UNIVERSITY OF MUMBAI

Janardan Bhagat Shikshan Prasarak Sanstha's

Changu Kana Thakur

Arts, Commerce and Science College, New Panvel (Autonomous)

Re-accredited A^+ Grade by NAAC

'College with Potential for Excellence 'Status Awarded by UGC

'Best College Award' by University of Mumbai

Programme: M.Sc.

(Choice Based Credit System)

Course: Organic Chemistry

Programme Code: MSCOC1018

Syllabus for Semester III and IV

(To be implemented from the Academic Year 2020-2021)

Preamble of the Syllabus:

Master of Science (M.Sc.) in Organic Chemistry is a post-graduate course of Changu Kana Thakur Arts, Commerce and Science College, New Panvel (Autonomous).

The students pursuing this course would have to develop in depth understanding of various aspects of the subject. The new curriculum of M.Sc. Organic Chemistry offers the courses which will prepare the students for critical thinking, understanding of the concepts in depth and skills for employability. The learning outcome based approach is intended to provide a focused and outcome based syllabus with an agenda to structure the teacher-learning experiences in a more student centric manner. The course combines the opportunity for students to acquire knowledge of wide range of cutting-edge fields in chemistry with sessions on theory, practical, presentation and a project supervised by one of the teacher.

Objectives of the Course:

1. Develop analytical thinking and apply the same for understanding principles, proposing mechanism and logical conclusions.
2. Comprehensive understanding of the interdisciplinary nature of Chemistry and emerging trends in Chemistry.
3. Competency in design and planning of synthesis and carry out with Good Laboratory Practices.
4. Access, search and use of chemical literature and acquiring necessary skills to succeed in research and advance studies.
5. Competency in handling instruments and interpretation of spectral data for structure determination of organic compounds.

Janardan Bhagat Shikshan Prasarak Sanstha's

Changu Kana Thakur

Arts, Commerce and Science College, New Panvel (Autonomous)

Draft Syllabus

Syllabus for the M.Sc. Semester III and IV

Credit Based Semester and Grading System

To be implemented from the academic year 2020-2021

SEMESTER III

Course Code	Unit	Topics	Credits	L/Week
PSC3TOC0	I	Organic Reaction Mechanisms	4	1
	II	Pericyclic Reactions		1
	III	Stereochemistry-I		1
	IV	Photochemistry		1
PSC3SOC0	I	Name reactions with mechanism and application	4	1
	II	Radicals in Organic Synthesis		1
	III	Enamines, Ylides and α-C-H functionalization		1
	IV	Metals / Non-metals in organic synthesis		1
PSC3NPS0	I	Natural products-I	4	1
	II	Natural products-II		1
	III	Advanced Spectroscopic Techniques-I		1
	IV	Advanced Spectroscopic Techniques -II		1
PSC3MBG0	I	Drug discovery, design and development	4	1
	II	Drug design, development and synthesis		1
	III	Biogenesis and biosynthesis of natural products		1
	IV	Green chemistry		1
PSC3BIC0	I	Biomolecules-I	4	1
	II	Biomolecules-II		1
	III	Biomolecules-III		1
	IV	Biomolecules-IV		1
PSC3TOP0 & PSC3SOP0		Practicals	4	8
PSC3NPP0 & (PSC3MBP0 or PSC3BIP0)		Practicals	4	8

SEMESTER IV

Course Code	Unit	Topics	Credits	L/Week
PSC4TOC0	I	Physical Organic Chemistry	4	1
	II	Supramolecular Chemistry		1
	III	Stereochemistry-II		1
	IV	Asymmetric Synthesis		1
PSC4SOC0	I	Designing Organic Synthesis-I	4	1
	II	Designing Organic Synthesis-II		1
	III	Electro-organic chemistry and selected methods of organic synthesis		1
	IV	Transition and rare earth metals in organic synthesis		1
PSC4NPH0	I	Natural products-III	4	1
	II	Natural products-IV		1
	III	Heterocyclic compounds-I		1
	IV	Heterocyclic compounds-II		1
PSC4IPR0	I	Introduction to Intellectual Property	4	1
	II	Trade Secrets		1
	III	Introduction to Cheminformatics		1
	IV	Applications		1
PSC4RMT0	I	Print	4	1
	II	Data Analysis		1
	III	Methods of scientific research and writing scientific papers		1
	IV	Chemical Safety & Ethical Handling of Chemicals		1
PSC4TOP0 & PSC4SOP0		Practicals	4	8
PSC4NPP0 & (PSC4IPP0 or PSC4RMP0)		Practicals	4	8

1. Credit based semester and grading system with effect from the academic year 2020-2021.
2. As per the credit system directives each credit will correspond to 15 hours of lectures or 30 hours of practical work.
3. Each student is expected to take 4 credits per theory paper and 2 credits per practical per semester.
4. At the end of each semester each student will be examined both in the theory and in the practical.
5. For the award of first class, the candidate must obtain at least 50% marks in the theory papers at the Semester I, II, III and IV of the M.Sc. examination taken together, in addition to the marks prescribed for the first class and the other rules of passing in the concerned regulation of the standard of passing.
6. The candidate is expected to submit a journal certified by the Head of the Department /institution at the time of the practical examination.
7. A candidate will not be allowed to appear for the practical examination unless he/she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.
8. Use of non-programmable calculator is allowed both at the theory and the practical examination.

Scheme of Examination for M.Sc. Organic Chemistry
Semester III and IV

Internal Theory examination (40 Marks)

1. One class test **20 Marks**
2. One seminar based on curriculum / publication of a research paper/ presentation of a research paper in seminar or conference (to be assessed by teacher of the institution teaching PG learners). **15 Marks**
   a) Selection of the topic, introduction, write up, references.
   b) Presentation.
3. Active participation and overall conduct as a responsible learner in routine class, communication, and leadership qualities in organizing departmental academic activities. **05 Marks**

There will not be any internal examination for practical.

External Theory Examination (60 Marks)

Paper	Time allotted in hours	Maximum marks
Paper- I	2.5	60
Paper-II	2.5	60
Paper-III	2.5	60
Paper-IV	2.5	60

It is recommended that a total of five questions be set, based on the syllabus with due weightage to the number of lectures allotted per topic. The candidates are expected to answer all five questions. Question 5 will be based on all four units and the remaining questions will be based on the units as indicated below

Question No.	Semester- III	Semester- III
01	Unit I	Unit I
02	Unit II	Unit II
03	Unit III	Unit III
04	Unit IV	Unit IV
05	From all four units	From all four units

Semester End Practical Examination (50 Marks)

Laboratory Work **40 Marks**

Journal **05 Marks**

Viva **05 Marks**

The practical examination will be held for two days as described below. The candidates will be examined practically and orally on each day.

Paper	Day	Experiments	Time duration in hours	Maximum marks
I	Day-1 Morning	01	3.5	50
II	Day-1 Evening	01	3.5	50
III	Day-2 Morning	01	3.5	50
IV	Day-2 Evening	01	3.5	50

M. Sc. Organic Chemistry
Semester III
Course Code - PSC3TOC0
Paper I- Theoretical Organic Chemistry-I

Unit 1 **Organic Reaction Mechanisms** **15 L**

1.1 **Organic reactive intermediates:** Methods of generation, structure, stability and important reactions involving carbanions, carbocations, nitrenes, carbenes, arynes and ketenes**.** **7L**

1.2 **Neighbouring group participation:** Mechanism and effects of anchimeric assistance, NGP by unshared/ lone pair electrons, π-electrons, aromatic rings, σ-bonds with special reference to norbornyl and bicyclo[2.2.2]octyl cation systems (formation of non-classical carbocation) **4L**

1.3 **Role of FMOs in organic reactivity:** Reactions involving hard and soft electrophiles and nucleophiles. **1L**

1.4 **Pericyclic reactions:** Recapitulation **3L**

Explanations for Woodward-Hoffmann Rules

- The Aromatic Transition structures [Huckel and Mobius]
- Frontier Orbitals
- Correlation Diagrams, FMO and PMO approach

Molecular orbital symmetry, Frontier orbital of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system.

