended books

1. Burger's medicinal chemistry and drug discovery. By Manfred E. Wolf.
2. Introduction to Medicinal chemistry. By Patrick.
3. Introduction to drug design. By Silverman

4. Comprehensive medicinal chemistry. Vol 1-5 By Hanzsch.
5. Principles of medicinal chemistry. By William Foye
6. Biochemical approach to medicinal chemistry. By Thomas Nogrady.
7. Pharmaceutical Chemistry and Drug synthesis By Roth and Kleeman
8. Pharmacology and Pharmacotherapeutics, R.S. Satoskar and S.D. Bhandarker, Popular Prakashan, Mumbai.
9. Pharmacology, H.P. Rang, M.M. Dale & J. M. Ritter : Churchill Livingstone, 4th edition.
10. Basic and Clinical Pharmacology, 9th edition – Bertram. G. Katzung.
11. Pharmacology and Pharmacotherapeutics, R.S. Satoskar and S.D. Bhandarker, Popular Prakashan, Mumbai.
12. Pharmacology, H.P. Rang, M.M. Dale & J. M. Ritter : Churchill Livingstone, 4th edition.
13. Basic and Clinical Pharmacology, 9th edition – Bertram. G. Katzung. Reference Books
14. Essentials of Medical Pharmacology, K.D. Tripati, J. P. Brothers Medical Publishers.
15. Lewis's Pharmacology, by J. Crossland, Churchill Livingstone.
16. Pharmacological Principles of Medical Practice, by Krantz and Care, Williams and Wilkins co.
17. Goodman and Gilman's, The Pharmacological Basis of Therapeutics. J. G. Hardman and Lee E. Limbard, Mc. Graw Hill, Health professions Division.
18. Burger's medicinal chemistry and drug discovery. By Manfred B. Wolf.
19. Introduction to Medicinal chemistry. By Graham Patrick.
20. Introduction to drug design. By R.B.Silverman
21. Comprehensive medicinal chemistry. Vol 1-5 by Hanzsch.

PAPER- III : CH(CPI)403 T

ELECTIVE-3A

Pharmaceutical Analysis

CPI - 41: Spectral Methods in Pharmaceutical Analysis
CPI - 42: Chromatography in Pharmaceutical Analysis-I
CPI - 43: Potentiometry, polarography, thermal and radiopharmaceutical methods-Applications
CPI - 44: Titrimetry, Chemical and Extraction methods in Pharmaceutical Analysis

CPI - 41: Spectral Methods in Pharmaceutical Analysis

(A) **Ultraviolet and Visible Spectroscopy** - Introduction, UV spectra of some representative drug molecules : Steroid enones, Ephedrine [the benzoid chromophore], ketoprofen [extended benzene chromophore], Procaine [amino group auxochrome], Phenyleprine [hydroxyl group auxochrome]. Application of UV-Vis Spectrophotometry to Pharmaceutical quantitative Analysis : Assay of Frusemide in tablet, Assay of Penicillin by derivatization. Assay of Drugs by i) Direct UV method ii) Suitable Chromogens and iii) Charge transfer Complexes. Difference spectrophotometry, Derivative Spectra, Applications of UV-Visible Spectrophotmetry in Pre - formulation and formulation.

(B) **Infrared Spectroscopy** - Introduction, Sample preparation, Application of IR Spectrophotomety in Structure Elucidation, interpretation of IR spectra of Paracetamol, aspirin, dexamethasone and phenoxymethyl pencillin potassium. Examples of IR Spectra of Drug molecules, IR Spectrophotometry as a fingerprint technique. **Near IR analysis (NIRA)** : Introduction, Examples of NIRA application

– determination of particle size in United states Pharmacopia grade Aspirin, determination of blend uniformity, determination of active ingredients in multi- component dosage forms, moisture determination.

