DR. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY, UTTAR PRADESH, LUCKNOW

Syllabus

For

M.Pharm. (Pharmaceutical Chemistry)

(Effective from the Session: 2017-18)

Master of Pharmacy (M. Pharm.)

SCHEMES FOR INTERNAL ASSESSMENTS AND END SEMESTER EXAMINATIONS (SEM. I & II)
(W.E.F. Session 2017-18)

PHARMACEUTICAL CHEMISTRY-MPC

Course Code	Course	Internal Assessment				End Semester Exams		Total Marks	Credit Points
		Continuous Mode	Sessional Exams		Total	Marks	Duration		
			Marks	Duration					
Semester I									
MPC101T (New)	Modern Pharmaceutical Analytical Techniques	10	15	1 Hrs	25	75	3 Hrs	100	4
MPC102T (New)	Advanced Organic Chemistry -I	10	15	1 Hrs	25	75	3 Hrs	100	4
MPC103T (New)	Advanced Medicinal Chemistry	10	15	1 Hrs	25	75	3 Hrs	100	4
MPC104T (New)	Chemistry of Natural Products	10	15	1 Hrs	25	75	3 Hrs	100	4
MPC105P (New)	Pharmaceutical Chemistry Practical I	20	30	6 Hrs	50	100	6 Hrs	150	6
-	Seminar/ Assignment	-	-	-	-	-	-	100	4
							Total	650	26
Semester II									
MPC201T (New)	Advanced Spectral Analysis	10	15	1 Hr	25	75	3 Hrs	100	4
MPC202T (New)	Advanced Organic Chemistry -II	10	15	1 Hr	25	75	3 Hrs	100	4
MPC203T (New)	Computer Aided Drug Design	10	15	1 Hr	25	75	3 Hrs	100	4
MPC204T (New)	Pharmaceutical Process Chemistry	10	15	1 Hr	25	75	3 Hrs	100	4
MPC205P (New)	Pharmaceutical Chemistry Practical II	20	30	6 Hrs	50	100	6 Hrs	150	6
-	Seminar/ Assignment	-	-	-	-	-	-	100	4
							Total	650	26

Schemes for Internal Assessments and End Semester Examinations (Semester III & IV)

Course Code	Course	Internal Assessment				End Semester Exams		Total Marks	Credit Points
		Continuous Mode	Sessional Exams		Total	Marks	Duration		
			Marks	Duration					
Semester III									
MRM301T (New)	Research Methodology and Biostatistics	40	60	2 Hr	100	-	-	100	4
MRM302T (New)	Journal Club	-	-	-	25	-	-	25	1
MRM303P (New)	Discussion /Presentation (Proposal Presentation)	-	-	-	50	-	-	50	2
MRM304P (New)	Research Work	350	-	-	-	-	-	350	14
							Total	525	21
Semester IV									
MRM401T (New)	Journal Club	-	-	-	25	-	-	25	1
MRM402P (New)	Discussion / Presentation (Proposal Presentation)	-	-	-	75	-	-	75	3
MRM403P (New)	Research Work and Colloquium	-	-	-	-	400	1 Hr	400	16
							Total	500	20

PHARMACEUTICALCHEMISTRY(MPC)

FIRST SEMESTER

MODERN PHARMACEUTICAL ANALYTICAL TECHNIQUES (MPC 101T)

Scope

This subject deals with various advanced analytical instrumental techniques for identification, characterization and quantification of drugs. Instruments dealt are NMR, mass spectrometer, IR, HPLC, GC etc.

Objectives

After completion of course student is able to know about chemicals and excipients-

- The analysis of various drugs in single and combination dosage forms.
- Theoretical and practical skills of the instruments.

THEORY **60 Hrs**

1. **a. UV-Visible spectroscopy:** Introduction, theory, laws, and instrumentation associated with UV-Visible spectroscopy. Choice of solvents and solvent effect. Applications of UV-Visible spectroscopy. Difference/ derivative spectroscopy. **10 Hrs**

   b. IR Spectroscopy: Theory, modes of molecular vibrations, sample handling, instrumentation of dispersive and Fourier -Transform IR spectrometer, factors affecting vibrational frequencies. Applications of IR spectroscopy and data interpretation.

   c. Spectroflourimetry: Theory of fluorescence, factors affecting fluorescence (Characterestics of drugs that can be analyzed by flourimetry), quenchers. Instrumentation and applications of fluorescence spectrophotometer.

   d. Flame Emission Spectroscopy and Atomic Absorption Spectroscopy: Principle, instrumentation, interferences and applications.

2. **NMR Spectroscopy:** Quantum numbers and their role in NMR, principle, instrumentation, solvent requirement in NMR, relaxation process, NMR signals in various compounds. Chemical shift, factors influencing chemical shift, spin-spin coupling, coupling constant, nuclear magnetic double resonance. Brief outline of principles of FT-NMR and 13C NMR. Applications of NMR spectroscopy. **10 Hrs**

3. **Mass Spectroscopy:** Principle, theory, instrumentation of mass spectroscopy, different types of ionization like electron impact, chemical, field, FAB and MALDI, APCI, ESI, APPI analyzers of quadrupole and time of flight, mass fragmentation and its rules, meta stable ions, isotopic peaks. Applications of mass spectroscopy. **10 Hrs**

4. **Chromatography:** Principle, apparatus, instrumentation, chromatographic parameters, factors affecting resolution, isolation of drug from excipients, data interpretation and applications of the following: **10 Hrs**

   a) Thin layer chromatography.
   b) High performance thin layer chromatography.
   c) Ion exchange chromatography.
   d) Column chromatography.
   e) Gas chromatography.
   f) High Performance Liquid chromatography.
   g) Ultra high performance liquid chromatography.

h) Affinity chromatography.
i) Gel chromatography.