Unit 2 **Pericyclic reactions** **15L**

2.1 **Cycloaddition reactions:** Supra and antra facial additions, 4n and 4n+2 Systems. Diels-Alder reactions (Diene, Dienophile, FMO approach, stereochemistry, endo rule, Intramolecular Diels-Alder reactions, regioselectivity/effect of substituents, Trapping of reactive intermediates), retro-Diels-Alder reaction. **7L**

2+2 Cycloadditions: Photocycloadditions, Ketenes, 1,3-Dipolar cycloadditions and cheletropic reactions

2.2 **Electrocyclic reactions:** Conrotatory and disrotatary motions, torquoselectivity, (4n) π and (4n+2) π electrons and allyl systems. Synthesis of endiandric acid A from an acyclic polyene. **3L**

2.3 **Sigmatropic rearrangements:** H-shifts and C-shifts, supra and antarafacial migrations, Alder 'ene' Reaction, Cope (including oxy-Cope and aza-Cope), Claisen and Sommelet-Hauser rearrangements. Synthesis of Citral from 3-methylbut -2-en-1-ol and 3-methylbut-2-enal. **5L**

Unit 3 **Stereochemistry-I** **15L**

3.1 Conformational analysis of medium rings: Eight **to** ten membered rings and their unusual properties**,** I-strain, transannular reactions **3L**

3.2 Stereochemistry of fused ring and bridged ring compounds: decalins, hydrindanes, perhydroanthracenes, steroids, and Bredt's rule. **5L**

3.3 Anancomeric systems**,** Effect of conformation on reactivity of cyclohexane derivatives in the following reactions (including mechanism): electrophilic addition, elimination, molecular rearrangements, reduction of cyclohexanones **(**with $LiAlH_4$, selectride and MPV reduction) and oxidation of cyclohexanols**.** **5L**

3.4	Stereospecific and Stereoselective reactions with specific examples	**2L**
Unit 4	**Photochemistry**	**15L**
4.1	**Principles of Photochemistry:** Recapitulation, Excited states and their properties, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process, experimental set up for photochemical reactions.	**3L**
4.2	**Photochemistry of carbonyl compounds:** $\pi \rightarrow \acute{\pi}^*$, $n \rightarrow \acute{\pi}^*$ transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction.	**7L**
4.3	**Photochemistry of olefins:** cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di- π- methane rearrangement including oxa- di-π--methane and aza-di-π--methane. Photochemical Cross-Coupling of Alkenes, Photodimerisation of alkenes.	**3L**
4.4	**Photochemistry of arenes:** 1, 2-, 1, 3- and 1, 4- additions. Photocycloadditions of aromatic Rings.	**1L**
4.5	Singlet oxygen and photo-oxygenation reactions. Photochemically induced Radical Reactions	**1L**

REFERENCES:

1. March's Advanced Organic Chemistry, Jerry March, sixth edition, 2007, John Wiley and sons.
2. A guide to mechanism in Organic Chemistry, 6th edition, 2009, Peter Sykes, Pearson education, New Delhi.
3. Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002)
4. Mechanism and theory in Organic Chemistry, T. H. Lowry and K. C. Richardson, Harper and Row.
5. Organic Reaction Mechanism, 4th edition, V. K. Ahluvalia, R. K. Parashar, Narosa Publication.
6. Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh, Macmillan Publishers, India.
7. Organic Chemistry, Part A and B, Fifth edition, 2007, Francis A. Carey and Richard J. Sundberg, Springer.
8. Carbenes, Nitrenes and Arynes. Von T. L. Gilchrist, C. W. Rees. Th. Nelson and Sons Ltd., London 1969.
9. Organic reactive intermediates, Samuel P. MacManus, Academic Press.
10. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press (2001)
11. Organic Chemistry, Seventh Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.Advanced Organic Chemistry: Reactions & Mechanisms, second edition, B. Miller and R. Prasad, Pearson.
12. Organic reactions & their mechanisms, third revised edition, P.S. Kalsi, New Age International Publishers.
13. Organic Chemistry: Structure and Function, P. Volhardt and N. Schore, 5th Edition, 2012
14. Organic Chemistry, W. G. Solomons, C. B. Fryhle, , 9th Edition, Wiley India Pvt. Ltd.,2009

15. Pericyclic Reactions, S. Sankararaman, Wiley VCH, 2005.
16. Advanced organic chemistry, Jagdamba Singh L. D. S. Yadav, Pragati Prakashan, 2011
17. Pericyclic reactions, Ian Fleming, Oxford University press, 1999.
18. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.
19. Organic chemistry, 8th edition, John McMurry.
20. Modern methods of Organic Synthesis, 4th Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004.
21. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books,2006
22. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman
23. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd.
24. Stereochemistry of Organic Compounds, Ernest L. Eliel and SamuelH. Wilen, Wiley-India edit
25. Stereochemistry, P. S. Kalsi, 4th edition, New Age International Ltd
26. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005
27. Bioorganic, Bioinorganic and Supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers
28. Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH.
29. Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992.
30. Large ring compounds, J.A.Semlyen, Wiley-VCH, 1997.
31. Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wiley-Eastern
32. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Sciertific Publication.
33. Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
34. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill
35. Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
36. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
37. Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A john Wiley and Sons, Ltd., Publication)

Course Code- PSC3SOC0
Paper II - Synthetic Organic Chemistry -I

Unit 1	**Name reactions with mechanism and application**	**15 L**
1.1	Mukaiyama esterification, Mitsonobu reaction, Darzen's Glycidic Ester Synthesis, Ritter reaction, Yamaguchi esterification, Peterson olefination.	**5L**
1.2	**Domino reactions:** Characteristics; Nazerov cyclization	**3L**
1.3	**Multicomponent reactions:** Strecker Synthesis, Ugi 4CC, Biginelli synthesis, Hantzsch synthesis, Pictet-Spengler synthesis	**5L**
1.4	**Click Reactions:** Characteristics; Huisgen 1,3-Dipolar Cycloaddition	**2L**
Unit 2	**Radicals in organic synthesis**	
2.1	**Introduction:** Generation, stability, reactivity and structural and stereochemical properties of free radicals, Persistent and charged radicals, Electrophilic and nucleophilic radicals.	**3L**
2.2	**Radical Initiators:** azobisisobutyronitrile (AIBN) and dibenzoyl peroxide**.**	**1L**
2.3	**Characteristic reactions:** Free radical substitution, addition to multiplebonds. Radical chain reactions, Radical halogenation of hydrocarbons (Regioselectivity), radical cyclizations, autoxidations: synthesis of cumene hydroperoxide from cumene.	**4L**
2.4	**Radicals in synthesis:** Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors. Cleavage of C-X, C-Sn, C-Co, C-S, O-O bonds. Oxidative coupling, C-C bond formation in aromatics: $S_{RN}Ar$ reactions	**4L**
2.5	Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation.	**3L**
Unit 3	**Enamines, Ylides and α-C-H functionalization**	**15 L**
3.1	**Enamines:** Generation & application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison between enamines and enolates. Synthetic reactions of enamines including asymmetric reactions of chiral enamines derived from chiral secondary amines.	**4L**
3.2	**Phosphorus, Sulfur and Nitrogen Ylides:** Preparation and their synthetic applications along with their stereochemical aspects. Wittig reaction, Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination.	**6L**
3.3	**α-C-H functionalization:** By nitro, sulfoxide, sulfone and phosphonate groups: generation of carbanions by strong bases (LDA/n-butyl lithium) and applications in C-C bond formation. Bamford-Stevens reaction, Julia olefination and its modification, Seyferth–Gilbert homologation, Steven's rearrangement.	**5L**
Unit 4	**Metals / Non-metals in organic synthesis**	**15L**
4.1	**Mercury in organic synthesis:** Mechanism and regiochemistry of oxymercuration and demercuration of alkenes, mercuration of aromatics, transformation of aryl mercurials to aryl halides. Organomercurials as carbene transfer reagents.	**3L**
4.2	**Organoboron compounds:** Mechanism and regiochemistry of hydroboration of alkenes and alkynes, asymmetric hydroboration using chiral boron reagents, 9-BBN hydroboration, oxazaborolidine (CBS catalyst) and	**3L**

functional group reduction by diborane.