(C)**Nuclear Magnetic Resonance Spectroscopy** - Introduction, 1H NMR : Application of NMR to Structure Confirmation in some drug molecules, ^{1}H NMR spectral analysis of Benzocaine, Phenacetin, Clofibrate and phenylephrine.^{13}C NMR : ^{13}C NMR spectrum of Salbutamol sulphate, Two Dimensional NMR Spectra – Proton- proton correlation spectrum of Tranexamic acid, Application of NMR to Quantitative analysis.

CPI - 42: Chromatography in Pharmaceutical Analysis-I

(A) **Thin Layer Chromatography** – Introduction, Instrumentation, TLC Chromatogram, Stationary Phases, Eluotropic series and Mobile phases, Modification of TLC, Adsorbents, detection of compounds on TLC plate following development, Applications of TLC analysis – qualitative identity tests, limit tests. High performance TLC (HPTLC), Applications of HPTLC – Assay for rifampicin (R), isoniazid (I) and pyrazinamide(P).

(B) **High performance Capillary Electrophoresis** – Introduction, Instrumentation, control of separation. Application of capillary electrophoresis in pharmaceutical analysis, Separation of Atenolol and related impurities. Analysis of Non-steroidal anti-inflammatory drugs. Micellar Electrokinetic Chromatography, Analysis of flavonoids by MECC.

(C) **Gas Chromatography** – Introduction, Instrumentation, Selectivity of Liquid Stationary Phases, Use of Derivatization in GC ,Application of GC in quantitative analysis, Determination of manufacturing and degradation residues by GC, Determination of pivolic acid in dipivefrin eye drops, Determination of residual solvents, Application of GC in Bioanalysis.

(D) **High Performance Liquid Chromatography** – Introduction, Instrumentation, Structural factors which govern rate of elution of drugs from HPLC columns, Application of

HPLC to the quantitative analysis of drugs in formulations, Assay of hydrocortisone cream with one point calibration against an internal standard, Assays involved in more specialized HPLC techniques, Assay of adrenaline injection by chromatography with an anionic ion-pairing agent.

CPI - 43:Chromatography in Pharmaceutical Analysis-II

(A**) Potentiometric Titrations**: assay of Aspirin, assay of Iron (II) succinate in ferromynS tablets, Determination of fluoride in tablets and solutions by Flouride Ion Selective Electrode.

(B) **Radiopharmaceuticals:** Fundamentals of radioactivity, Measurement of radioactivity, Radiopharmaceuticals-requirements, radiochemical methods in analysis-Isotope dilution analysis IDA, Radioimmuno assay RIA-Thyroxin, and thyroid stimulating Hormone.

(C) **Thermal Method of Analysis:** Classification of thermoanalytical techniques, Applications of DSC/DTA/TGA in pharmaceutical analysis- Detection of polymorphisim and pseudopolymorphisim in pharmaceutical by DSC/DTA. Analysis of Drug Phenacetin by DSC.

(D) **Polarography:** Pharmaceutical applications of polarography in analysis of Antibiotics, Alkaloids, Trace metals and metal containing drugs, Blood serum and cancer diagnosis, insecticides, Vitamins, Hormones.

CPI - 44: Titrimetry, Chemical and Extraction methods in Pharmaceutical Analysis

(A**) Titrimetry and Chemical Methods** - Introduction, Direct Acid/Base titrations in the aqueous phase, Indirect Titrations in aqueous phase – estimation of alcohols and hydroxyl values by reaction with acetic anhydride. Non-aqueous titrations – analysis of phenylephrine, Argentimetric Titrations – assays of Sodium chloride, potassium chloride, thiamine hydrochloride, Complexometric Titrations – metal salts estimations, Redox Titrations - assays of ferrous salts, hydrogen peroxide, sodium perborate and benzoyl peroxide by titration with $KMnO_4$, Iodometric Titrations – Asasy of phenolglycerol injection , Ion-pair Titrations, Diazotization Titrations – assay of sulphanilamide, Karl-Fischer Titrations

(B) **Extraction Methods -** Introduction, Commonly used excipients in formulations – (i) tablets and capsules (ii) suspensions and solutions (iii) creams and ointments. Solvent Extraction methods, (i) extraction of organic bases and acids utilizing their ionized and un-ionized forms. Partition between organic solvents, ion-pair extraction. Solid phase Extraction – Introduction, Methodology, types of adsorbents used in Solid phase Extraction – (i) Lipohilic silica gels. (ii) Polar surfaced modified silica gels.

