Punyashlok Ahilyadevi Holkar Solapur University, Solapur

NAAC Accredited-2015

'B' Grade (CGPA 2.62)

Name of the Faculty: Science & Technology

CHOICE BASED CREDIT SYSTEM

Syllabus: Pharmaceutical Chemistry

Name of the Course: M.Sc. II (Sem.– III & IV)

(Syllabus to be implemented from w.e.f. June 2021)

M. Sc. II, PHARMACEUTICAL CHEMISTRY COURSE SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS) (w.e.f. June 2021)

A two-year duration **M. Sc. Pharmaceutical Chemistry** course syllabus has been prepared as per the CBCS semester system. M. Sc. II, SEM-III & SEM-IV Pharmaceutical Chemistry syllabus will be implemented from June 2021. The syllabus has been prepared taking into consideration the syllabi of other Universities, SET, NET, UGC guidelines, and the specific inputs of the Expert Committee Members.

General Structure of the Course:

The course will be of four semesters spread over two academic years. Each semester will have four theory papers of 80 marks for university external examination and 20 marks for internal examination of each semester and four practicals of 160 marks, 40 marks for internal practical of each semester. The distribution of marks is mentioned below

Theory Paper (Semester exam), 16 X 80+20 marks	1600 marks
Practicals (semester end exam.), 16 X 40+10 marks	800 marks
Seminar/Tutorial/ Industrial Visit/ Field Tour for each semester, 4 X 25	100 marks
Total:	2500 marks

Ratio of marks (Theory: Practical):

M. Sc. Sem.- III & IV (STRUCTURE) w. e. f. 2021-22

Semester	code	Title of the paper	Semester Examination			L	T	P	Credit
			Theory/Pr		Total				
			UA	CA					
SEM-III		**Hard core**							
	HCT-3.1	Advanced Organic Chemistry-I	80	20	100	4	--	-	4
	HCT-3.2	Chemistry of Bioactive Heterocycles	80	20	100	4		-	4
		Soft core (Any one)							
	SCT- 3.1	Drug Development	80	20	100	4		-	4
	SCT- 3.2	Biochemistry	80	20				-	
		Open elective (Any one)							
	OET-3.1	Medicinal Chemistry	80	20	100	4		-	4
	OET-3.2	Drug Regulatory Affairs	80	20				-	
		Seminar/Tutorial/ Industrial Visit/ Field Tour	---	**25**	**25**	--	**1**	--	**1**
		Hard Core Practical							
	HCP- 3.1	Organic Chemistry-I	40	10	50	-	-	3	2
	HCP- 3.2	Organic Chemistry-II	40	10	50	-	-	3	2
		Soft Core Practical (Any One)							
	SCP- 3.1	Pharmaceutical Chemistry	40	10	50	-	-	3	2
	SCP- 3.2	Biochemistry							
		Open Elective Practical							
	OEP-3.1/3.2	Review Work	40	10	50	-	-	3	2
		Add-on-self learning-(MOOC/SWAYAM COURSE/INTERNSHIP/INDUSTRAIL TRAINING/ Courses offered by College/University *)	--	--	--	--	--	--	4
		Total for semester III	480	145	625	--	--	---	29
SEM-IV		**Hard core**							
	HCT- 4.1	Photochemistry and Pericyclic Reactions	80	20	100	4		-	4
	HCT- 4.2	Advanced Organic Chemistry-II	80	20	100	4	--	-	4

	HCT- 4.3	Pharmaceutical Dosage Forms	80	20	100	4		-	4
		Soft Core (Any one)						-	
	SCT- 4.1	Pharmaceutical Technology	80	20	100	4		-	4
	SCT- 4.2	Industrial Pollution and Control	80	20				-	
		Seminar/Tutorial/ Industrial Visit/ Field Tour	**---**	**25**	**25**	**--**	**1**	**--**	**1**
	HCP-4.1	Spectral Analysis	40	10	50	-	-	3	2
	HCP-4.2	Project Work /In plant training	40	10	50	-	-	3	2
	HCP-4.3	Pharmaceutical Technology	40	10	50	-	-	3	2
	SCP-4.1/4.2	Pharmaceutical Formulation	40	10	50	-	-	3	2
		Total for semester IV	480	145	625	--	--	**---**	25

*** Add on College course List should be submitted to the University for Information**

L = Lecture; T = Tutorials; P = Practical

4 Credits of Theory = 4 Hours of teaching per week

2 Credit of Practical = 4 hours per week

HCT = Hard core theory,

SCT = Soft core theory,

HCP = Hard core practical

SCP = Soft core practical,

OET = Open elective theory,

OEP = Open elective practical,

HCMP = Hard core main project

Note:

To train the students for the SET/NET/GATE and other competitive examinations, University/College assessment questions should test the understanding of candidate rather than the memory. The question paper should cover all the Units included in the syllabus

of the respective paper and the weightage of the questions should correspond to the number of lectures allotted to the respective Units / Topics.