4.3 **Organosilicons:** Salient features of silicon governing the reactivity of organosilicons, preparation and important bond-forming reactions of alkyl silanes, alkenyl silanes, aryl silanes and allyl silanes. β-silyl cations as intermediates. Iodotrimethylsilane in organic synthesis. **3L**

4.4 **Silyl enol ethers:** Application: As nucleophiles (Michael reaction, Mukaiyama aldol reaction), in ring contraction reactions. **2L**

4.5 **Organotin compounds:** Preparation of alkenyl and allyl tin compounds; application in C-C bond formation, in replacement of halogen by H at the same C atom. **2L**

4.6 **Selenium in organic synthesis:** Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and seleno acetals as α-C-H activating groups **2L**

REFERENCES:

1. Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5th Edition, Springer Verlag
2. Modern Methods of Organic Synthesis, 4th Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004.
3. Chem. Rev. 2002, 102, 2227-2302, Rare Earth Metal Triflates in Organic Synthesis, S. Kobayashi, M. Sugiura, H. Kitagawa, and W.W.L. Lam.
4. Organic Chemistry, Clayden Greeves Warren and Wothers, Oxford Press (2001).
5. Moder Organic Synthesis: An Introduction, G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, (2007).
6. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Academic Press (2002).
7. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon 3rd Edn., Nelson Thornes
8. Organic Chemistry, 7th Edn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
9. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti & B. Czako (2005), Elsevier Academic Press
10. Advanced Organic Chemistry: Reactions & Mechanisms, 2nd Edn., B. Miller & R. Prasad, Pearson
11. Organic reactions and their mechanisms, 3rd revised edition, P.S. Kalsi, New Age International Publishers
12. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004
13. Name Reactions and Reagents in Organic Synthesis, 2nd Edn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
14. Name Reactions, Jie Jack Lie, 3rd Edn., Springer
15. Organic Electrochemistry, H. Lund, and M. Baizer, 3rd Edn., Marcel Dekker.

Course code - PSC3NPS0
Paper III- Natural products and Spectroscopy

Unit 1 Natural products-I **15 L**

1.1 **Carbohydrates:** Introduction to naturally occurring sugars: Deoxysugars, aminosugars, branched sugars. Structure elucidation of lactose and D-glucosamine (synthesis not expected).Structural features and applications of inositol, starch, cellulose, chitin and heparin**.** **5L**

1.2 **Natural pigments:** General structural features, occurrence, biological importance and applications of: carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll). Structure elucidation of β-carotene and Cyanin (with synthesis). Synthesis of ubiquinone from 3, 4, 5-trimethoxy methyl benzoate. **5L**

1.3 **Terpenoids:** Occurrence, classification, structure elucidation, Stereochemistry, spectral data and synthesis of zingiberene. Synthesis of cinerolone, jasmolone and allethrolone. **3L**

1.4 **Alkaloids:** Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of coniine. **2L**

Unit 2 Natural products-II **15L**

2.1 **Multi-step synthesis of natural products:** Synthesis of the following natural products with special reference to reagents used, stereochemistry and functional group transformations: **10L**

a) Woodward synthesis of Reserpine from benzoquinone
b) Corey synthesis of Longifolene from resorcinol
c) Gilbert-Stork synthesis of Griseofulvin from phloroglucinol
d) Corey's Synthesis of Caryophyllene from 2-Cyclohexenone and Isobutylene
e) Synthesis of Juvabione from Limonene
f) Woodward synthesis of Strychnine

2.2 **Prostaglandins:** Classification, general structure and biological importance. Structure elucidation of PGE_1. **2L**

2.3 **Insect Growth Regulator**s: General idea, structures of JH_2 and JH_3. **1L**

2.4 **Plant Growth Regulators:** Structural features and applications of arylacetic acids, gibberellic acids and triacontanol. **2L**

Synthesis of triacontanol (synthesis of stearyl magnesium bromide and 12-bromo-1-tetrahydropyranyloxydodecane expected)

Unit 3 Advanced Spectroscopic Techniques-I **15 L**

3.1 **Proton NMR spectroscopy:** Recapitulation, chemical and magnetic equivalence of protons, First order, second order, Spin system notations (A_2, AB, AX, AB_2, AX_2, AMX and A_2B_2-A_2X_2 spin systems with suitable examples). Long range coupling (Allylic coupling, 'W' coupling and Coupling in aromatic and hetero aromatic systems), Temperature effects, Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents. **7L**

3.2 **^{13}C–NMR spectroscopy:** Recapitulation, equivalent and non-equivalent carbons (examples of aliphatic and aromatic compounds), ^{13}C- chemical shifts, calculation of ^{13}C- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to ^{19}F and ^{31}P. **4L**

3.3	Spectral problems based on UV, IR, ^{1}HNMR and ^{13}CNMR and Mass Spectroscopy.	**4L**
Unit 4	**Advanced Spectroscopic Techniques-II**	**15L**
4.1	**Advanced NMR techniques:** DEPT experiment, determining number of Attached hydrogens (methyl/methylene/methine and quaternary carbons), two dimensional spectroscopic techniques, COSY and HETCOR spectra, NOE and NOESY techniques.	**10L**
4.2	Spectral problems based on UV, IR, ^{1}HNMR, ^{13}CNMR (Including 2D technique) and Mass spectroscopy	**5L**

REFERENCES:

1. Natural product chemistry, A mechanistic, biosynthetic and ecological approach, Kurt B.G. Torssell, Apotekarsocieteten – Swedish Pharmaceutical Press.
2. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.
3. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan, 2011.
4. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974
5. Natural Product Chemistry Vol.1 and 2, K. Nakanishi J. Goto. S. Ito Majori and S. Nozoo, Academic Press, 1974.
6. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co. 2008.
7. Natural Products: Chemistry and Biological Significance Interscience, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J. B. Harborne, Longman, Essex, 1994.
8. Organic Chemistry, Vol 2, I.L. Finar, ELBS, 6th edition, Pearson.
9. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.
10. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
11. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
12. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers, 1998.
13. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers, 1998.
14. Total. Synthesis of Longifolene, J. Am. Chem. Soc., E. J. Corey, M. Ohno, R. B. Mitra, and P. A. Vatakencherry. 1964, 86, 478.
15. Total. Synthesis of Longifolene, J. Am. Chem. Soc. 1961, 83, 1251.
16. The structure and total synthesis of 5-Vetivone, J. A. Marshall and P. C. Johnson, J. Org. Chem., 35, 192 (1970).
17. Total synthesis of spirovetivanes, J. Am. Chem. Soc. 1967, 89, 2750.
18. The Total Synthesis of Reserpine, Woodward, R. B.; Bader, F. E.; Bickel, H., Frey, A. J.; Kierstead, R. W. Tetrahedron 1958, 2, 1-57.
19. Total synthesis of Griseofulvin, Stork, G.; Tomasz, M. J. Am. Chem. Soc. 1962, 84, 310.