Recommended Text Books:

1. Pharmaceutical Analysis by David G. Watson
2. Practical pharmaceutical chemistry Part I by Beckett & Stenlake
3. Pharmaceutical analysis by Ashtoshkar
4. Physical pharmacy by AN.Martin,J, Swarlbick etal
5. Biopharmaceutics and pharmacokinetics by Brahmanikar
6. Text book of physical pharmaceuticals by Subramaniyan
7. Inorganic pharmaceutical chemistry By Black
8. British Pharmacopoeia Vol I,II
9. Indian Pharmacopoeia Vol I,II
10. Bently's Text book of pharmaceutics by Rowlins
11. The science and practice of pharmacy by Remington
12. Thermal methods of Analysis-D.G Watson

PAPER-III: CH(CPI) 403 T

ELECTIVE-3B

Bioorganic Chemistry

CPI-45: Carbohydrates
CPI-46: Nucleic acids and Lipids
CPI-47: Proteins and Enzymes
CPI-48: Coenzymes and Vitamins

CPI-45: Carbohydrates **15 Hrs**

Introduction to the importance of Carbohydrates. Types of naturally occuring sugars. Deoxy sugars, aminosugars, branched chain sugars mrthyl ethers and acid derivatives of sugars. Determination of configuration and determination of ring size of D-glucose and D-Fructose. Conformational analysis of monosaccharides. $^4C_1$ and $^1C_4$ conformations of D-glucose. Reactions of six carbon sugars: Ferrier, Hanesian reaction and Ferrier rearrangement. Synthesis of amino, halo and thio sugars. Structure, ring size determination of sucrose and maltose. Conformational structures of sucrose, lactose, maltose, cellobiose and gentobiose. Structure and biological functions of starch, cellulose, glycogen and chitin. Role of sugars in cell to cell recognition, blood groups.

CPI-46: Nucleic acids & lipids **15 Hrs**

Nucleic acids: Retro synthetic analysis of nucleic acids - Nucleotides, Nucleosides, Nucleotide bases and Sugars. Structure and synthesis of nucleosides and nucleotides. Primary, secondary and tertiary structure of DNA. Types of mRNA, tRNA and rRNA. Replication, transcription and translation. Genetic code. Protein biosynthesis. DNA finger printing.

Lipids: Introduction and classification of lipids. Stereochemical notation in lipids. Chemical synthesis and biosynthesis of phospholipids and glycolipids. Properties of lipid aggregates, micelles, bilayers, liposomes and biological membranes.

CPI-47: Proteins and Enzymes **15 Hrs**

Proteins: Introduction. Peptide bond, classification and nomenclatue of peptides. Amino acid sequence of polypeptides and proteins: terminal residue analysis and partial hydrolysis. Peptide synthesis by solution phase and solid phase synthesis methods. Proteins - Biological importance and classification - Primary, secondary and tertiary structure of proteins.

Enzymes: Definition. Classification based on mode of action. Mechanism of enzyme catalysis - Lock and Key, Induced- Fit and three point contact models. Enzyme selectivity –chemo, regio, diastereo and enantio selectivity – illustration with suitable examples. Factors affecting enzyme catalysis. Enzyme inhibition - reversible and irreversible inhibition. Enzymes in organic synthesis. Immobilised enzymes

CPI-48: Coenzymes and Vitamins **15 Hrs**

Coenzymes: Introduction. Co-factors - cosubstrates - prosthetic groups.