M. Sc. II (Pharmaceutical Chemistry)

SEMESTER-III

Paper Code: HCT 3.1

Advanced Organic Chemistry-I

Credit: 04 **60 L**

Unit-I: Free radical reactions **[15]**

Types of free radical reactions, detection by ESR, free radical substitution mechanism, mechanism at aromatic substrates, neighboring group assistance. Reactivity for aliphatic and aromatic substitution at a bridge head. Reactivity in attacking radicals. The effect of solvent on reactivity. Allylic hydrogenation (NBS), Oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salt, Sandmeyers reaction. Free radical rearrangement, Hunsdiecker reaction

Unit -II: Name reactions **[18]**

Darzen, Prins, Henry, Strecker amino acid synthesis. Bamford-Steven, Baylis-Hillmann, Corey-Fuchs Reaction, Julia Olefination, Mukaiyama aldol, Mitsunobu, Corey-Winter olefination, Shapiro, Ritter, Stille, Heck, Sonogashira, Suzuki, Negishi, Kumada, Hiyama, Tsuji-Trost, Duff, Chugaev, Petasis, McMurry reaction and Coupling. Ring closing metathesis (Grubb's metathesis), Aldol-Tishchenko reaction (Evans-Tishchenko reaction).

Unit-III: Rearrangements **[15]**

Pummerer, Payne, Eschenmoser fragmentation, Brook, Wagner-Meerwein, Wolf, Semipinacol, Epoxide rearrangement with lewis acid, Tiffeneau-Demjanov, von Richter, Wittig, Neber, Smiles, Steven, Hofmann, Iodolactonisation Hoffmann-Loffler Fretag reactions

Unit-IV: Reagents **[12]**

Lithium dialkylcuprate, DCC, DDQ, Organotin reagents, Peterson's synthesis, Trimethylsilyl iodide, Peracids, PPA, Ozone, Selenium dioxide, Periodic acid, Iodoisobenzyldiacetate

Reference Books:

1. A guidebook to Mechanism in Organic Chemistry (Orient- Longmens)- Peter Sykes
2. Organic Reaction Mechanism (Benjamin)-R. Bresslow
3. Mechanism and Structure in Organic Chemistry (Holt Reinhartwinston)- B. S. Gould
4. Organic Chemistry (McGraw Hill)-Hendrikson, Cram and Hammond
5. Basic principles of Organic Chemistry (Benjamin) J. D. Roberts and M. C. Caserio.
6. Reactive intermediates in Organic Chemistry 9 Jojn Wiley) N. S. Issacs.
7. Organic reaction mechanism (Mc Graw Hill) R. K. Bansal
8. Advanced organic chemistry, part B: Reaction and synthesis by Francis A. Carey, Richard Y. Sandburg.
9. Organic Chemistry by Clayden, Greeves, Warren and Wothers.

Paper Code: HCT 3.2

Chemistry of Bioactive Heterocycles

Credits: 04 **60 L**

Heterocyclic compounds - Nomenclature, synthesis, reactivity, aromatic character, and medicinal importance of following heterocycles:

UNIT I: 3- and 4- Membered heterocycles **[10]**

Baldwin rules for 3, 4, 5, 6-membered ring closures

3-membered rings: Aziridines, Oxiranes, Thiaranes,

4-membered rings: Azetidines, Oxitanes and Thietanes

UNIT II: 5-Membered heterocycles **[17]**

Five-membered rings with one heteroatom: Pyrrolidine, Furan, Pyrrole and Thiophene

Five-membered rings with two heteroatoms: Imidazole, Pyrazole, Oxazole, Isoxazole, Thiazole, Isothiazole.

Five-membered rings with three heteroatoms: Triazoles, Oxadiazole, Thiadiazole, Tetrazole.

UNIT III: 6-Membered heterocycles **[17]**

Six-membered rings with one heteroatom: Pyran, Pyridine Six-membered rings with two heteroatoms: Piperazine, Morphine, Thiomorphine, Pyridazines, pyrimidines, pyrazines, Six-membered rings with three heteroatoms: Hexahydro-1,3,5-triazine Six-membered rings with three heteroatoms: Tetrazine

UNIT- IV: Benzofused heterocycles **[16]**

Benzofused heterocycles Benzopyrroles, Benzofuran, Indole, Benzothiophene, Benzoxazole, benzthiazole, Benzimidazole, Quinolines, Isoquinoline, Quinazolines, Coumarins and Chromones, Purines and Pteridines

Reference Books:

1. R. M. Acheson: An introduction to chemistry of heterocyclic compounds (Interscience)

2. Joule and Smith: Heterocyclic chemistry (Van Nossstrand)

3. R.K. BANSAL: Heterocyclic chemistry (Wiley E)

4. L.A. Paquitte: Principals of modern heterocyclic chemistry

5. M.H. Palamer: The structure and reactions of heterocyclic compounds.

6. A.R. Katrtzhy and A.V. Bootton: Advances in Heterocyclic chemistry (A.P.)

7. Finar: Organic chemistry (Vol. 1 and 2)

8. Conn and Stumf: Outline of Biochemistry

9. Williams, Introduction to the chemistry of enzyme action.

10. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman AcademicPress. 11.Stralegies for Organic Drug Synthesis and Design. D. Lednicer, John Wiley.