20. Synthesis of (±)-4-demethoxydaunomycinone,A. V. Rama Rao, G. Venkatswamy , S. M. Javeed M. , V. H. Deshpande, B. Ramamohan Rao, J. Org. Chem., 1983, 48 (9), 1552.
21. The Alkaloids, The fundamental Chemistry A biogenetic approach, Marcel Dekker Inc. New York, 1979.
22. Comprehensive Organic Chemistry by Barton and Olis, Pergamon Press, Oxford, 1979.
23. Medicinal Natural Products, a Biosynthetic Approach, Derick Paul, John Wiley and Sons, 2002.
24. Biosynthesis of Natural Products, Mannitto Paolo, Ellis Horwoocl Limited, 1981.
25. Selected Organic synthesis, Ian Fleming, John Wiley and Sons, 1973.
26. Total synthesis of Natural Products, J. Apsimon, John Wiley and Sons.
27. The Logic of Chemical Synthesis, E. J. Corey and Xue-Min Cheng, Wiley Interscience.
28. Classics in Total Synthesis, K. C. Nicolaou and E. J. Sorensen, Weinhem: VCH, 1996.
29. Spectroscopy of Organic compounds, P.S. Kalsi, New Age International Pub. Ltd. And Wiley Eastern Ltd., Second edition, 1995.
30. Applications of Absorption Spectroscopy of Organic compounds, J. R. Dyer, Prentice Hall of India, 1987.
31. Spectrometric Identification of Organic compounds, R.M. Silverstein and others, John Wiley and Sons Inc., 5th ed., 1991
32. Absorption spectroscopy of organic Molecules, V.M. Parikh, 1974.
33. Spectroscopic methods in organic chemistry, Williams and Fleming, Tata McGraw Hill, 4th ed, 1989.
34. Organic spectroscopy, William Kemp, ELBS, 3rd ed., 1987.
35. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., . 3122
36. Introduction to spectroscopy, Donald L. Pavia, Gary M. Lampman George S. Kriz, James R. Vyvyan, 4th ed., 2009.
37. Organic spectroscopic structure determination: a problem-based learning approach Douglass F. Taber, Oxford University Press, 17-Sep-2007.
38. Organic Spectroscopy: Principles And Applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004
39. Alkaloids, V.K. Ahuluwalia, Ane Books Pvt. Ltd.
40. Biotransformations in Organic Chemistry, 5thEdition, Kurt Faber, Springer
41. Structure Determination of Organic Compounds, E Pretsch, P. Buhlmann, C. Affolter, Springer

Course code - PSC3MBG0
Paper IV- Medicinal, Biogenesis and Green Chemistry

Unit 1	**Drug discovery, design and development**	**15 L**
1.1	**Introduction, important terms used in medicinal chemistry:** receptor, therapeutic index, bioavailability, drug assay and drug potency. General idea of factors affecting bioactivity: Resonance, inductive effect, bioisosterism, spatial considerations. Basic pharmacokinetics: drug absorption, distribution, metabolism (biotransformation) and elimination. Physical and chemical parameters like solubility, lipophilicity, ionization, pH, redox potential, H-bonding, partition coefficient and isomerism in drug distribution and drug-receptor binding.	**7L**
1.2	**Procedures in drug design:** Drug discovery without a lead: Penicillin, Librium. Lead discovery: random screening, non-random (or targeted) screening. Lead modification: Identification of the pharmacophore, Functional group modification. Structure-activity relationship, Structure modification to increase potency and therapeutic index: Homologation, chain branching, ring-chain transformation, bioisosterism, combinatiorial synthesis (basic idea).	**8L**
Unit 2	**Drug design, development and synthesis**	**15L**
2.1	Introduction to quantitative structure activity relationship studies. QSAR parameters: - steric effects: The Taft and other equations; Methods used to correlate regression parameters with biological activity: Hansch analysis- A linear multiple regression analysis	**5L**
2.2	Introduction to modern methods of drug design and synthesis- computer aided molecular graphics based drug design, drug design via enzyme inhibition (reversible and irreversible), bioinformatics and drug design.	**3L**
2.3	Concept of prodrugs and soft drugs. (a) Prodrugs: Prodrug design, types of prodrugs, functional groups in prodrugs, advantages of prodrug use. (b) Soft Drugs: concept and properties.	**3L**
2.4	**Synthesis and application of the following drugs:** Fluoxetine, cetirizine, esomeprazole, fluconazole, zidovudine, methotrexate, diclofenac, labetalol and Favipiravir Remdesivir: Structure and applications	**4L**
Unit 3	**Biogenesis and biosynthesis of natural products**	**15 L**
3.1	Primary and secondary metabolites and the building blocks, general pathway of amino acid biosynthesis.	**3L**
3.2	Acetate pathway: Biosynthesis of malonyl CoA, saturated fatty acids, prostaglandins from arachidonic acid, aromatic polyketides	**4L**
3.3	Shikimic Acid pathway: Biosynthesis of shikimic acid, aromatic amino acids, cinnamic acid and its derivatives, lignin and lignans, benzoic acid and its derivatives, flavonoids and isofalvonoids.	**4L**
3.4	Mevalonate pathway: Biosynthesis of mevalonic acid, monoterpenes-geranyl cation and its derivatives, sesquiterpenes-farnesyl cation and its derivatives and diterpenes.	**4L**
Unit 4	**Green chemistry**	**15L**
4.1	Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and	**1L**

reaction conditions, green catalysts.

4.2 **Use of the following in green synthesis with suitable examples:** **9L**

a) Green reagents: dimethylcarbonate, polymer supported reagents.
b) Green catalysts: Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts [Aliquat 336, benzyltrimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers], biocatalysts.
c) Green solvents: water, ionic liquids, deep eutectic solvents, supercritical carbon dioxide.
d) Solid state reactions: solid phase synthesis, solid supported synthesis
e) Microwave assisted synthesis: reactions in water, reactions in organic solvents, solvent free reactions.
f) Ultrasound assisted reactions.

4.3 Comparison of traditional processes versus green processes in the syntheses of ibuprofen, adipic acid, 4-aminodiphenylamine, p-bromotoluene and benzimidazole. **3L**

4.4 **Green Catalysts:** Nano catalyst, Types of Nano catalysts, Advantages and Disadvantages of Nano catalysts, Idea of Magnetically separable Nano catalysts. **2L**

Course code - PSC3BIC0
Paper IV- Bioorganic Chemistry

Unit 1 **Biomolecules-I** **15 L**

1.1 **Amino acids, peptides and proteins:** Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures, α- helix, β-sheets, super secondary structure. Tertiary structure of protein: folding and domain structure. Quaternary structure. **2L**

1.2 **Nucleic acids:** Structure and function of physiologically important nucleotides (c-AMP, ADP, ATP) and nucleic acids (DNA and RNA), replication, genetic code, protein biosynthesis, mutation **3L**

1.3 Structure: Purine & pyrimidine bases, ribose, deoxyribose, nucleosides and nucleotides (ATP, CTP, GTP, TTP, UTP) formation of polynucleotides strand with its shorthand representation**.** **3L**

1.4 RNAs (various types in prokaryotes and eukaryotes) m- RNA and r- RNA– general account, t- RNA-clover leaf model, Ribozymes**.** **2L**

1.5 **DNA:** Physical properties – Effect of heat on physical properties of DNA (Viscosity, buoyant density and UV absorption), Hypochromism, Hyperchromism and Denaturation of DNA. Reactions of nucleic acids (with DPA and Orcinol). **2L**

1.6 **Chemical synthesis of oligonucleotides:** Phosphodiester, Phosphotriester, Phosphoramidite and H- phosphonate methods including solid phase approach **3L**

Unit 2 **Biomolecules-II** **15L**

2.1 **Chemistry of enzymes:** Introduction, nomenclature, classes and general types of reactions catalyzed by enzymes. Properties of enzymes: a) enzyme efficiency/ catalytic power b) enzyme specificity; Fischer's 'lock and key' **6L**

and Koshland 'induced fit' hypothesis. Concept and identification of active site.