Classification — Vitamin derived coenzymes and metabolite coenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate (TPP), pyridoxal phosphate (PLP), oxidized and reduced forms of I) nicotinamide adenosine dinucleotide / their phosphates (NAD), NADH, $NADP^+$ NADPH) ii) Flavin adenine nucleotide FAD, $FADH_2$ and iii) Flavin mononucleotide (FMN, $FMNH_2$) lipoic acid, biotin, tetrahydrofolate and ubiquinone. Adenosine triphosphate (ATP) and adenosine diphosphate (ADP), S-adenosyl methionine (SAM) and

uridine diphospho sugars (UDP-sugars) Mechanism of reactions catalyzed by the above coenzymes.

Vitamins: Introduction, classification and biological importance of vitamins. Structure determination and synthesis of vitamins A, B_1, and B_2. Synthesis of vitamins - B_6, C, E and K. Structure of vitamin B_{12}.

Reference Books:

1. Organic Chemistry Vol.I and Vol.II by I.L.Finar
2. Carbohydrate Chemistry by Barton Volumes
3. Carbohydrate chemistry by G.J.Boons
4. The chemistry of natural products:vol.V - carbohydrates by S.F.Dyke
5. Organic Chemistry by McMurry
6. Nucleic acids in Chemistry and Biology by G M Blackbum MI Gait
7. Lehninger Principles of Biochemistry by D L Nelson and M M Coxon
8. Outlines of Biochemistry by Conn and Stumpf
9. Enzyme structure and mechanism by Fersht and Freeman
10. Enzymes for green organic synthesis by V.K.Ahluwalia
11. Biotransformations in Organic Chemistry by K Faber.
12. Principles of biochemistry by Horton & others.
13. Bioorganic chemistry - A chemical approach to enzyme action by Herman Dugas and Christopher Penney.
14. Concepts in Biotechnology by D.Balasubramanian & others
15. Chemistry and physiology of the vitamins by H.R.Rosenberg.

PAPER-IV: CH(CPI)404 T

ELECTIVE-4A

Advanced Heterocyclic Chemistry

CPI - 49: Non aromatic heterocyclics & aromaticity
CPI - 50: Five and six membered heterocyclics with two hetero atoms
CPI - 51: Heterocyclics with more than two hetero atoms
CPI - 52: Larger ring and other heterocycles

CPI - 49: Non aromatic heterocyclics & Aromaticity

Different types of strains, interactions and conformational aspects of nonaromatic heterocycles. Synthesis, reactivity and importance of the following ring systems. Azirines, Aziridines, Oxiranes, Thiiranes, Diazirenes, Diaziridines, Oxaziridines, Azetidines, Oxetanes andthietanes

Aromaticity: Introduction, Aromatic and anti aromatic compounds. Criteria for aromaticity. Huckel's 4n+2 electron rule for benzene and non benzenoid aromatic compounds. Eg. Cyclopropenium ion, cyclopentadienyl ion, cycloheptatrienium ion, azulene and annulenes.

CPI - 50: Five and six membered heterocyclics with two hetero atoms

Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyrazole, Imidazole, Oxazole, Thiazole, Isoxazole, Isothiazole, Pyridazine, Pyrimidine. Pyrazine, Oxazine, thiazine, benzimidazole, benzoxazole and benzthiazole.

CPI - 51: Heterocyclics with more than two hetero atoms

Synthesis, reactivity, aromatic character and importance of the following Heterocycles: 1,2,3-triazoies,1,2,4-triazoles, Tetrazoles, 1,2,4-oxadiazole, 1 ,3,4-oxadiazole, 1,2,5- oxadiazole, 1,2,3-thiadiazoles, 1,3,4- thiadiazoles, 1,2,5- thiadiazoles, 1,2,3-triazine, 1,2,4- triazine, 1,3,5-triazine, tetrazines. Synthesis and importance of purines and pteridines. Syntheis of Caffeine, theobromine and theophylline.

CPI - 52: Larger ring and other heterocycles

Synthesis, structure, stability and reactivity of Azepines, Oxepines and Thiepines. Synthesis of Diazepines rearrangements of 1,2 - diazepines. Synthesis of Benzoazepines, Benzodiazepines, Benzooxepines, Benzothiepines, Azocines and Azonines. Synthesis of selenophenes, Tellerophenes, Phospholes and Boroles.