5. **a. Electrophoresis:** Principle, instrumentation, working conditions, factors affecting separation and applications of the following: **10 Hrs**

a) Paper electrophoresis.
b) Gel electrophoresis.
c) Capillary electrophoresis.
d) Zone electrophoresis.
e) Moving boundary electrophoresis.
f) Isoelectric focusing.

b. X-ray Crystallography: Production of X-rays, different X-ray methods, Bragg's law, rotating crystal technique, X-ray powder technique, types of crystals and applications of X-ray diffraction.

6. **a. Potentiometry:** Principle, working, Ion selective electrodes and application of potentiometry. **10 Hrs**

b. Thermal Techniques: Principle, thermal transitions and instrumentation (Heat flux and power-compensation and designs), modulated DSC, hyper DSC, experimental parameters (Sample preparation, experimental conditions, calibration, heating and cooling rates, resolution, source of errors) and their influence, advantage and disadvantages, pharmaceutical applications.

Differential Thermal Analysis (DTA): Principle, instrumentation and advantage and disadvantages, pharmaceutical applications, derivative differential thermal analysis (DDTA).

TGA: Principle, instrumentation, factors affecting results, advantage and disadvantages, pharmaceutical applications.

c. Immunological Assays: RIA (Radio immune assay), ELISA, bioluminescence assays.

REFERENCES

1. Spectrometric Identification of Organic compounds by Robert M Silverstein, Sixth edition, John Wiley & Sons, 2004.
2. Principles of Instrumental Analysis by Douglas A Skoog, F. James Holler, Timothy A. Nieman, 5th edition, Eastern press, Bangalore, 1998.
3. Instrumental Methods of Analysis by Willards, 7th edition, CBS Publishers.
4. Practical Pharmaceutical Chemistry by Beckett and Stenlake, Vol II, 4th edition, CBS Publishers, New Delhi, 1997.
5. Organic Spectroscopy by William Kemp, 3rd edition, ELBS, 1991.
6. Quantitative Analysis of Drugs in Pharmaceutical Formulation by P D Sethi, 3rd Edition, CBS Publishers, New Delhi, 1997.
7. Pharmaceutical Analysis - Modern Methods – Part B by J W Munson, Vol 11, Marcel. Dekker Series
8. Spectroscopy of Organic Compounds, 2nd edn., P.S. Kalsi, Wiley Eastern Ltd., Delhi.
9. Textbook of Pharmaceutical Analysis by KA. Connors, 3rd Edition, John Wiley & Sons, 1982.
10. Introduction to Spectroscopy by Pavia D.L., Lampman G.M. and Kriz G.S., Harcourt College Publishers, Philadelphia.
11. Analytical Profile of Drug Substance (All volume) by Florey K., Academic Press, Elsevier, Massachusetts.

12. Thin Layer Chromatography: A Laboratory Handbook, Stahl E., Springer, Berlin.
13. Undergraduate Instrumental Analysis, Obonson J.W.R., Marcel Dekker Inc, New York.
14. Absorption Spectroscopy of Organic Molecules by Parikh V.H., Addison-Wesley Publishing Co., London.

ADVANCED ORGANIC CHEMISTRY - I
(MPC 102T)

Scope

The subject is designed to provide in-depth knowledge about advances in organic chemistry, different techniques of organic synthesis and their applications to process chemistry as well as drug discovery.

Objectives

Upon completion of course, the student shall be to understand

- The principles and applications of retro-synthesis.
- The mechanism & applications of various named reactions.
- The concept of disconnection to develop synthetic routes for small target molecule.
- The various catalysts used in organic reactions.
- The chemistry of heterocyclic compounds.

THEORY **60 Hrs**

1. Basic Aspects of Organic Chemistry: **12 Hrs**

1. Organic intermediates: Carbocations, carbanions, free radicals, carbenes and nitrenes. Their method of formation, stability and synthetic applications.
2. Types of reaction mechanisms and methods of determining them,
3. Detailed knowledge regarding the reactions, mechanisms and their relative reactivity and orientations.
    a) Addition reactions
    b) Substitution reactions (Nucleophilic uni- & bimolecular i.e. SN1 and SN2)
    c) Elimination reactions (E1 & E2; Hoffman & Saytzeff's rule).
    d) Rearrangement reactions.

2. Study of Mechanism and Synthetic Applications of Following Named Reactions: **12 Hrs**

Ugi reaction, Brook rearrangement, Ullmann coupling reactions,Dieckmann Reaction, Doebner-Miller Reaction, Sandmeyer Reaction, Mitsunobu reaction, Mannich reaction, Vilsmeyer-Haack Reaction, Sharpless asymmetric epoxidation, Baeyer-Villiger oxidation, Shapiro & Suzuki reaction, Ozonolysis and Michael addition reaction

3. Synthetic Reagents & Applications: Aluminiumisopropoxide, N-bromosuccinamide, diazomethane,dicyclohexyl-carbodimide, Wilkinson reagent, Witting reagent. Osmium tetroxide, titanium chloride, diazopropane, diethyl azodicarboxylate, Triphenylphosphine, Benzotriazol-1-yloxy) tris (dimethylamino) phosphonium hexafluoro-phosphate (BOP). **12 Hrs**

Protecting Groups:

a) Role of protection in organic synthesis.

b)Protection for the hydroxyl group, including 1,2-and1,3-diols:ethers, esters, carbonates, cyclic acetals & ketals

c) Protection for the carbonyl group: Acetals and Ketals

d) Protection for the carboxyl group: Amides and hydrazides,esters

e) Protection for the amino group and amino acids: Carbamates

4. Heterocyclic Chemistry: Organic Name reactions with their respective mechanism and application involved in synthesis of drugs containing five, six membered and fused hetrocyclics such as Debus-Radziszewski imidazole synthesis, Knorr Pyrazole Synthesis Pinner Pyrimidine Synthesis, Combes Quinoline Synthesis, Bernthsen Acridine Synthesis, **12 Hrs**

Smiles rearrangement and Traube purine synthesis.