2.2 **Factors affecting enzyme kinetics:** Substrate concentration, enzyme concentration, temperature, pH, product concentration etc. Reversible and Irreversible inhibition. **4L**

2.3 Mechanism of enzyme action: transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Mechanism of chymotrypsin catalyzed hydrolysis of a peptide bond **5L**

Unit 3 **Biomolecules - III** **15 L**

3.1 Chemistry of coenzymes. Structure, mechanism of action and bio-modeling studies of the following coenzymes: nicotinamide adenine dinucleotide, flavin adenine dinucleotide, thiamine pyrophosphate, pyridoxal phosphate, Vitamin B12, biotin, lipoic acid, Coenzyme A. **12L**

3.2 Oxidative phosphorylation, chemiosmosis, rotary model for ATP synthesis and role of cytochrome in oxygen activation. **3L**

Unit 4 **Biomolecules – IV** **15L**

4.1 Role of main enzymes involved in the synthesis and breakdown of glycogen. **2L**

4.2 Enzyme catalyzed organic reactions: Hydrolysis, hydroxylation, oxidation and reduction. **6L**

4.3 Enzymes in organic synthesis. Fermentation: Production of drugs/drug intermediates by fermentation. Production of chiral hydroxy acids, vitamins, amino acids, β-lactam antibiotics. Synthesis of chemicals via microbial transformation, synthesis of L-ephedrine. Chemical processes with isolated enzymes in free form (hydrocyanation of m-phenoxybenzaldehyde) and immobilized form (production of 6-aminopenicillanic acid). **7L**

REFERENCES:

1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.
2. Stryer, Lubert; Biochemistry; W. H. Freeman publishers**.**
3. Voet, D. and J. G. Voet (2004) Biochemistry, 3rd Edition, John Wiley & sons, Inc. USA.
4. Zubay, Goffrey L; Biochemistry; Wm C. Brown publishers.
5. V. Polshettiwar, R. Luque, A. Fihri, H. Zhu, M. Bouhrara and J-M Basset, Chem. Rev. 2011, 111, 3036-3075;
6. R. B. Nasir Baig and R. S. Varma, Chem. Comm., 2013, 49, 752-770;
7. M. B. Gawande, A. K. Rathi, P. S. Varma, Appl. Sci., 2013, 3, 656-674;
8. J. Govan and Y. K. Gun'ko, Nanomaterials, 2014, 4, 222-214.
9. K. Philippot and P. Serp, Nanomaterials in catalysis, First Edition. Edited by P. Serp and K. Philippot; 2013 Wiley –VCH Verlag GmbH & Co. K GaA
10. D. Astruc, Nanomaterials and Catalysis, Wiley-VCH Verlag GmbH & Co. KGaA, 2008, 1-48;
11. C. N. R. Roa, A. Muller and A. K. Cheetham, The chemistry of Nanomaterials, Wiley-VCH Verlag GmbH & Co. KGaA, 2005, 1-11;
12. The organic chemistry of drug design and drug action, Richard B. Silverman, 2nd edition, Academic Press

13. Medicinal chemistry, D.Sriram and P. Yogeeswari, 2nd edition, Pearson
14. An introduction to drug design-S. S. Pandeya and J. R. Dimmock (New age international)
15. Burger's medicinal chemistry and drug discovery. by Manfred E. Wolf
16. Introduction to Medicinal chemistry. by Graham Patrick
17. Medicinal chemistry-William O. Foye
18. T. B. of Organic medicinal and pharmaceutical chemistry-Wilson and Gisvold's (Ed. Robert F. Dorge)
19. An introduction to medicinal chemistry-Graham L. Patrick, OUP Oxford, 2009.
20. Principles of medicinal chemistry (Vol. I and II)-S. S. Kadam, K. R. Mahadik and K.G. Bothara , Nirali prakashan.
21. Medicinal chemistry (Vol. I and II)-Burger
22. Strategies for organic drug synthesis and design - D. Lednicer Wiley
23. Pharmacological basis of therapeutics-Goodman and Gilman's (McGraw Hill)
24. Enzyme catalysis in organic synthesis, 3rd edition. Edited by Karlheinz Drauz, Harold Groger, and Oliver May, Wiley-VCH Verlag GmbH & Co KgaA, 2012.
25. Biochemistry, Dr U Satyanarayan and Dr U Chakrapani, Books and Allied (P) Ltd.
26. Bioorganic, Bioinorganic and Supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers
27. The Organic Chemistry of Enzyme-Catalysed Reactions, Academic Press, By Richard B. Silverman
28. Enzymes: Practical Introduction to structure, mechanism and data analysis, By Robert A. Copeland, Wiley-VCH, Inc.
29. The Organic Chemistry of Biological Pathways By John McMurry, Tadhg Begley by Robert and company publishers
30. Bioorganic Chemistry- A practical approach to Enzyme action, H. Dugas and C. Penny. Springer Verlag, 1931
31. Biochemistry: The chemical reactions in living cells, by E. Metzler Academic Press.
32. Concepts in biotechnology by D. Balasubrarnanian & others
33. Principals of biochemistry by Horton & others.
34. Bioorganic chemistry - A chemical approach to enzyme action by Herman Dugas and Christopher Penney.
35. Medicinal Natural Products: A Biosynthetic Approach by Paul M. Dewick. 3rd Edition, Wiley.
36. Natural product chemistry, A mechanistic, biosynthetic and ecological approach, Kurt B. G. Torssell, Apotekarsocieteten – Swedish pharmaceutical press.
37. Natural products Chemistry and applications, Sujata V Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House.
38. Natural Products Volume- 2, By O. P. Agarwal.
39. Chemistry of Natural Products, F. F. Bentley and F. R. Dollish, 1974.
40. Natural Product Chemistry Vol.1 and 2, K. Nakanishi J. Goto. S. Ito Majori and S. Nozoo, Academic Press, 1974.
41. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co.

42. Green Chemistry: An Introductory Text, 2nd Edition, Published by Royal Society of Chemistry, Authored by Mike Lancater.
43. Organic synthesis in water. By Paul A. Grieco, Blackie.
44. Green chemistry, Theory and Practical, Paul T. Anastas and John C. Warner.
45. New trends in green chemistry By V. K. Ahulwalia and M. Kidwai, 2nd edition, Anamaya Publishers, New Delhi.
46. An introduction to green chemistry, V. Kumar, Vishal Publishing Co.
47. Organic synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal.

Semester III: Practicals

Course code: PSC3TOP0 & PSC3SOP0

Separation of a ternary mixture of organic compounds and identification including derivative preparations using micro-scale technique (Minimum 8 experiments)

1. Separation of a ternary mixture (S-S-S, S-S-L, S-L-L and L-L-L) (for solid mixture: water insoluble/ soluble including carbohydrates) based upon differences in the physical and the chemical properties of the components.
2. Identification of the two components (indicated by the examiner) using micro-scale technique.
3. Preparation of derivatives (any one of separated compound).