12. Heterocyclic Chemistry Vol. 1-3, R. R. Gupta, M. Kumar, and V. Gupta, SpringerVerlag.

13. The Chemistry of Heterocycles, T Eicher and S. Hauptmann, Thieme.

14. Heterocyclic Chemistry, J. A. Joule, K. Mills and G. F. Smith, Chapman ans Hall.

15. Heterocyclic Chemistry, T. L. Gilchrist, Longman Scientific Technical

16. Contemporary Heterocyclic Chemistry, G. R. Newkome and W. W. Poudler, Wiley.

17. An Introduction to the Heterocyclic Compounds, R. M. Acheson, John Wiley.

18. Comprehensive Heterocyclic Chemistry, A. R. Katrizky and C. W. Rees, eds,Pergamon Press.

Paper Code: SCT 3.1

Drug Development

Credits: 04 **60 L**

Unit-I: Concept of drug **[15]**

Concept of drug, Sources of drugs, Drug development, Lipinski rule of 5, Physico chemical properties of molecules: lipophilicity, electrokinetic parameters, steric parameters, pKa (eg. Cimetidine development), and solubility. Types of receptors, Protein and Protein Data Bases,

Unit-II: Computer aided drug designing: **[15]**

Structure and ligand-based drug designing, Lead and drug like properties, concept of lead identification and modification, Structure-activity relationship (SAR), Factors affecting bioactivity, History, and development of QSAR, Types of molecular descriptors, Methods of molecular descriptor selection, 2D QSAR modeling, Introduction to molecular docking and illustrations (NNRTIs and COX-inhibitors).

Unit – III: Pharmacokinetics **[15]**

Introduction to drug absorption, distribution, metabolism, elimination, and toxicity (ADMET). Pharmacokinetic models, bioavailability, Pharmacokinetic parameters (volume of distribution, elimination half-life, clearance). Concept of pro-drug and soft drug.

Unit IV: Pharmacodynamics **[15]**

Introduction to LD_{50}, ED_{50}, IC_{50}, MIC, MEC and Ki. Dose-response relationships, drug potency and efficacy. Principles of drug action, mechanisms of drug action, drug receptor interactions, combined effect of drugs.

Reference Books:

1. Graham L. Patrick, An Introduction to Medicinal Chemistry, Fifth Edition, Oxford University Press

2. Edward H. Kerns and Li Di, Drug-like Properties: Concepts, Structure Design and Methods, Elsevier, 2008
3. Ashutosh Kar, Medicinal Chemistry, New Age International Publishers, Fourth Edition
4. Gupta, S. P. (2011) QSAR & Molecular Modeling. Anamaya Pub.: New Delhi.
5. Jayashree Ghosh, A Textbook of Pharmaceutical Chemistry, 3/eS, Chand Publications
6. Grigauge A, Introduction to Medicinal Chemistry; Wiley-VCH
7. Pandey S S, Dimmock J R, An Introduction to Drug Design; New Age International
8. Wolff Ed M EV, Burger's Medicinal Chemistry and Drug Discovery (6th Edition); John Wiley
9. Silverman R B, The Organic Chemistry of Drug Design and Drug Action; Academic Press
10. William Foye, Lippicott, Principles of Medicinal Chemistry (4th Edition); William and Wilkins
11. Kadam S S, Mahadik, Bothera, Principles of Medicinal Chemistry (11^{th} Edition); Nirali Publication
12. Satoskar R S, Bhandarkar, Pharmacology and Pharmacotherapeutics; PopularPrakashan
13. Organic Chemistry: Clayden, Greeves, Warren and Wo

Paper Code: SCT 3.2

Biochemistry

Credits: 04 **60 L**

Unit-I: **[15]**

Introduction of Biochemistry: The molecular logic of life; Structural hierarchy in themolecular organization of Cells. The chemical unity of diverse living organisms, prokaryotic and Eukaryotic. Scope of the subject in pharmaceutical Sciences

Carbohydrates: Classification, basic chemical structure, monosaccharides, aldoses, andketoses, cyclic structure of monosaccharides, stereoisomerisms, anomers and epimers. Reducing properties of monosaccharides, disaccharides, oiligosaccharides, polysaccharides, structural studies methylation and periodate oxidation. Polysaccharide's structure and function of complex carbohydrates, proteoglycans, glycoproteins,
Glycolipids, mucopolysaccharides

Unit-II: **[15]**

Protein: Classification and properties of amino acids, Primary, Secondary, Tertiary and Quaternary structure of protein. Synthesis, purification, characterization, and sequencing of protein molecules.

Lipids: Classification, structure, and function of lipids. Acylglycerols, circulating lipids: lipoproteins, chylomicrons, LDL, HDL, and VLDL. Pathalogical changes in lipid levels. Formation of micelles, monolayers, bilayer, liposomes. Lipid metabolism: Beta oxidation of fatty acids

Unit III: **[15]**

Nucleic acids: Molecules of Heredity: Structure of deoxyribonucleic acid (DNA) and ribonucleicacid (RNA), DNA double helix, A, B, and Z forms of DNA, DNA as genetic material, genetic code, flow of genetic information, DNAreplication, transcription and translation

Vitamins and Co-enzymes: Classification, water-soluble and fat-soluble vitamins. Structure, dietary requirements, deficiency conditions, coenzyme forms.

Unit IV: **[15]**

Bioinorganic Chemistry: Principles of coordination Chemistry related to Bioinorganic– Proteins, nucleic acids, and other metal binding biomolecules. Choice, uptake, and assembly of metal containing units in Biology. Control and utilization of metal ion concentration in cells. Metal ion folding and cross linking of biomolecules. Binding of metal ions and complexes to biomolecular active centers

Reference Books:

1. Principle of Biochemistry, Lehinger D.L. Nelson and M.M. Cox. Macmillan worth Publishers
2. Biochemistry, L. Stryker, W.H. Freeman, San Francisco
3. Schaum's Outline Steries of Theory and Problems of Biochemistry, Philip W. Kuchel and G.B.Ralston. Int. Ed., McGraw-Hill Book Co.
4. Problem Approaches in Biochemistry. Wood and Hood
5. Principle of Biochemistry, Lehinger D.L. Nelson and M.M. Cox. Macmillanworth Publishers
6. Biochemistry, L. Stryer, W.H. Freeman, San Francisco
8. Problem Approaches in Biochemistry Wood and Hood
9. Biochemistry by Satyanarayana