Synthesis of few representative drugs containing these hetrocyclic nucleus such as Ketoconazole, Metronidazole, Miconazole, celecoxib, antipyrin, Metamizole sodium, Terconazole, Alprazolam, Triamterene, Sulfamerazine, Trimethoprim, Hydroxychloroquine, Quinine, Chloroquine, Quinacrine, Amsacrine, Prochlorpherazine, Promazine, Chlorpromazine, Theophylline, Mercaptopurine and Thioguanine.

5. Synthon Approach and Retrosynthesis Applications : 12 Hrs

a) Basic principles, terminologies and advantages of retrosynthesis; guidelines for dissection of molecules.Functional group interconvertion and addition (FGI and FGA)

b) C-X disconnections; C-C disconnections – alcohols and carbonyl compounds; 1,2-, 1,3-,1,4-, 1,5-, 1,6-difunctionalizedcompounds.

c) Strategies for synthesis of three, four, five and six-membered rings.

REFERENCES

1. "Advanced Organic chemistry, Reaction, Mechanisms and Structure" by J. March, John Wiley and Sons, New York.
2. "Mechanism and Structure in Organic Chemistry", E.S. Gould, Hold Rinchart and Winston, New York.
3. "Organic Chemistry" Clayden, Greeves, Warren and Woihers., Oxford University Press 2001.
4. "Organic Chemistry" Vol I and II. I.L. Finar. ELBS, Pearson Education Lts, Dorling Kindersley 9India) Pvt. Ltd.
5. A Guide to Mechanisms in Organic Chemistry by Peter Skyes (Orient Longman, New Delhi).
6. Reactive Intermediates in Organic Chemistry by Tandom and Gowel, Oxford & IBH Publishers.
7. Combinational Chemistry – Synthesis and Applications by Stephen R Wilson & Anthony W Czarnik, Wiley – Blackwell.
8. Organic Chemistry by Carey, F. 5th Edition (Viva Books Pvt. Ltd.).
9. Organic Synthesis - The Disconnection Approach by S. Warren, Wily India.
10. Principles of Organic Synthesis by R.C. Norman and JM Coxan, Nelson Thorns.
11. Organic Synthesis - Special Techniques. VK Ahluwalia and R Agarwal, Narosa Publishers.
12. Organic Reaction Mechanisms IVth Edtn, VK Ahluwalia and RK Parashar.
13. Organic Chemistry by Morrison R.T., Boyd R.N., and Bhattacharjee, S.K. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), New Delhi.
14. The Art of Writing Reasonable Organic Reaction Mechanisms, by Grossman R.B., Springer, New York.
15. Name Reactions: A Collection of Detailed Reaction Mechanisms by Li J.J., Springer, Berlin.
16. Strategic Applications of Named Reactions in Organic Synthesis: Background and Detailed Mechanisms by Kurti L., Czako B., Elsevier Academic Press, Amsterdam.
17. An Introduction to the Chemistry of Heterocyclic Compounds by Acheson R.M., Wiley (India) Pvt. Ltd, New Delhi.
18. Heterocyclic Chemistry by Joule J.A. and Mills K., Blackwell Publishing, New Jersey.
19. Heterocyclic Chemistry by Gilchrist T.L., Pearson Education Ltd, Singapore.
20. Heterocyclic Chemistry by Bansal R.K., New Age International Publishers, New Delhi.

ADVANCED MEDICINAL CHEMISTRY
(MPC 103T)

Scope

The subject is designed to impart knowledge about recent advances in the field of medicinal chemistry at the molecular level including different techniques for the rational drug design.

Objectives

At completion of this course it is expected that students will be able to understand-

- Different stages of drug discovery.
- Role of medicinal chemistry in drug research.
- Different techniques for drug discovery.
- Various strategies to design and develop new drug like molecules for biological targets.
- Peptidomimetics.

THEORY **60 Hrs**

1. **Drug Discovery:** Stages of drug discovery, lead discovery; identification, validation and diversity of drug targets. **12 Hrs**

Biological Drug Targets: Receptors, types, binding and activation, theories of drug receptor interaction, drug receptor interactions, agonists vs antagonists, artificial enzymes.

2. **Prodrug Design and Analog design:** **12 Hrs**

a) **Prodrug design:** Basic concept, Carrier linked prodrugs/Bioprecursors, Prodrugs of functional group, Prodrugs to improve patient acceptability, Drug solubility, Drug absorption and distribution, site specific drug delivery and sustained drug action. Rationale of prodrug designand practical consideration of prodrug design.

b) **Combating Drug Resistance:** Causes for drug resistance, strategies to combat drug resistance in antibiotics and anticancer therapy, Genetic principles of drug resistance.

c) **Analog Design:** Introduction, Classical & Non classical, Bioisosteric replacement strategies, rigid analogs, alteration of chain branching, changes in ring size, ring position isomers, design of stereo isomers and geometric isomers, fragments of a lead molecule, variation in inter atomic distance.

3. **a) Medicinal Chemistry Aspects of the Following Class of Drugs**: Systematic study, SAR, Mechanism of action and synthesis of new generation molecules of following class of drugs: **12 Hrs**

Anti-hypertensive drugs, psychoactive drugs, anticonvulsant drugs, H1 & H2 receptor antagonist, COX1 & COX2 inhibitors, adrenergic & cholinergic agents, antineoplastic and antiviral agents.

b) Stereochemistry and Drug Action: Realization that stereo selectivity is a pre-requisite for evolution. Role of chirality in selective and specific therapeutic agents. Case studies, Enantioselectivity in drug adsorption, metabolism, distribution and elimination.