Course code: PSC3NPP0 & (PSC3MBP0 or PSC3BIP0)

Single step organic preparation (1.0 g scale) involving purification by Steam distillation / Vacuum distillation or Column chromatography (Minimum 8 experiments)

1. Preparation of acetanilide from aniline and acetic acid using Zn dust. (Purification by column chromatography)
2. Preparation of 1-nitronaphthalene from naphthalene. (Purification by steam distillation)
3. Preparation of acetyl ferrocene from ferrocene. (Purification by column chromatography)
4. Preparation of 3-nitroaniline from 1, 3-dinitrobenzene. (Purification by column chromatography)
5. Preparation of benzyl alcohol from benzaldehyde. (Purification by vacuum distillation).
6. Preparation of methyl salicylate from salicylic acid. (Purification by vacuum distillation).
7. Preparation of 4-methylacetophenone from toluene. (Purification by vacuum distillation).
8. Preparation of phenyl acetate from phenol. (Purification by vacuum distillation)
9. Preparation of 2-chlorotoluene from *o*-toluidine. (Purification by steam distillation)
10. Preparation of fluorenone from fluorene. (Purification by column chromatography)
11. Preparation of dimethylphthalate from phthalic anhydride. (Purification by vacuum distillation)

Note:

1. Students are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and **safety aspects including MSDS** (ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.
2. Students are expected to purify the product by Steam distillation / Vacuum distillation or Column chromatography, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

References for Practicals:

1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
2. Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd
3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
5. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
6. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
7. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
8. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
9. Handbook of Organic Analysis- Qualitative and Quantitative, H. Clark, Adward Arnold.
10. Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008, B.S.Furniss, A. J.Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
11. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
12. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

Important Note:

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

Semester IV

Course Code - PSC4TOC0
Paper I- Theoretical Organic Chemistry-II

Unit 1	**Physical Organic Chemistry**	**15 L**
1.1	Structural effects and reactivity: Linear free energy relationship (LFER) in determination of organic reaction mechanism: The Hammett equation, Substituent constant (σ) and σ values, Reaction constants (ρ), reactions with positive and negative ρ values, Nonlinear Hammett plots (concave upwards and downwards deviations)	**9L**
1.2	Uses of Hammett equation, deviations from Hammett equation. Dual parameter correlations, Inductive substituent constants, Calculation of k values, Taft equation, Solvent effects, Grunwald-Winstein equation, Dimroth's ET parameter, Spectroscopic correlations, Thermodynamic implications.	**6L**
Unit 2	**Supramolecular chemistry**	**15L**
2.1	Principles of molecular associations and organizations as exemplified in biological macromolecules like nucleic acids, proteins and enzymes.	**3L**
2.2	Synthetic molecular receptors: receptors with molecular cleft, molecular, tweezers, receptors with multiple hydrogen sites.	**3L**
2.3	Structures and properties of crown ethers, cryptands, cyclophanes, calixarenes, rotaxanes and cyclodextrins. Synthesis of crown ethers, cryptands and calixarenes	**5L**
2.4	Molecular recognition and catalysis, molecular self-assembly. Supramolecular Polymers, Gelsand Fibers.	**4L**
Unit 3	**Stereochemistry- II**	**15L**
3.1	Racemization and resolution of racemates including conglomerates: Mechanism of racemization, methods of resolution: mechanical, chemical, kinetic and equilibrium asymmetric transformation and through inclusion compounds with stereospecific reactions.	**3L**
3.2	Determination of enantiomer and diastereomer composition: enzymatic method, chromatographic methods. Methods based on NMR spectroscopy: use of chiral derivatising agents (CDA), chiral solvating agents (CSA) and Lanthanide shift reagents (LSR).	**3L**
3.3	Correlative method for configurational assignment: chemical, optical rotation, and NMR spectroscopy.	**4L**
3.4	Molecular dissymmetry and chiroptical properties: Linearly and circularly polarized light. Circular birefringence and circular dichroism. ORD and CD curves. Cotton effect and its applications. The octant rule and the axial α–haloketone rule with applications.	**5L**
Unit 4	**Asymmetric Synthesis**	**15L**
4.1	Principles of asymmetric synthesis: Introduction, the chiral pool in Nature, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions	**3L**
4.2	Synthesis of L-DOPA [Knowles's Mosanto process]. Asymmetric reactions with mechanism: Aldol and related reactions, Cram's rule, Felkin-Anh model, Sharpless enantioselective epoxidation, hydroxylation,	**9L**

aminohydroxylation, Diels-Alder reaction, reduction of prochiral carbonyl compounds and olefins.

4.3 Use of chiral auxiliaries in diastereoselective reductions, asymmetric amplification. Use of chiral BINOLs, BINAPs and chiral oxazolines asymmetric transformations **3L**

REFERENCES:

1. March's Advanced Organic Chemistry, Jerry March, sixth edition, 2007, John Wiley and sons.
2. A guide to mechanism in Organic Chemistry, 6th edition, 2009, Peter Sykes, Pearson education, New Delhi.
3. Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002).
4. Mechanism and theory in Organic Chemistry, T. H. Lowry and K. C. Richardson, Harper and Row.
5. Organic Reaction Mechanism, 4th edition, V. K. Ahluvalia, R. K. Parashar, Narosa Publication.
6. Reaction Mechanism in Organic Chemistry, S.M. Mukherji, S.P. Singh, Macmillan Publishers, India.
7. Organic Chemistry, Part A and B, Fifth edition, 2007, Francis A. Carey and Richard J. Sundberg, Springer.
8. Carbenes, Nitrenes and Arynes. Von T. L. Gilchrist, C. W. Rees. Th. Nelson and Sons Ltd., London 1969.
9. Organic reactive intermediates, Samuel P. MacManus, Academic Press.
10. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press (2001).
11. Organic Chemistry, Seventh Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson. Advanced Organic Chemistry: Reactions & Mechanisms, second edition, B. Miller and R. Prasad, Pearson.
12. Organic reactions & their mechanisms, third revised edition, P.S. Kalsi, New Age International Publishers.
13. Organic Chemistry: Structure and Function, P. Volhardt and N. Schore, 5th Edition, 2012
14. Organic Chemistry, W. G. Solomons, C. B. Fryhle, , 9th Edition, Wiley India Pvt. Ltd.,2009.
15. Pericyclic Reactions, S. Sankararaman, Wiley VCH, 2005.
16. Advanced organic chemistry, Jagdamba Singh L. D. S. Yadav, Pragati Prakashan, 2011
17. Pericyclic reactions, Ian Fleming, Oxford University press, 1999.
18. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India 1979.
19. Organic chemistry, 8th edition, John McMurry
20. Modern methods of Organic Synthesis, 4th Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004

21. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books,2006
22. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman
23. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd.
24. Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley-India edit
25. Stereochemistry, P. S. Kalsi, 4th edition, New Age International Ltd
26. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005
27. Bioorganic, Bioinorganic and Supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers
28. Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH.
29. Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992.
30. Large ring compounds, J.A. Semlyen, Wiley-VCH, 1997.
31. Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wiley-Eastern
32. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
33. Molecular Photochemistry, N. J. Turro, W. A. Benjamin.
34. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill
35. Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
36. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
37. Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A john Wiley and Sons, Ltd., Publication)