Recommended Books:

1. Heterocyclic Chemistry, T.Gilchrist
2. An introduction to the Chemistry of heterocyclic compounds, R.M.Acheson
3. Heterocyclic Chemistry, J.A.Joule & K.Mills
4. Principles of Modern Heterocyclie Chemistry, A.Paquette
5. Heterocyclic Chemistry, J,A.Joule & Smith
6. Handbook of Heterocyclic Chemistry, A.R.Katritzky
7. The aromaticity III level, units 17-19 British open university volumes
8. Aromatic character and aromaticity by G.M.Badger
9. Non-benzenoid aromatic compounds by D.Ginsberg
10. Nonbenzenoid compounds by Lloy

PAPER- IV : CH(CPI)404 T

ELECTIVE 4B

Green chemistry and Organic materials

CPI - 53: Principles of Green chemistry
CPI - 54: Green Synthesis
CPI - 55: Organic nanomaterials
CPI - 56: Supramolecular chemistry

CPI - 53: Principles of Green chemistry

Green chemistry: Introduction - **Principles of Green Chemistry**: Designing a Green Synthesis using these principles; Prevention of Waste/by-products; maximum incorporation of the starting materials used in the synthesis into the final products (Atom Economy); prevention/minimization of hazardous/toxic products; designing safer chemicals ; selection of appropriate auxiliary substances - green solvents, ionic liquids and solvent-free synthesis: energy requirements for reactions - use of microwaves, ultrasonic energy in organic synthesis; prevention of unnecessary derivatization – careful use of protecting groups; use of catalytic reagents in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

CPI - 54: Green Synthesis

i) Microwave Assisted Organic Synthesis (MAOS): introduction, benefits and limitations
a) Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Claisen rearrangement and Diels- Alder reaction.
b)Microwave assisted Solvent-free reactions: Deacetylation, saponification of esters, alkylation of reactive methylene compounds and synthesis of nitriles from aldehydes.
ii)Ultrasound Assisted Organic Synthesis: introduction, applications of ultrasound-Cannizaro reaction, Reformatsky reaction and Strecker synthesis.
iii)Organic Synthesis in Green Solvents: introduction
a) Aqueous Phase Reactions: Diels-Alder Reaction, Heck reaction, Hoffmann elimination, Claisen-Schmidt condensation hydrolysis and diydroxylation reactions.
b)Organic Synthesis using Ionic liquids: Introduction, applications-Beckmann rearrangement Suzuki Cross-Coupling Reaction and Diels- Alder reaction.
iv) Green Catalysts in organic synthesis: introduction
a) Phase Transfer Catalysts in Organic Synthesis: Introduction, Williamson ether synthesis and Wittig reaction
b) Biocatalysts in Organic Synthesis: Biochemical (microbial) oxidations and reductions.

CPI - 55: Organic nanomaterials

Introduction: The 'top-down' approach, the 'bottom-up' approach and Nanomanipulation.
Molecular Devices: Photochemical devices, Liquid crystals, Molecular wires, Rectifiers, Molecular switches and Molecular Muscles.
New Carbon family: Types of Fullerenes, Types of Carbon nanotubes (Zig-Zag, Armchair and Chiral), Graphenes. Growth, Chemical Synthesis and optoelectronic properties of Fullerenes, CNTs (Zig Zag, Armchair and Chiral), singlewalled CNTs (SWCNTs) and multi walled MWCNTs)and Graphenes.
Structures of aromatics belts, nano car and molecular machines.
Optoelectronic molecules: OLEDs, Organic Solar Cells (Basic OLED mechanism and structures) - Natural Benz heterazoles and their synthetic modifications as optoelectronic molecules.

CPI - 56: Supramolecular chemistry

I**ntroduction**: Supramolecular interactions (ion-ion, ion-dipole, H-bonding, cation-π, anion-π, π-π and Van der Walls interactions),Ionophore and molecular receptors.

Host-Guest Chemistry: Lock and key anology, Structures and applications of Cryptands,Spherands, Calixerenes, Cyclodextrins, Cyclophanes, Carcerands and hemicarcirands.