Textbooks:

1. Ligand field theory & its application: B.N.Figgis & M.A. Hitchman (2000) Wiely VCH publ. Chapters 5, 6, 8, 9, 11
2. Principles of Bioinorganic Chemistry: S.J. Lippard & J.M Berg (1994), Universityscience books, Mill Valley, California Chapters-1,2,3,5,6,7,8
3. Inorganic Chemistry: Shriver & Atkins (1999) Oxford
4. Inorganic Electronic spectroscopy: A.B.P. Lever, 2nd edn (1984), Elsevier Science Publishers, New York
5. Biological Chemistry of the Elements: R.J.P. Williams & F.R. de Salvia, Oxford University, Press-(1991)

6. Bioinorganic Chemistry: Inorganic elements in the Chemistry of life: An introduction & guide: W.Kaim, B.Schwederski, VCH,(1991)

Paper Code: OET 3.1

Medicinal Chemistry

Credits: 04 **60 L**

Classification, SAR, Mechanism of action and Synthesis* of drugs for following classes:

Unit-I: **[15]**

Sulfonamides: Sulfisoxazole, Sulfapyridine, Sulfacetamide* and Sulfamethoxazole*

Antibiotics: Penicillin: Ampicillin*, Amoxycillin. Cephalosporin: Cefazolin, Cefadroxil, Cefixime*, Tetracycline, Chloramphenicol*, Amino glycosides: Streptomycin

Antimalerials: Chloroquine*

Unit-2: **[15]**

Antiviral: Acyclovir, Remdesivir.

Antifungal: Clotrimazole, Miconazole, Itraconazole

NSAIDs: Aspirin*, Ibuprofen*, Paracetamol*, Diclofenac*, Aceclofenac, Indomethacin, Nimesulide and COX-II inhibitors

Unit-3: **[15]**

Antianginal: Nitrates, Nifedipine, Propranolol*

Anti-hypertensive Drugs: Verapamil, Captopril*, Atenolol

Antidiabetics: Insulin, Tolbutamide, Glipizide, Metformin*, Pioglitazone

Antihistamines: Diphenylhydramine*, Chlorpheniramine, Cetrizine

Unit-4: **[15]**

Anaesthetics: Halothane, Lidocaine and Thiopental*

Sedative and hypnotics: Phenobarbital, Diazepam*, Alprazolam

Anticonvulsant: Phenytoin*, Carbamzepine, Valproic acid

Antidepressant: Amitriptiline, Phenelzine*

Antineoplastic: Alkylating agent, Antimetabolites

Reference Books:

1. Comprehensive medicinal chemistry- Corwin and Hansch
2. Medicinal chemistry-Burgers (Vol-I-VI)
3. Principles of medicinal chemistry-William O Foye
4. Textbook of medicinal chemistry- Vol-I&II- Surendra N Pandey
5. Principles of medicinal chemistry- S SKadam, K R Mahadik and K G Bothara
6. Introductory medicinal chemistry- Kennewell and Taylor
7. Wilson and Giswold`sText book of Organic medicinal and Pharmaceutical chemistry- Jaimes N Delgado and William A Remere
8. Fundamentals of microbiology- Forpischer
9. Genetics of antibiotics producing microorganisms- G Sermouti
10. Organic Chemistry: Clayden, Greeves, Warren and Wo
11. Organic Synthesis: The Disconnection Approach: Stuart Warren
12. Designing Organic Synthesis: Stuart Warren

Paper Code: OET 3.2

Drug Regulatory Affairs

Credits: 04 **60 L**

Unit-I: Drug Regulatory Aspects **[15]**

Central and State regulatory bodies (FDA, DCGI, CDSO); Drugs and Cosmetics Act (Special emphasis-Schedule M and Y); Various licenses - (Test license, Import license for testing of drugs and API's, Mfg., Contract and Loan license manufacturing)

Unit-II: Good Manufacturing Practices (GMP) **[15]**

GMP, cGMP, WHO, ICH guidelines. Export permissions and manufacturing for other countries; Understanding of the plant lay-outs with special emphasis on the environment & safety (HVAC, Water systems, Stores management, Effluent etc.); Quality Assurance Vs Quality Control.

Unit-III: Drug Approval Agencies **[15]**

USFDA, CDER, INDA, NDA, ANDA, CTD Formats of dossiers, e-submission, DMF, BMR, Orange Book, RLD (Reference listed drug)

A brief introduction to the guidelines for Europe, Japan, Australia, South Africa, GMP audits, role of Quality Assurance, product approvals and supply.

Unit-IV: IPR & Patents **[15]**

Development of IP law in India, IPR regime, Role of IP in Pharma industry. Indian Patents Act, Procedure for patent application, Grant and opposition proceedings, Patent licensing, Patent infringement proceedings. Patent search, Patent analysis & Patent drafting. Other countries patent system.