Course Code- PSC4SOC0
Paper II- Synthetic Organic Chemistry-II

Unit 1 Designing Organic Synthesis-I **15 L**

1.1 Protecting groups in Organic Synthesis: Protection and deprotection of the hydroxyl, carbonyl, amino and carboxyl functional groups and its applications. **3L**

1.2 Concept of umpolung (Reversal of polarity): Generation of acyl anion equivalent using 1,3-dithianes, methyl thiomethyl sulfoxides, cyanide ions, cyanohydrin ethers, nitro compounds and vinylated ethers. **3L**

1.3 Introduction to Retrosynthetic analysis and synthetic planning: Linear and convergent synthesis; Disconnection approach: An introduction to synthons, synthetic equivalents, disconnection approach, functional group interconversions (FGI), functional group addition (FGA), functional group removal (FGR) importance of order of events in organic synthesis, one and two group C-X disconnections (1,1; 1,2; 1,3 difunctionalized compounds), selective organic transformations: chemoselectivity, regioselectivity, stereoselectivity, enantioselectivity **9L**

Unit 2	**Designing Organic Synthesis-II**	**15L**
2.1	General strategy: choosing a disconnection-simplification, symmetry, high yielding steps, and recognisable starting material.	**3L**
2.2	One group C-C Disconnections: Alcohols (including stereoslectivity), carbonyls (including regioselectivity), Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.	**6L**
2.3	Two group C-C Disconnections: 1,2- 1,3- 1,4- 1,5- and 1,6-difunctionalized compounds, Diels-Alder reactions, α, β-unsaturated compounds, control in carbonyl condensations, Michael addition and Robinson annelation.	**6L**
Unit 3	**Electro-organic chemistry and Selected methods of Organic synthesis**	**15L**
3.1	**Electro-organic chemistry:** **Introduction:** Electrode potential, cell parameters, electrolyte, working electrode, choice of solvents, supporting electrolytes. **Cathodic reduction:** Reduction of alkyl halides, aldehydes, ketones, nitro compounds, olefins, arenes, electro-dimerization. **Anodic oxidation:** Oxidation of alkylbezene, Kolbe reaction, Non-Kolbe oxidation, Shono Oxidation	**7L**
3.2	**Selected Methods of Organic synthesis** Applications of the following in organic synthesis: • Crown ethers, cryptands, micelles, cyclodextrins, catenanes. • Organocatalysts: Proline, Imidazolidinone. • Pd catalysed cycloaddition reactions: Stille reaction, Saeguse-Ito oxidation to enones, Negishi coupling. • Use of Sc(OTf), and Yb(OTf) as water tolerant Lewis acid catalyst in aldol condensation, Michael reaction, Diels-Alder reaction, Friedel – Crafts reaction.	**8L**
Unit 4	**Transition and rare earth metals in organic synthesis**	**15L**
4.1	**Introduction to basic concepts:** 18 electron rule, bonding in transition metal complexes, C-H activation, oxidative addition, reductive elimination, migratory insertion.	**3L**
4.2	Palladium in organic synthesis: π-bonding of Pd with olefins, applications in C-C bond formation, carbonylation, alkene isomerisation, cross-coupling of organometallics and halides. Representative examples: Heck reaction, Suzuki-Miayura coupling, Sonogashira reaction and Wacker oxidation. Heteroatom coupling for bond formation between aryl/vinyl groups and N, S, or P atoms.	**5L**
4.3	Olefin metathesis using Grubb's catalyst.	**1L**
4.4	Application of Ni, Co, Fe, Rh, and Cr carbonyls in organic synthesis.	**4L**
4.5	Application of samarium iodide including reduction of organic halides, aldehydes and ketones, α-functionalised carbonyl and nitro compounds.	**1L**
4.6	Application of Ce (IV) in synthesis of heterocyclic quinoxaline derivatives and its role as a de-protecting agent**.**	**1L**

REFERENCES:

1. Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5th Edition, Springer Verlag
2. Modern Methods of Organic Synthesis, 4th Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004.
3. Chem. Rev. 2002, 102, 2227-2302, Rare Earth Metal Triflates in Organic Synthesis, S. Kobayashi, M. Sugiura, H. Kitagawa, and W.W.L. Lam.
4. Organic Chemistry, Clayden Greeves Warren and Wothers, Oxford Press (2001).
5. Modern Organic Synthesis: An Introduction, G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, (2007).
6. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Academic Press (2002).
7. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon, 3rd Edn., Nelson Thornes
8. Organic Chemistry, 7th Edn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
9. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti & B. Czako (2005), Elsevier Academic Press
10. Advanced Organic Chemistry: Reactions & Mechanisms, 2nd Edn., B. Miller & R. Prasad, Pearson
11. Organic reactions and their mechanisms, 3rd revised edition, P.S. Kalsi, New Age International Publishers
12. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004
13. Name Reactions and Reagents in Organic Synthesis, 2nd Edn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
14. Name Reactions, Jie Jack Lie, 3rd Edn., Springer
15. Organic Electrochemistry, H. Lund, and M. Baizer, 3rd Edn., Marcel Dekker.

Course Code- PSC4NPH0
Paper III- Natural products and Heterocyclic Chemistry

Unit 1 Natural products-III **15 L**

1.1 **Steroids:** General structure, classification. Occurrence, biological role, important structural and stereochemical features of the following: corticosteroids, steroidal hormones, steroidal alkaloids, sterols and bile acids. **5L**

1.2 Synthesis of 16-DPA from cholesterol and plant sapogenin. **2L**

1.3 Synthesis of the following from 16-DPA: androsterone, testosterone, oestrone, oestriol, oestradiol and progesterone. **5L**

1.4 **Insect pheromones**: General structural features and importance. Types of pheromones (aggregation, alarm, releaser, primer, territorial, trail, sex pheromones etc.), advantage of pheromones over conventional pesticides. Synthesis of bombykol from acetylene, disparlure from 6-methylhept-1-ene, grandisol from 2-methyl-1, 3-butadiene**.** **3L**

Unit 2 Natural products-IV **15L**

2.1 **Vitamins:** Classification, sources and biological importance of vitamin B_1, B_2, B_6, folic acid, B_{12}, C, D_1, E (α-tocopherol), K_1, K_2, H (β- biotin). **6L**
Synthesis of the following:
Vitamin A from β-ionone and bromoester moiety.
Vitamin B_1 including synthesis of pyrimidine and thiazole moieties
Vitamin B_2 from 3, 4-dimethylaniline and D(-) ribose
Vitamin B_6 from: 1) ethoxyacetylacetone and cyanoacetamide, 2) ethyl ester of N-formyl-DL-alanine (Harris synthesis)
Vitamin E (α-tocopherol) from trimethylquinol and phytyl bromide
Vitamin K_1 from 2-methyl-1, 4-naphthaquinone and phytol

2.2 **Antibiotics:** Classification on the basis of activity. Structure elucidation, spectral data of penicillin-G and chloramphenicol. Synthesis of chloramphenicol (from benzaldehyde and β-nitroethanol) **6L**
penicillin-G and phenoxymethylpenicillin from D-penicillamine and t-butyl phthalimide malonaldehyde (synthesis of D-penicillamine and t-butyl phthalimide malonaldehyde expected).