Self-assembly: Ladder, polygons, helices, rotaxanes, catanenes, Molecular necklace, dendrimers, self-assembly capsules their synthesis, properties and applications.

Enantioselective molecular recognition: Cyclodextrins, Crown ethers with chiral frame work, Chiral receptor from Kemp's triacid. Chiral receptors for tartaric acid.

Recommended books:

1. P.T. Anastes & J.K. Warmer: Oxford Green Chemistry- Theory and Practical, University Press (1998).
2. A.S. Matlack: Introduction to Green Chemistry, Marcel Deckkar, (2001).
3. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
4. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).
5. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers
6. Enantioselective organocatalysis, Peter I Dallco, Willey-VCH
7. Core Concepts in Supramolecular Chemistry and Nanochemistry by Jonathan W. Steed, David R. Turner and Karl J. Wallace; John-Wiley and Sons Publications
9. Supramolecular Chemistry by Jonathan W. Steed and Jerry L. Atwood, John-Wiley and Sons Publications
10. Supramolecular Chemistry-Concepts and Perspectives by J M. Lehn; Wiley-VCH (1995) Publications
11. Supramolecular Chemistry by P. D. Beer, P. A. Gale and D. K. Smith; Oxford University Press (1999)
12. Stereochemistry of organic compounds - Principles & Applications by D Nasipuri
13. Nanochemistry by G.B. Sergeev; Elsevier
14. Nanochemistry: A chemical approach to nano materials , G.A. Ozin & A.C. Arsenault; RSC publishers.

SEMESTER -IV
PRACTICALS

Paper-V: CPI – 451P: Quantitative Analysis of Pharmaceuticals

Assay of pharmaceuticals - Redox titrations

Assay of analgin in tablets by iodometry
Assay of ascorbic acid in raw material by iodometry
Assay of ascorbic acid in tablets by cerimetry
Determination of hydrogen peroxide in medicament by Permanganometry

Assay of pharmaceuticals - Complexometric titrations

Assay of Calcium in Calcium gluconate
Assay Zinc in Bacitracin zinc

Assay of pharmaceuticals - Non-aqueous titrations:

Assay of diphenylhydramine hydrochloride in tablets
Assay of ephedrine hydrochloride in capsules
Assay of Ibuprofen in tablets

Assay of pharmaceuticals – Potentiometry/Conductometric

Potentiometric estimation of Sulphanilamide
Potentiometric estimation of Atropine
Conductometric estimation of analysis Amidazophen (aminophenazone)
Conductometric estimation of analysis Asprin

Assay of pharmaceuticals - UV-Visible Spectrophotometry

Assay of Riboflavin in tablets
Assay of Diazepam in tablets
Assay of Nimuselide in nimuselide tablets

Assay of pharmaceuticals – by other methods

Dissolution profile of paracetamol & ampicillin
Determination of Sodium and potassium ions in pharmaceuticals by flamephotometry
Determination of Quinine sulphate & Riboflavin by florimetry.

Identification of unknown pharmaceuticals and intermediates by interpretation of IR, UV, ^{1}H and ^{13}C NMR and Mass spectra

Chromatography:

1. Identification of unknown organic compounds by interpretation of IR, UV, ^{1}H -NMR, ^{13}C-NMR and mass spectral data. A minimum of 08 simple organic molecules should be studied initially as examples along with the spectral elucidation of the drugs as mentioned below tobe studied.

(Asprin, p-Chloroacetophenone, clofibrate, Ibuprofen, Phenylacetic acid, p-MethylBenzoylchloride, L-Dopa, Benzocaine)

2. Thin layer chromatography: Determination of purity of a given sample, monitoring the progress of chemical reactions, identification of unknown organic compounds by comparing the Rf values of known standards.

3. Separation by column chromatography: Separation of a mixture of *ortho* and *para* nitroanilines using silicagel as adsorbant and chloroform as the eluent. The column chromatography should be monitored by TLC.

Paper-VI: CPI - 452P: PROJECTWORK