Reference books:

1. CDSO publications and updates of drug and Cosmetics act and rules (Govt. of India).

2. CDER Publications and Guidance

3. EMEA Publications and Guidance

4. Orange Book, ICH guidelines, Indian Patents Act

5. Country specific Regulatory Guidelines (available from internet)

6. Govt. Publications on issues affecting sales, distribution, manufacturing, excise, etc.

7. J. D. Nally, "Good manufacturing Practice for Pharmaceuticals" Informa Healthcare

8. I. Kanfer& L. Shargel, "Generic Product Development BE issued" Informa Healthcare

9. R. A. Guarino, "New Drug Approval Process. The Global challenges". Informa Healthcare

10. Watcher and Nash, "Pharmaceutical Process Validation". Marcel Dekker

11. Pharmaceutical Product Dev. IVIVC by Murthy, Sunkara and David

12. USPTO and WIPO Guidelines

13. S. W. Deshpande, Drugs and Cosmetics Act, 1940 and Rules, 1945 and Drugs [PriceControl] Order, 1995

M. Sc. Pharmaceutical Chemistry

SEMESTER – IV

Paper Code: HCT 4.1

Photochemistry and Pericyclic Reactions

Credits: 04 **60 L**

UNIT-I: Molecular Orbital Theory **[10]**

Molecular orbitals, Calculation of energies of orbitals in cyclic and acyclic systems. Determination energies and stabilities of different systems. Calculation of charge densities. PMO theory and reactivity index.

UNIT-II: Pericyclic Reactions-I **[15]**

Features and classification of pericyclic reactions, Phases, nodes and symmetry properties of molecular orbital in ethylene, 1,3-butadiene, 1,3,5-hexatriene. Allyl cation, allyl radical, pentadienyl cation and pentadienyl radical. Thermal and photochemical reactions. **Electrocyclic reactions:** Con-rotation and dis-rotation, electrocyclic closure and opening in 4n and 4n+2 systems, Woodward-Hoffmann selection rules for electrocyclic reactions. Explanation for the mechanism of electrocyclic reactions by: (i) Symmetry properties of HOMO of open chain partner; (ii) Conservation of orbital symmetry and orbital symmetry correlation diagram and (iii) Huckel-Mobius aromatic and antiaromatic transition state method.

UNIT-III: Pericyclic Reactions-II **[15]**

Cycloaddition reactions: Suprafacial and antarafacial interactions. (π2- cycloadditions. Cycloreversions. Stereochemical aspects in supra–supra, antara-supra and antara-antara (π2 and π4 cycloadditions. Diels-Alder reaction. Woodward-Hoffmann selection rules for cycloaddition reactions. Explanation for the mechanism of cycloaddition reactions by 1) Conservation of orbital symmetry and orbital symmetry correlation diagrams 2) Fukui

Frontier Molecular Orbital (FMO) theory and (3) Huckel Mobius aromatic and antiaromatic transition state method. Endo-exo selectivity in Diels Alder reaction and it's explanation by FMO theory. Examples of cycloaddition reactions.

Sigmatropic reactions: [1,j] and [i,j] shifts. Suprafacial and antarafacial shifts. Selection rules for [i,j] shifts. Cope, degenerate Cope and Claisen rearrangements. Explanation for the mechanism of sigmatropic reactions by 1) symmetry properties of HOMO 2) Huckel-Mobius aromatic and antiaromatic transition state method. Introduction to chelotropic reactions and the explanation of mechanism by FMO theory.

UNIT- IV: Photochemistry [20]

Photochemistry of (π, π∗) transitions: Excited state of alkenes, cis-trans isomerisation, photochemistry state, electrocyclisation and Sigmatropic rearrangements, di π-methane rearrangement.

Intermolecular reactions: photocycloadditions, photodimerasation of sample and conjugated olefins, addition of olefins to α, β unsaturated carbonyl compounds, excimers and exiplexes. Photoaddition reactions. Excited states of aromatic compounds, photodimerisation of benzene, photosubstitution reactions of aromatic compounds and Photo-Fries rearrangement.

Photochemistry of (n, π∗) transitions: Excited state of carbonyl compounds, hemolytic cleavage of α-bond-Norrish type I reaction in acyclic, cyclic ketones and strained cycloalkanediones.

Intermolecular abstraction of hydrogen: Photo reduction and photo oxidation-influence of temperature, solvent, nature of hydrogen donors and structure of the substrate.

Intramolecular abstraction of hydrogen: Norrish type II reaction in ketones, esters and 1, 2-diketones.

Addition to C-C multiple bonds: Paterno-Buchi reaction, photodecarboxylation, photochemistry of alkyl peroxides, hypohalites and nitriles. Barton reaction. Photochemistry of azo compounds, diazo compounds, azides and diazonium salts. Singlet oxygen-photo oxygenation reactions. Ene reaction, formation of dioxetanes and endoperoxides. Chemiluminescent reactions. Oxidative coupling.

Reference Books:

1. Lehar and Merchand: Orbital Symmetry
2. R. B. Woodward and Hoffman: Conservation of Orbital symmetry.

3. Photochemistry and pericyclic reactions by Jagdamba Shingh
4. Cixon and Halton: Organic photochemistry
5. Arnold: Photochemistry
6. N. Turro: Modern Molecular Photochemistry
7. Rohatgi- Mukherji: Fundamentals of photochemistry.
8. Ginsburg: Nionbenzoid aromatic compound
9. A. Streetwise: Molecular orbital theory for organic chemistry.
10. E. Cler: The aromatic sextet.
11. Lloyd: Carbocyclic non- benzoid aromatic compounds.
12. G. M. Bandger; The structure and reactions of aromatics compounds
13. W. B. Smith; Molecular orbital methods in Organic Chemis

Paper Code: HCT 4.2

Advanced Organic Chemistry-II

Credits: 04 **60 L**

Unit-I: Fused and bridged rings **[15]**

Cis- and trans- decalins and nine methyl decalines and perhydraphenanthrene, perhydroanthracene. Bridged rings, Nomenclature stereo chemical restrictions. The Bredts rule, Reactivities.