2.3 **Naturally occurring insecticides:** Sources, structure and biological properties of pyrethrums (pyrethrin I), rotenoids (rotenone). Synthesis of pyrethrin I. **2L**

2.4 Synthesis of exaltone and muscone. **1L**

Unit 3 Heterocyclic compounds-I **15L**

3.1 Heterocyclic compounds: Introduction, classification, Nomenclature of heterocyclic compounds of monocyclic (3-6 membered) (Common, systematic (Hantzsch-Widman) and replacement nomenclature) **3L**

3.2 Structure and nucleophilic ring opening reactions of aziridines, oxiranes, oxetanes and azetidines **2L**

3.3 Structure, reactivity, synthesis and reactions of pyridine, pyridine N-oxide, pyridazine, pyrimidine, pyrazine, pyrrole, pyrazoles, Imidazoles, thizoles and oxazoles **10L**

Unit 4 Heterocyclic compounds-II **15L**

4.1 Nomenclature of heterocyclic compounds of bicyclic/tricyclic (5-6 Membered) fused heterocycles (up to three hetero atoms)**.** (Common, systematic (Hantzsch-Widman) and replacement nomenclature) **3L**

4.2 Structure, reactivity, synthesis and reactions of quinoline, isoquinoline, indole, coumarines, purines, benzimidazoles, benzthiazoles, quinoxaline, cinnoline and quinazoline **12 L**

REFERENCES:

1. Natural product chemistry, A mechanistic, biosynthetic and ecological approach, Kurt B.G. Torssell, Apotekarsocieteten –Swedish Pharmaceutical Press.
2. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.
3. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan, 2011.
4. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974

5. Natural Product Chemistry Vol.1 and 2, K. Nakanishi J. Goto. S. Ito Majori and S. Nozoo, Academic Press, 1974.
6. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co. 2008.
7. Heterocyclic chemistry, 3rd edition, Thomas L. Gilchrist, Pearson Education, 2007.
8. Heterocyclic Chemistry, Synthesis, Reactions and Mechanisms, R. K. Bansal, Wiley
9. Eastern Ltd., 1990.
10. Heterocyclic Chemistry, J. A. Joule and G. F. Smith, ELBS, 2nd edition, 1982.
11. The Conformational Analysis of Heterocyclic Compounds, F.G. Riddell, Academic Press, 1980.
12. Principles of Modern Heterocyclic Chemistry, L.A. Paquette, W.B. Benjamin, Inc., 1978.
13. An Introduction to the Chemistry of Heterocyclic Compounds, 2nd edition, B.M. Acheson, 1975.
14. Natural Products: Chemistry and Biological Significance Interscience, J. Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J. B. Harborne, Longman, Essex, 1994.
15. Organic Chemistry, Vol 2, I.L. Finar, ELBS, 6th edition, Pearson.
16. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.
17. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
18. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the mericas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
19. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers, 1998.
20. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers, 1998.
21. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.
22. Comprehensive Organic Chemistry by Barton and Olis, Pergamon Press, Oxford, 1979.
23. Medicinal Natural Products, a Biosynthetic Approach, Derick Paul, John Wiley and Sons, 2002.
24. Biosynthesis of Natural Products, Mannitto Paolo, Ellis Horwoocl Limited, 1981.
25. Selected Organic synthesis, Ian Fleming, John Wiley and Sons, 1973.

Course Code- PSC4IPR0
Paper IV- Intellectual Property Rights & Cheminformatics

Unit 1 **15 L**

1.1 **Introduction to Intellectual Property:** Historical Perspective, Different types of IP, Importance of protecting IP. **2L**

1.2 **Patents:** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India. **5L**

1.3 **Industrial Designs:** Definition, How to obtain, features, International design registration. **2L**

1.4	**Copyrights:** Introduction, How to obtain, Differences from Patents.	**2L**
1.5	**Trade Marks:** Introduction, How to obtain, Different types of marks– Collective marks, certification marks, service marks, trade names etc.	**2L**
1.6	**Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India.	**2L**
Unit 2		**15L**
2.1	**Trade Secrets:** Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.	**2L**
2.2	**IP Infringement issue and enforcement:** Role of Judiciary, Role of law enforcement agencies-Police, Customs etc.	**2L**
2.3	**Economic Value of Intellectual Property:** Intangible assets and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.	**5L**
2.4	**Different International agreements:** **a. World Trade Organization (WTO):** 1. General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement 2. General Agreement on Trade Related Services (GATS) Madrid Protocol. 3. Berne Convention 4. Budapest Treaty **b. Paris Convention** **WIPO** and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.	**6L**
Unit 3		**15L**
3.1	**Introduction to Cheminformatics:** History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation.	**5L**
3.2	**Representation of molecules and chemical reactions:** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.	**5L**
3.3	**Searching Chemical Structures:** Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	**5L**
Unit 4	**Applications:**	**15L**
	Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand based and Structure based Drug design, Application of Cheminformatics in Drug Design.	

REFERENCES:

1. Andrew R. Leach & Valerie J. Gillet (2007) *An Introduction to Cheminformatics.* Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley–VCH
3. Gupta, S. P. *QSAR and Molecular Modeling.* Springer-Anamaya Pub.: New Delhi.

Course Code- PSC4RMT0
Paper IV- Research Methodology

Unit 1 **15 L**

1.1 **Print:** Primary, Secondary and Tertiary sources. **5L**
Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

1.2 **Digital:** Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus. **5L**

1.3 **Information Technology and Library Resources:** The Internet and World wide web, Internet resources for Chemistry, finding and citing published information. **5L**

Unit 2 **DATA ANALYSIS** **15L**

The Investigative Approach: Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.

Analysis and Presentation of Data: Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis

Unit 3 **METHODS OF SCIENTIFIC RESEARCH AND WRITING** **15L**

3.1 **SCIENTIFIC PAPERS:** Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.

3.2 **Writing Scientific Papers:** Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism

Unit 4 **CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS** **15L**

Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory

chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

REFERENCES:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in Chemistry*, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data Analysis for Chemistry* Oxford University Press.
3. Topping, J., (1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill London.
4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters 3-5
5. Levie, R. De. (2001) *How to use Excel in Analytical Chemistry and in general scientific data analysis* Cambridge University Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

Semester IV: Practicals

Course code: PSC4TOP0 & PSC4SOP0

Two steps preparations (Minimum 8 experiments)

1. Acetophenone → Acetophenone phenyl hydrazine → 2-phenyl indole.
2. 2-naphthol → 1-phenyl azo-2-naphthol → 1-amino-2-naphthol.
3. Cyclohexanone → cyclohexanone oxime → Caprolactum.
4. Hydroquinone → hydroquinone diacetate → 2,5-dihydroxyacetophenone.
5. 4-nitrotoluene → 4-nitrobenzoic acid → 4-aminobenzoic acid.
6. *o*-nitroaniline → *o*-phenylene diamine → Benzimidazole.
7. Benzophenone → benzophenone oxime → benzanilide.
8. *o*-chlorobenzoic acid → N-phenyl anthranilic acid → acridone.
9. Benzoin → benzil → benzilic acid.
10. Phthalic acid → phthalimide → anthranilic acid.
11. Resorcinol → 4-methyl-7-hydroxy coumarin → 4-methyl-7-acetoxy Coumarin
12. Anthracene → anthraquinone → anthrone

Note:

1. Students are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and **safety aspects including MSDS** ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.
2. Students are expected to purify the product by recryllization, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

Course code: PSC4NPP0 & (PSC4IPP0 or PSC4RMP0)

Session-I:

Combined spectral identification: Interpretation of spectral data of organic compounds (UV, IR, PMR, CMR and Mass spectra).

A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard text-book/reference material etc.

(**Minimum 8 spectral analysis)**

Session-II: Project evaluation OR Internship

References for Practicals:

1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis- V. K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
2. Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd
3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
5. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
6. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
7. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
8. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
9. Handbook of Organic Analysis- Qualitative and Quantitative, H. Clark, Adward Arnold.
10. Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008, B.S.Furniss, A. J.Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
11. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
12. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

Important Note:

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