4. **Rational Design of Enzyme Inhibitors**: Enzyme kinetics & principles of enzyme inhibitors, enzyme inhibitors in medicine, enzyme inhibitors in basic research, rational design of non-covalently and covalently binding enzyme inhibitors. **12 Hrs**

5. **Peptidomimetics:** Therapeutic values of peptidomimetics, design of peptidomimetics by manipulation of the amino acids, modification of the peptide backbone, incorporating **12 Hrs**

conformational constraints locally or globally.

Chemistry of prostaglandins, leukotrienes and thromboxones.

REFERENCES

1. Burger's Medicinal Chemistry and Drug Discovery by Abraham D.J., John Wiley and Sons Inc., New York.
2. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry by Block J.H. and Beale J.M., Lippincott Williams and Wilkins, Philadelphia.
3. Foye's Principles of Medicinal Chemistry by Lemke T.L., Williams D.A., Roche V.F. and Zito S.W., Lippincott Williams and Wilkins, Philadelphia.
4. Synthesis of Essential Drugs by Vardanyan R.S. and Hruby V.J., Elsevier, Philadelphia.
5. Medicinal Chemistry: A Biochemical Approach by Nogrady T., Oxford University Press, New York.
6. An Introduction to Medicinal Chemistry by Patrick G.L., Oxford University Press, New York.
7. Comprehensive Medicinal Chemistry by Hansch C., Pergamon Press, Oxford.
8. Fundamentals of Medical Chemistry by Thomas G., Wiley Publication, New Jersey.
9. The Organic Chemistry of Drug Design and Action by Silverman R.B., Academic Press Inc., San Diego.
10. Introduction to Medicinal Chemistry: How Drugs Act and Why by Gringuaz A., Wiley-VCH.
11. The Practice of Medicinal Chemistry by Wermuth C.G., Academic Press, Cambridge.
12. Peptidomimetics in Organic and Medicinal Chemistry by Guarna A. and Trabocchi A., Wiley Publication, New Jersey.
13. Medicinal and Pharmaceutical Chemistry by Singh H. and Kapoor V.K., Vallabh Prakashan, Delhi.
14. Essentials of Medicinal Chemistry by Korolkovas A., John Wiley and Sons Inc., New York.
15. The Strategies for Organic Chemistry of Drug Synthesis by Lednicer D., John Wiley and Sons Inc., New York.
16. Computational and Structural Approaches to Drug Design edited by Robert M. Stroud and Janet. F Moore.
17. Introduction to Quantitative Drug Design by Y.C. Martin.
18. Drug Design Volumes by Arienes, Academic Press, Elsevier Publishers, Noida, Uttar Pradesh..

CHEMISTRY OF NATURAL PRODUCTS
(MPC 104T)

Scope

The subject is designed to provide detail knowledge about chemistry of medicinal compounds from natural origin and general methods of structural elucidation of such compounds. It also emphasizes on isolation, purification and characterization of medicinal compounds from natural origin.

Objectives

At completion of this course it is expected that students will be able to understand-

- Different types of natural compounds and their chemistry and medicinal importance.
- The importance of natural compounds as lead molecules for new drug discovery.
- The concept of rDNA technology tool for new drug discovery
- General methods of structural elucidation of compounds of natural origin.
- Isolation, purification and characterization of simple chemical constituents from natural source.

THEORY **60 Hrs**

1. Study of Natural products as leads for new pharmaceuticals for the following class of drugs- **12 Hrs**

a) Drugs affecting the central nervous system: Morphine alkaloids
b) Anticancer drugs: Paclitaxel and Docetaxel, Etoposide, and Teniposide
c) Cardiovascular drugs: Lovastatin, Teprotide and Dicoumarol
d) Neuromuscular blocking drugs: Curare alkaloids
e) Anti-malarial drugs and analogues
f) Chemistry of macrolide antibiotics (Erythromycin, Azithromycin, Roxithromycin, and Clarithromycin) and β - Lactam antibiotics (Cephalosporins and Carbapenem)

2. **a) Alkaloids:** General introduction, classification, isolation, purification, molecular modification and biological activity of alkaloids, general methods of structural determination of alkaloids, structural elucidation and stereochemistry of Ephedrine, Morphine, Ergot, Emetine and Reserpine. **12 Hrs**

b) Flavonoids: Introduction, isolation and purification of flavonoids, General methods of structural determination of flavonoids- Structural elucidation of Quercetin.

c) Steroids: General introduction, chemistry of sterols, sapogenin and cardiac glycosides. Stereochemistry and nomenclature of steroids, chemistry of contraceptive agents male & female sex hormones (Testosterone, Estradiol, Progesterone), adrenocorticoids (Cortisone), contraceptive agents and steroids (Vitamin D).

3. **a) Terpenoids:** Classification, isolation, isoprene rule and general methods of structural elucidation of terpenoids; Structural elucidation of drugs belonging to mono (citral, menthol, camphor), di (Retinol, Phytol, Taxol) and tri terpenoids (Squalene, Ginsenoside) carotinoids (β-Carotene). **12 Hrs**

b) Vitamins: Chemistry and physiological significance of vitamin A, B1, B2, B12, C, E, Folic acid and Niacin.

4. a). Recombinant DNA technology and drug discovery rDNA technology, hybridoma technology, new pharmaceuticals derived from biotechnology. Oligonucleotide **12 Hrs**

therapy. Gene therapy: Introduction, clinical application and recent advances in gene therapy, principles of RNA & DNA estimation.

b). Active constituent of certain crude drugs used in Indigenous system-
Diabetic therapy– Gymnema sylvestre, Salacia reticulate, Pterocarpus marsupiam, Swertia chirata, Trigonella foenum graccum;
Liver dysfunction – Phyllanthus niruri;
Antitumor – Curcuma longa Linn.