Unit-II: Protecting Groups **[10]**

Protection and deprotection of hydroxyl, carbonyls in aldehydes and ketones, amines, carboxylic acids, alkenes and alkynes

Unit-III: Asymmetric synthesis **[15]**

Stereoselectivity in cyclic compounds, enantio-selectivity, diastereo-selectivity, enatiomeric and diastereomeric excess, stereoselective aldol reactions, Cram's rule, Prelog rule, Felkin Anh rule, Cram's chelate model, Prochirality, Asymmetric synthesis, use of chiral auxiliaries, chiral reagents and catalysts, asymmetric hydrogenation, asymmetric epoxidation and asymmetric dihydroxylation, Proline catalyzed asymmetric reaction, diastereo-selectivity in crotyl boronate, hydroboration, allyl boranes, and alkylation to enolates. Synthetic and Industrial applications.

Unit-IV: Disconnection Approach **[20]**

Introduction to: Grounding of organic chemistry for understanding retrosynthesis; Retrosynthetic analysis and designing of the synthesis; Disconnection approach: An introduction to synthons, synthetic equivalents, disconnection approach, functional group interconversions, importance of order of events in organic synthesis, one and two group C-X disconnections, selective organic transformations: chemoselectivity, regioselectivity,

stereoselectivity, enentioselectivity, Reversal of polarity, cyclization reactions, amine synthesis

i) One group C-C Disconnections:

Alcohols (including stereoslectivity), carbonyls (including regioselectivity), Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis

ii) Two group C-C Disconnections:

Diels-Alder reactions, 1,3difunctionalized compounds and α, β-unsaturated compounds, control in carbonyl condensations, 1,5 difunctionalized compounds, Michael addition and Robbinson annulation

Reference Books:

1. Finar I L, Organic Chemsitry
2. Trivedi J P, Stereochemistry
3. Nasipuri D, Stereochemistry
4. P S Kalsi : Stereochemistry of Organic Compounds
5. Nogradi M, Stereoselective synthesis: A practical approach
6. Organic Synthesis: The Disconnection Approach: Stuart Warren
7. Designing Organic Synthesis: Stuart Warren
8. Organic Synthesis: Strategy and Control: Paul Wyatt and Stuart Warren
9. The Logic of Chemical Synthesis: E. J. Corey and Xue-Min Chelg
10. Classics in Total Synthesis I, II and III: K. C. Nicolaou and others
11. Organic Synthesis Concepts, Methods, Starting Materials: J. Fuhrhop, G. Penzlin
12. Some Modern Methods of Organic Synthesis: W. Carruthers
13. Organic Synthesis: M. B. Smith
14. Principles of Organic Synthesis: R. Norman and J. M. Coxan
15. Advanced Organic Chemistry: Jerry March
16. Organic Chemistry: Clayden, Greeves, Warren and Wo

Paper Code: HCT 4.3

Pharmaceutical Dosage Forms

Credits: 04 **60 L**

Unit-I: Solid Dosage Forms **[15]**

Routes of administration, Types of dosage forms, Oral solids: tablets, types of tablets, methods of tablet production - wet granulation, coating of tablets. Quality control methods and measurement of tablet properties, packaging.

Unit-II: Other Dosage Forms **[15]**

Oral liquids: Suspensions and Emulsions: Definition, types, stability, suspending/ emulsifying agents, evaluation, and packaging.

Parenterals, Ophthalmic products, Aerosols, Inhalation products.

Topical lipids, semisolids, and powders.

Unit-III: Drug Formulation **[15]**

Concept of excipients, classifications with examples, colours, flavours and preservatives in formulations.

Concept of Pre-formulation, factors influencing designing of dosage forms, drug excipients interaction, stability studies.

Unit-IV: Drug delivery systems: **[15]**

Fundamental of novel drug delivery: Rationale of sustained release, controlled release dosage forms. Oral controlled drug delivery systems, mucosal drug delivery system, ocular drug delivery systems, parenteral drug delivery systems, transdermal drug delivery systems.

Reference Books:

1. The theory and practice of Industrial pharmacy (CBS) Leon Lachman,
2. Dispensing of pharmaceuticals (CBS) Cooper and Gunn
3. The Science and Practice of Pharmacy by Remington
4. Biopharmaceutics and Pharmacokinetics by Brahmankar
5. Pharmaceutical dosage forms and drug delivery systems by Ansel
6. The science of dosage forms design by Aulton

Paper Code: SCT 4.1

Pharmaceutical Technology

Credits: 04 **60 L**

Unit-I: API manufacturing units **[15]**

Chemical process, Chemical plants/Industry, Process flow diagram, Factors affecting chemical processes, Reaction systems, Reactors used in API manufacturing, Plant layout and Effluent Treatment Plant (ETP).

Unit-II: Unit Process **[15]**

Scale up techniques, plant layout of Oxidation: oxidation of Methanol, Liquid phase oxidation with oxygen-Acetaldehyde to Acetic acid, Halogenation: Technical Halogenations-Manufacturing processes for monochloroacetic acid, Chloral, Monochlorobenzene, and Vinyl chloride (Ethylene and Acetylene), Nitration: Typical industrial Nitration process (Nitrobenzene, and α-Nitronaphthalene); Esterification: Esterification by organic acid, Manufacture of Vinyl acetate and Cellulose related to active pharmaceutical ingredients (API) manufacturing-plant layout, Technology transfer

Unit-III: Unit operation in tableting **[15]**

Milling/Mixing, Granulation, Screening, Drying, Blending, Compression, Coating, Plant layout.

Unit-IV: Validation **[15]**

Validation, Qualifications (DQ, IQ, OQ, PQ), Master plan of validation, Process validation, Cleaning validation, Computer system validation, Utilities validation, Validation of manufacturing equipments and analytical instruments, Analytical method validation, Regulatory guidelines.

Reference Books:

1. The Theory and Practice of Industrial Pharmacy (CBS) by Leon Lachman
2. The Science and Practice of Pharmacy by Remington
3. Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up, Peter J. Harrington, John Wiley and Sons Inc. Publication 2011
4. Strategies for Organic Drug Synthesis and Design by Daniel Lednicer, 2nd Edition, John Wiley and Sons Inc. Publication, 2008
5. Process Chemistry in Pharmaceutical Industry, Kumar Gadamasetti, Vol I & II, CRC Press; First edition, 2007.
6. Practical Process Research and Development, Neal G. Anderson, Academic Press., 2000
7. Principles of Process Research and Chemical Development in the Pharmaceutical Industry by O. Repic, John Wiley & Sons. Inc Publication New York, NY, 1998.
8. Organic Synthesis, Groggins P. H, (Third Edition). P. H. Groggins. McGraw-Hill, New York, 1947.
9. Fire Safety Management by Satish Tandon, Arise Publishers & Distributors; 1st edition, 2008.
10. Pollution Prevention of Chemical Processes, Allen David, Wiley-Blackwell, 1996.
11. The Treatment and Handling of Wastes, Bradshaw, A.D. Chapman and Hall for the Royal Society; First Edition edition, 1992.
12. Good Pharmaceutical Manufacturing Practice: Rationale and Compliance by Sharp John, CRC Press; 1st edition, 2004
13. Management Information Systems by Laudon Kenneth C. Prentice Hall; 12th edition, 2011.
14. Plant Design and Economics for Chemical Engineers by Peters, Max S., McGrawHill Science/Engineering/Math; 5 editions, 2002.
15. Textbook of Pharmaceutical Validation (First Edition), by A. A. Kulkarni, V.S. Kashikar, A.H. Hosmani, I.D. Gonjari, Pharma Career Publications

16. ICH Guidelines, www.ich.org

17. WHO Guidelines

18. GMP Guidelines

19. P.H.Groggins: Unit processes in organic synthesis (MGH)

20. F.A.Henglein: Chemical Technology (Perga mon)

21. M.G.Rao & M. Sitting: Outlines of Chemical Technology (EWP)

22. Clausen, Mattson: Principle of Industrial Chemistry

Paper Code: SCT 4.2

Industrial Pollution and Control

Credits: 04 **60 L**

Unit-I: Environmental Chemistry **[15]**

Environmental segments, atmospheric structure, photochemical smog,global warming, greenhouse effect, consequences of global warning, ozone layer depletion and its effects.

Unit-II: Air pollution **[15]**

Introduction, classification of air pollutant, sources and effect of air pollution on man and environment, industry and energy related air pollution particulate matter, sulphur oxide, transport related air pollution-carbon monoxide, nitrogen oxide and atmospheric lead, effect of carbon monoxide and Nitrogen oxide and lead control of automobile emission, Acid rain

Unit-III: Water pollution **[15]**

Water resources, classification of water pollutants and their effect (including heavy metal), analysis of industrial effluents-general physicochemical measurements like temperature, colour, odour suspended, solid, dissolved solid, pH, acidity, alkalinity, dissolved oxygen, COD and BOD, basic and advanced waste water treatment, coagulation, setting, floation, filtration, cation exchange membrane separation process, electrochemical process.

Unit-IV: Pollution Management **[15]**

Solid waste management, R & D, pilot plant, scale up process, inventory control, Toxic effect of hazardous chemicals, safety and health management Sources of soil pollution, effect of soil pollution, agricultural pollution, pesticides pollution control.

Reference Books:

1. Industrial chemistry – Dr. B. K. Sharma
2. Environmental Chemistry – Banerji Samir K.

3. Environmental Pollution – Katyal T; Satake M. Raj K. Vth Edition.
4. Environmental Pollution couses effects and control – Sethi I; Sethi M. S.; Eqbal S.
5. Environmental Water Pollution – Mishra S. G. Prasad, D. Gaur H. S.