5. Structural characterization of natural compounds structural characterization of natural compounds using IR, 1HNMR, 13CNMR and MS Spectroscopy of specific drugs e.g., Penicillin, Morphine, Camphor, Vit-D, Quercetin and Digitalis glycosides. **12 Hrs**

REFERENCES

1. Organic Chemistry by Finar I.L., Volume II: Stereochemistry and the Chemistry of Natural Products, Pearson Education, New Jersey.
2. Organic Chemistry by Agarwal O.P., Natural Products, Krishna Prakashan Media (P) Ltd., Meerut.
3. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis by Harborne J.B., Springer (India) Pvt. Ltd., New Delhi.
4. Biologically Active Natural Products: Pharmaceuticals by Cutler S.J. and Cutler H.G., CRC Press, London.
5. Textbook of Pharmacognosy and Phytochemistry by Jarald E.E. and Jarald S.E., CBS Publishers and Distributors Pvt. Ltd., New Delhi.
6. Pharmacognosy and Phytochemistry: A Comprehensive Approach by Deore S.L., Khadabadi S.S., Baviskar B.A., PharmaMed Press, Hyderabad.
7. Indian Herbal Pharmacopoeia, Indian Drug Manufacturers Association and Regional Research Laboratory, Jammu.
8. Trease and Evans Pharmacognosy by Evans V.C., Harcourt Publishers Ltd., Sydney.
9. Textbook of Pharmacognosy by Wallis T. E., CBS Publishers and Distributors, New Delhi
10. Pharmacognosy by Tyler V.E., Lea & Febiger, Philadelphia.
11. The Practical Evaluation of Phytopharmaceutical by Brain K.R. and Turner T.D., Wright, Bristol.
12. Thin Layer Chromatography: A Laboratory Hand Book by Stahl E., Springer International Edition, New York.
13. Modern Methods of Plant Analysis by Peech and M.V. Tracey, Springer-Verlag, Berlin, Heidelberg.
14. Phytochemistry Vol. I and II by Miller, Jan Nostrant Rein Hld.
15. Recent Advances in Phytochemistry Vol. I to IV by Scikel Runeckles, Springer Science & Business Media.
16. Chemistry of Natural Products Vol I onwards IWPAC.
17. Natural Product Chemistry Nakanishi Gggolo, University Science Books, California.
18. Natural Product Chemistry “A Laboratory Guide” – Rapheal Khan.
19. The Alkaloid Chemistry and Physiology by RHF Manske, Academic Press.
20. Introduction to Molecular Phytochemistry – CHJ Wells, Chapmannstall.
21. Organic Chemistry of Natural Products Vol I and II by Gurdeep and Chatwall, Himalaya Publishing House.

PHARMACEUTICAL CHEMISTRY PRACTICAL - I
(MPC 105P)

1. Analysis of Pharmacopoeial compounds and their formulations by UV Vis spectrophotometer, RNA & DNA estimation.
2. Simultaneous estimation of multi component containing formulations by UV spectrophotometry.
3. Experiments based on Column chromatography.
4. Experiments based on HPLC.
5. Experiments based on Gas Chromatography.
6. Estimation of riboflavin/quinine sulphate by fluorimetry.
7. Estimation of sodium/potassium by flame photometry.

To perform the following reactions of synthetic importance-

1. Purification of organic solvents, column chromatography
2. Claisen-Schimidt reaction.
3. Benzyllic acid rearrangement.
4. Beckmann rearrangement.
5. Hoffmann rearrangement.
6. Mannich reaction.
7. Synthesis of medicinally important compounds involving more than one step along with purification and Characterization using TLC, melting point and IR spectroscopy (4 experiments).
8. Estimation of elements and functional groups in organic natural compounds.
9. Isolation, characterization like melting point, mixed melting point, molecular weight determination, functional group analysis, co-chromatographic technique for identification of isolated compounds and interpretation of UV and IR data.
10. Some typical degradation reactions to be carried on selected plant constituents.

SECOND SEMESTER

ADVANCED SPECTRAL ANALYSIS
(MPC 201T)

Scope

This subject deals with various hyphenated analytical instrumental techniques for identification, characterization and quantification of drugs. Instruments dealt are LC-MS, GC-MS, ATR-IR, DSC etc.

Objectives

At completion of this course it is expected that students will be able to understand-

- Interpretation of the NMR, Mass and IR spectra of various organic compounds.
- Theoretical and practical skills of the hyphenated instruments.
- Identification of organic compounds.

THEORY **60 Hrs**

1. **UV and IR Spectroscopy:** Wood ward – Fieser rule for 1,3- butadienes, cyclic dienes and α,β-carbonyl compounds and interpretation compounds of enones. **12 Hrs**
ATR-IR, IR Interpretation of organic compounds.

2. **NMR Spectroscopy:** 1-D and 2-D NMR, NOESY and COSY, HECTOR, INADEQUATE techniques, interpretation of organic compounds. **12 Hrs**

3. **Mass Spectroscopy:** Mass fragmentation and its rules, fragmentation of important functional groups like alcohols, amines, carbonyl groups and alkanes, meta stable ions, Mc-Lafferty rearrangement, ring rule, isotopic peaks, interpretation of organic compounds. **12 Hrs**

4. **Chromatography:** Principle, instrumentation and applications of the following : **12 Hrs**

a) GC-MS
b) GC-AAS.
c) LC-MS.
d) LC-FTIR.
e) LC-NMR.
f) CEMS.
g) High performance thin layer chromatography.
h) Supercritical fluid chromatography.
i) Ion chromatography.
j) I-EC (Ion-Exclusion Chromatography).
k) Flash chromatography.

5. **a).Thermal Methods of Analysis:** Introduction, principle, instrumentation and application of DSC,DTA and TGA. **12 Hrs**

b). Raman Spectroscopy: Introduction, principle, instrumentation and applications.

c).Radioimmunoassay: Biological standardization, bioassay, ELISA, Radioimmunoassay of digitalis and Insulin.

REFERENCES

1. Instrumental Analysis by Skoog D.A., Holler F. J., Crouch S. R., Indian Edition, Brooks/Cole, Boston.
2. Instrumental Methods of Analysis, CBS Publishers & Distributors by Willard H.H., Merrit L.L., Dean J.A., Settle P.A., New Delhi.
3. Organic Spectroscopy by Kemp W., Palgrave, New York.
4. Spectrometric Identification of Organic Compounds by Silverstein R. M., 6th Edition, John Wiley and Sons, New Jersey.
5. Introduction to Spectroscopy by Pavia D.L., Lampman G.M., and Kriz G.S., Harcourt College Publishers, Philadelphia.
6. Quantitative Analysis of Drugs in Pharmaceutical Formulations by HPTLC by Sethi P. D., CBS Publishers, New Delhi.
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8. Pharmaceutical Analysis- Modern Methods- Part B by Munson J. W., Volume 11, Marcel Dekker Series, New York.
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10. Vogel's Text Book of Quantitative Chemical Analysis by Mendham J., Denny R.C., Barnes, J.D. Thomas M.J.K., Pearson Education Asia, Singapore.
11. A Textbook of Pharmaceutical Analysis Connors K.A., Wiley Intescience, New York.
12. Introduction to Modern Liquid Chromatography by Snyder L. R., Joseph. J., K., Dolan J. W. Wiley Publications, New Jersey.
13. Methods in Plant Biochemistry: Plant Phenolics by Harborne J.B. and Dey P.M., Academic Press Inc. New York.
14. The Chemistry of Flavonoid Compounds *by* Geissman T.A., Pergamon Press, Oxford.
15. Pharmaceutical Analysis- Modern methods – Part B by J W Munson, Volume 11, Marcel Dekker Series.

ADVANCED ORGANIC CHEMISTRY - II
(MPC 202T)

Scope

The subject is designed to provide in-depth knowledge about advances in organic chemistry, different techniques of organic synthesis and their applications to process chemistry as well as drug discovery.

Objectives

Upon completion of course, the student shall able to understand

- The principles and applications of green chemistry
- The concept of peptide chemistry.
- The various catalysts used in organic reactions.
- The concept of stereochemistry and asymmetric synthesis.

THEORY **60 Hrs**

1. Green Chemistry: **12 Hrs**

a. Introduction, principles of green chemistry.

b. Microwave assisted reactions: Merit and demerits of its use, increased reaction rates, mechanism, superheating effects of microwave, effects of solvents in microwave assisted synthesis, microwave technology in process optimization, it sapplications in various organic reactions and heterocycles synthesis.

c. Ultrasound assisted reactions: Types of sonochemical reactions, homogenous, heterogeneous liquid-liquid and liquid-solid reactions, synthetic applications

d. Continuous flow reactors: Working principle, advantages and synthetic applications.

2. Chemistry of peptides: **12 Hrs**

a. Coupling reactions in peptide synthesis

b. Principles of solid phase peptide synthesis, t-BOC and FMOC protocols, various solid supports and linkers: Activation procedures, peptide bond formation, deprotection and cleavage from resin, low and high HF cleavage protocols, formation of free peptides and peptide amides, purification and case studies, site-specific chemical modifications of peptides.

c. Segment and sequential strategies for solution phase peptide synthesis with any two case studies.

d. Side reactions in peptide synthesis: Deletion peptides, side reactions initiated by proton abstraction, protonation, overactivation and side reactions of individual amino acids.

3. Photochemical Reactions: Basic principles of photochemical reactions. Photo-oxidation, photo-addition and photo-fragmentation. **12 Hrs**

Pericyclic reactions: Mechanism, types of pericyclic reactions such as cycloaddition, electrocyclic reaction and sigmatrophic rearrangement reactions with examples.

4. Catalysis: **12 Hrs**

a. Types of catalysis, heterogeneous and homogenous catalysis, advantages and disadvantages

b. Heterogeneous catalysis – preparation, characterization, kinetics, supported catalysts, catalyst deactivation and regeneration, some examples of heterogeneous

catalysis used in synthesis of drugs.

c. Homogenous catalysis, hydrogenation, hydroformylation, hydrocyanation, Wilkinson catalysts, chiral ligands and chiralinduction, Ziegler-Natta catalysts, some examples of homogenous catalysis used in synthesis of drugs.

d. Transition-metal and Organo-catalysis in organic synthesis: Metal-catalyzed reactions

e. Biocatalysis: Use of enzymes in organic synthesis, immobilized enzymes/cells in organic reaction.

f. Phase transfer catalysis: Theory and applications.

5. Stereochemistry & Asymmetric Synthesis: 12 Hrs

a. Basic concepts in stereochemistry: Optical activity, specificrotation, racemates and resolution of racemates, the Cahn-Ingold-Prelog (CIP) sequence rule, meso compounds, pseudoasymmetric centres, axes of symmetry, Fischers D and L notation, cis-trans isomerism, E and Z notation.

b. Methods of asymmetric synthesis using chiral pool, chiral auxiliaries and catalytic asymmetric synthesis, enantiopure separation and Stereo selective synthesis with examples.

REFERENCES

1. Advanced Organic Chemistry, Reaction, Mechanism and Structure by March J., John Wiley & Sons, New York.
2. Heterogenous Catalysis In Organic Chemistry by Smith G. V. and Notheisz F., Academic Press, Cambridge.
3. Organic Chemistry by Carey F. A., 5th Edition, Tata McGraw-Hill Publishing Company Ltd. New Delhi.
4. Organic Chemistry by Clayden J., Greeves N., Warren S., Wothers P., Oxford University Press, Oxford.
5. Combinatorial Chemistry A Practical Approach by Fenniri H., Oxford University Press, Oxford.
6. Organic Synthesis-The Disconnection Approach by Warren S., Wiley India, New Delhi.
7. Medicinal Chemistry: An Introduction by Thomas G., John Wiley and Sons Ltd., New York.
8. The Organic Chemistry of Drug Design and Drug Action by Silverman R.B., Elsevier, Amsterdam.
9. Practical Organic Chemistry by Mann F.G, and Saunders, B.C., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education Ltd.), Singapore.
10. Mechanism and Structure in Organic Chemistry", ES Gould, Hold Rinchart and Winston, New York.
11. Organic Chemistry by Francis Carey, 5th edition (Viva Books Pvt. Ltd.).
12. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxan, Nelson thorns.
13. Organic Synthesis- Special Techniques by V.K. Ahluwalia and R Aggarwal, Narosa Publishers.