M. Sc. II (Pharmaceutical Chemistry)

PRACTICAL COURSE

SEMESTER-III

HCP 3.1 Organic Chemistry-I

Two /Three stages organic preparations starting with 5g or less. (Any five)

(TLC Analysis is recommended)

1. Preparation of Benzanilide by Beckmann rearrangement
2. Preparation of Antharanilic acid
3. Preparation of Phthalimide
4. Preparation of N- Bromosuccinamide
5. Preparatin of p- Aminobenzoic acid
6. Preparation of p- chloronitrobenzene by Sandmeyer reaction
7. Preparation of p- Iodonitrobenzene by Sandmeyer reaction
8. Pinacol- Pinacolone rearrangement
9. Preparation of Acetophenones by Fries rearrangement
10. Preparation of aromatic aldehydes by Vilsmer Hack reaction or R. T.
11. Wittig reaction
12. Preparation of Benzopyrazole

(Other suitable experiments may be added)

HCP 3.2 Organic Chemistry-II

Isolation of following constituents from the natural sources: (Any five)

1. Isolation of lycopene from tomato fruits
2. Isolation of limonene from citrus rinds
3. Isolation of β-carotene from carrots
4. Isolation of Eugenol from cloves
5. Isolation of Piperine from black pepper

6. Isolation of Nicotine from tobacco
7. Isolation of Curcumin from turmeric
8. Isolation of capsaicinoids from peppers by Soxhlet extraction

(**Note:** Other suitable experiments may be added)

SCP 3.1 Pharmaceutical Chemistry

Drug synthesis / Molecular modeling: Synthesis of medicinally important compounds: (TLC Analysis is recommended) **(Any five)**

1. Benzocain
2. Coumarins
3. Benzimidazole
4. Paracetamol
5. Iodoform
6. Phenyl azo-2 naphthol
7. 2-Phenyl quinoline-4-carboxylic acid from benzaldehyde.

(**Note:** Other suitable experiments may be added)

SCP 3.2 Biochemistry **(Any five)**

1. Estimation of carbohydrates
2. Estimation of proteins
3. Molar extinction coefficient of molecules
4. Extraction and estimation of lipids
5. Direct microscopic counts
6. Total viable counts
7. Control of microbial growth
8. Determination of MIC (plate method)
9. Isolation of Bacterial, animal, plant and plasmid DNA
10. Agarose gel electrophoresis of DNA

OEP 3.1/3.2 Review Work

There will be computer laboratory session for hands on Chem draw software and literature survey by using Google Scholar/ Science Direct/Scopus/Web of Science etc. A student shall be expected to carry out literature survey in the field of interest and to select a topic for his/her project work in consultation with the supervisor. It shall be

expected that a student justifies the gravity and also the relevance of the problem through his/her seminar. Candidates are expected to do the following work at computer laboratory.

1. Literature survey
2. Work plan
3. Handling of Chem draw software for structure drawing
4. Chem draw assignment
5. Synopsis preparation

Evaluation based on the efforts put in by the student to carry out his/her dissertation work & the results obtained thereof. At the time of practical examination, candidates are expected to submit the synopsis which includes work done/ review of literature for the proposed work along with presentation. It will be valued for 40 marks.

PRACTICAL COURSE

SEMESTER-IV

HCP 4.1 Spectral Analysis

Identification of Pharmaceutically important Intermediates by the analysis of their spectra. Photocopies of UV, IR, NMR and Mass spectra of standard compounds are to be interpreted to determine the structure of the compound. At the time of practical examination, candidates are expected to submit the Journal.

HCP 4.2 Project Work /In plant training

Candidates are expected to work on assigned research project and submit the results at the end of the semester in the form a dissertation. Open defense of the student on his/her dissertation shall be arranged. This defense shall be in front of the panel of examiners. This will be valued for 40 marks.

Project work involving organic synthesis/evaluation of biological studies or in-plant training in any of the pharmaceutical or chemical industry for at least 21 days will be considered. Project should be completed under the guidance of a faculty member in the same Department or Industry or research organization. In case of Industry / research organization one member of that body can also be included as project guide.

Guidelines for Assessment

- Quality of Literature survey and Novelty in the problem
- Clarity of Problem definition and Feasibility of problem solution
- Clarity of objective and scope
- Quality of work attempted
- Presentation skills

HCP 4.3 Pharmaceutical Technology **(Any five)**

1. Assay of Paracetamol Tablet
2. Assay of Chloramphenicol Capsule
3. Assay of Aspirin Tablet
4. Assay of Vitamin-C
5. Preparation and Evaluation of Tablet
6. Draw Plant Layout of Tablet Unit
7. Draw Process Flow chart of parenteral formulation
8. Validation of UV-Visible spectroscopic analytical method
9. Performance Qualification of IR
10. Evaluation of Packaging Material (Glass/Plastic)

(**Note:** Other suitable experiments may be added)

SCP 4.1/4.2 Pharmaceutical formulation **(Any five)**

1. Preparation of weak Iodine solution
2. Preparation of Paracetamol Suspension,
3. Preparation of Castor Oil Emulsion
4. Preparation of Simple Syrup IP
5. Preparation of Lemon Syrup
6. Preparation of Sodium chloride eye lotion
7. Preparation of Methyl salicylate Ointment
8. Pre-formulation studies: Drug-drug interaction and drug excipient interaction in physical mixture,
9. Determination of solubility of Paracetamol in water, 0.1N HCl, 0.1N NaOH, Phosphate buffer pH 6.8 and 7.4
10. Study of Stability drug: Room Temperature, UV light, and Sun light

(**Note:** Other suitable experiments may be added)

Reference books:

1. A Textbook of Practical Organic Chemistry - A. I. Vogel.
2. Practical Organic Chemistry - Mann & Saunders.
3. A Handbook of Quantitative & Qualitative Analysis- H. T. Clarke.
4. Organic Synthesis Collective Volumes by Blat.
5. Reagents in Organic Synthesis by Fieser and Fieser.
6. Organic Practicals by Ahluwalia.
7. Systematic Lab Experiments in Organic Chemistry by Arun Sethi. (New Age).
8. Advanced Practical Medicinal Chemistry by Ashutosh Kar