COMPUTER AIDED DRUG DESIGN
(MPC 203T)

Scope

The subject is designed to impart knowledge on the current state of the art techniques involved in computer assisted drug design.

Objectives

At completion of this course it is expected that students will be able to understand

- Role of CADD in drug discovery.
- Different CADD techniques and their applications.
- Various strategies to design and develop new drug like molecules.
- Working with molecular modeling softwares to design new drug molecules.
- The in silico virtual screening protocols.

THEORY **60 Hrs**

1. **Introduction to Computer Aided Drug Design (CADD):** History, different techniques and applications: Quantitative structure activity relationships: Basics, history and development of QSAR: Physicochemical parametersand methods to calculate physicochemical parameters: Hammett equation and electronic parameters (sigma), lipophilicity effects and parameters (log P, pi-substituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physicochemical parameters. **12 Hrs**

2. **Quantitative Structure Activity Relationships:** Applications: Hansch analysis, Free Wilson analysis and relationship between them, Advantages and disadvantages; Deriving 2D-QSARequations. **12 Hrs**

3D-QSAR approaches and contour map analysis.

Statistical methods used in QSAR analysis and importance of statistical parameters.

3. **Molecular Modeling and Docking:** **12 Hrs**

a) Molecular and Quantum Mechanics in drug design.

b) Energy Minimization Methods: comparison between global minimum conformation and bioactive conformation.

c) Molecular docking and drug receptor interactions: Rigid docking, flexible docking and extra-precision docking.Agents acting on enzymes such as DHFR, HMG-CoAreductase and HIV protease, choline esterase (AchE & BchE).

4. **Molecular Properties and Drug Design:** **12 Hrs**

a) Prediction and analysis of ADMET properties of new molecules and its importance in drug design.

b) De novo drug design: Receptor/enzyme-interaction and its analysis, Receptor/enzyme cavity size prediction, predicting the functional components of cavities, Fragment based drug design.

c) Homology modeling and generation of 3D-structure of protein.

5. **Pharmacophore Mapping and Virtual Screening:** Concept of pharmacophore, pharmacophore mapping, identification of Pharmacophore features and Pharmacophore modeling; Conformational search used in pharmacophore mapping. **12 Hrs**

In Silico Drug Design and Virtual Screening Techniques Similarity based methods and Pharmacophore based screening, structure based In-silico virtual screening protocols.

REFERENCES

1. Computational and Structural Approaches to Drug Design by Stroud R.M., Moore J. F., RSC Publisher, London.
2. Quantitative Drug Design: A Critical Introduction by Martin Y.C., CRC Press, London.
3. Drug Design by Ariens E.J., Volume 1 to 10, Academic Press, Cambridge.
4. Molecular Modeling: Basics Principles and Applications by Holtje H.D., Sippl W., Rognan D., Folkers G., Wiley-VCH, New Jersey.
5. Molecular Modeling: Principles and Applications by Leach A., Pearson, New York.
6. Molecular Modeling and Drug Design by Vinter J. G. and Gardner M., CRC Press, Florida.
7. Comprehensive Medicinal Chemistry by Hansch C., Pergamon Press, Oxford.
8. Pharmacophores and Pharmacophore Searches by Langer T., Hoffmann R.D., Volume-32, Wiley-VCH, Weinheim.
9. Introduction to the Principles of Drug Design and Action by Smith H.J., Williams H., Tylor and Francis, Oxfordshire.
10. The Organic Chemistry of Drug Design and Action by Silverman R.B., Academic Press Inc., San Diego.
11. Burger's Medicinal Chemistry and Drug Discovery by Abraham D.J., John Wiley and Sons Inc., New York.
12. An Introduction to Medicinal Chemistry by Patrick G.L., Oxford University Press, New York.
13. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry by Block J.H. and Beale J.M., Lippincott Williams and Wilkins, Philadelphia.
14. Computer-aided Drug Design Methods and Applications by Perun T.J. and Propst C.L., Saurabh Prakashan Pvt. Ltd., New Delhi.
15. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press, Taylor & Francis group.
16. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis.
17. Strategy of Drug Design: A Guide to Biological Activity by Purcell W.P., Bass G.E., Clayton J.M., PharmaMed Press, Hyderabad.
18. Textbook of Drug Design and Discovery by Larsen P.K., Liljefors T. and Madsen U. Taylor and Francis Inc, Oxfordshire.
19. Structure Based Drug Design by Veerapandian P., CRC Press, London.

PHARMACEUTICAL PROCESS CHEMISTRY
(MPC 204T)

Scope

Process chemistry is often described as scale up reactions, taking them from small quantities created in the research lab to the larger quantities that are needed for further testing and then to even larger quantities required for commercial production. The goal of a process chemist is to develop synthetic routes that are safe, cost-effective, environmentally friendly, and efficient. The subject is designed to impart knowledge on the development and optimization of a synthetic route/s and the pilot plant procedure for the manufacture of Active Pharmaceutical Ingredients (APIs) and new chemical entities (NCEs) for the drug development phase.

Objectives

At completion of this course it is expected that students will be able to understand

- The strategies of scale up process of apis and intermediates.
- The various unit operations and various reactions in process chemistry.

THEORY **60 Hrs**

1. **Process Chemistry:** Introduction, Synthetic strategy. **12 Hrs**

Stages of scale up process: Bench, pilot and large scale process.

In-process control and validation of large scale process.

Case studies of some scale up process of APIs.

Impurities in API, types and their sources including genotoxic impurities.

2. **Unit Operations:** **12 Hrs**

a) Extraction: Liquid equilibria, extraction with reflux, extraction with agitation, counter current extraction.

b) Filtration: Theory of filtration, pressure and vacuum filtration, centrifugal filtration.

c) Distillation: azeotropic and steam distillation.

d) Evaporation: Types of evaporators, factors affecting evaporation.

e) Crystallization: Crystallization from aqueous, non-aqueous solutions factors affecting crystallization, nucleation. Principle and general methods of preparation of polymorphs, hydrates, solvates and amorphous APIs.

3. **Unit Processes-I:** **12 Hrs**

a) Nitration: Nitrating agents, Aromatic nitration, kinetics and mechanism of aromatic nitration, process equipment for technical nitration, mixed acid for nitration,

b) Halogenation: Kinetics of halogenations, types of halogenations, catalytic halogenations. Case study on industrial halogenation process.

c) Oxidation: Introduction, types of oxidative reactions, Liquid phase oxidation with oxidizing agents. Nonmetallic Oxidizing agents such as H2O2, sodium hypochlorite,Oxygen gas, ozonolysis.

4. Unit Processes – II: **12 Hrs**

a) Reduction: Catalytic hydrogenation, heterogeneous and homogeneous catalyst; hydrogen transfer reactions, metal hydrides. Case study on industrial reduction process.

b) Fermentation: Aerobic and anaerobic fermentation. Production of

i. Antibiotics; Penicillin and Streptomycin,

ii. Vitamins: B2 and B12

iii. Statins: Lovastatin, Simvastatin

c) Reaction progress kinetic analysis.

i. Streamlining reaction steps, route selection,

ii. Characteristics of expedient routes, characteristics of cost-effective routes, reagent selection, families of reagents useful for scale-up.

5. Industrial Safety: 12 Hrs

a) MSDS (Material Safety Data Sheet), hazard labels of chemicals and Personal Protection Equipment (PPE)

b) Fire hazards, types of fire & fire extinguishers.

c) Occupational Health & Safety Assessment Series 1800 (OHSAS-1800) and ISO-14001(Environmental Management System), Effluents and its management

REFERENCES

1. A Guide to the Chemical Basis of Drug Design by Burger A., Volume 1-8, Wiley Interscience Publication (John Wiley & Sons), New York.
2. Safety and Health in Industry A Handbook by Sharma A.M., BS Publications Hyderabad.
3. Pharmaceutical Manufacturing Encyclopedia, Volume 2.
4. Process Chemistry in the Pharmaceutical Industry: Challenges in an Ever- Changing Climate-An Overview by Gadamasetti K., Vol-2, CRC Press, London.
5. Effects of Pharmaceutical Processing on Drug Polymorphs and Solvates by Brittain H.G., and Fiese E.F., (In Brittain H.G., Ed. Polymorphism in Pharmaceutical Solids) Vol. 95: Drugs and the Pharmaceutical Sciences, Marcel Dekker, New York.
6. Introduction to Chemical Processes: Principles, Analysis, Synthesis by Murphy R.M., McGraw-Hill Education, New York.
7. Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up by Harrington P. J., John Wiley and Sons, Inc, New Jersey.
8. Unit processes in Organic Synthesis by Groggins P.H., McGraw-Hill, New York.
9. Chemical Technology by Henglein F.A., 1st English Edition, Pergamon Press Ltd., Oxford London.
10. Dryden's Outlines of Chemical Technology by Rao M.G., and Sittig M., East-West Press, New Delhi.
11. Principles of Industrial Chemistry by Clausen C.A., and Mattson G.C., Wiley-Blackwell, New Jersey.
12. Industrial Chemicals by Lowenheim F.A. and Moran M.K., John Wiley Sons, Toronto.
13. A Text Book of Chemical Technology by Shukla S.D., and Pandey G.N., Vol. II, Vikas Publishing House Pvt. Ltd, Jalandhar.
14. Shreve's Chemical Process Industries by Austin G.T., McGraw Hill Education, New York.
15. Industrial Chemistry (including Chemical Engineering) by Sharma B.K., Goel Publishing House, New Delhi.
16. ICH Guidelines.
17. United States Food and Drug Administration official website www.fda.gov.

PHARMACEUTICAL CHEMISTRY PRACTICALS – II
(MPC 205P)

1. Synthesis of organic compounds by adapting different approaches involving (3 experiments)
   a) Oxidation.
   b) Reduction/hydrogenation.
   c) Nitration.
2. Comparative study of synthesis of APIs/intermediates by different synthetic routes (2 experiments).
3. Assignments on regulatory requirements in API (2 experiments).
4. Comparison of absorption spectra by UV and Wood ward – Fieser rule.
5. Interpretation of organic compounds by FT-IR.
6. Interpretation of organic compounds by NMR.
7. Interpretation of organic compounds by MS.
8. Determination of purity by DSC in pharmaceuticals.
9. Identification of organic compounds using FT-IR, NMR, CNMR and Mass spectra.
10. To carry out the preparation of following organic compounds.
11. Preparation of 4-chlorobenzhydrylpiperazine. (An intermediate for cetirizine HCl).
12. Preparation of 4-iodotolene from p-toluidine.
13. NaBH4 reduction of vanillin to vanillyl alcohol.
14. Preparation of Umbelliferone by Pechhman reaction.
15. Preparation of triphenyl imidazole.
16. To perform the Microwave irradiated reactions of synthetic importance (Any two).
17. Determination of log P, MR, hydrogen bond donors and acceptors of selected drugs using softwares.
18. Calculation of ADMET properties of drug molecules and its analysis using Softwares, Pharmacophore modeling.
19. 2D-QSAR based experiments.
20. 3D-QSAR based experiments.
21. Docking study based experiment.
22. Virtual screening based experiment.