MANONMANIAM SUNDARANAR UNIVERISTY,
TIRUNELVELI-12

SYLLABUS

UG - COURSES – AFFILIATED COLLEGES

Course Structure for B.Sc. Chemistry
(Choice Based Credit System)
(with effect from the academic year 2020-2021 onwards)

Semester-VI				
Part	**Subject Status**	**Subject Title**	**Subject Code**	**Credit**
3	Core	Inorganic Chemistry III		4
3	Core	Physical Chemistry III		4
3	Core	Organic Chemistry IV		4
3	Major Elective II	Green Chemistry / Nano Chemistry		4
3	Major Practical	Physical Chemistry Experiments		2
3	Major Project	Major Project		7

Total Marks: 100 Internal Exam: 25 marks + External Exam: 75 marks

A. **Scheme for internal Assessment**:
Maximum marks for written test: **20 marks**
3 internal tests, each of **I hour** duration shall be conducted every semester.
To the average of the **best two** written examinations must be added the marks scored in. The **assignment** for 5 marks.

The break up for internal assessment shall be:
Written test- 20 marks; Assignment -5 marks Total - 25 marks

B. Scheme of External Examination
3 hrs. examination at the end of the semester
A – Part : 1 mark question two - from each unit
B – Part : 5 marks question one - from each unit
C – Part : 8 marks question one - from each unit

- **Conversion of Marks into Grade Points and Letter Grades**

S.No	Marks	Letter Grade	Grade point (GP)	Performance
1	90-100	O	10	Outstanding
2	80-89	A+	9	Excellent
3	70-79	A	8	Very Good
4	60-69	B+	7	Good
5	50-59	B	6	Above Average
6	40-49	C	5	Pass
7	0-39	RA	-	Reappear
8	0	AA	-	Absent

- **Cumulative Grade Point Average (CGPA)**

$$\mathbf{CGPA} = \frac{\mathbf{\Sigma\,(GP \times C)}}{\mathbf{\Sigma C}}$$

- **GP** = Grade point, **C** = Credit
- CGPA is calculated only for Part-III courses
- CGPA for a semester is awarded on cumulative basis

- **Classification**
  a) First Class with Distinction : CGPA $\geq$ 7.5*****
  b) First Class : CGPA $\geq$ 6.0
  c) Second Class : CGPA $\geq$ 5.0 and $<$ 6.0
  d) Third Class : CGPA $<$ 5.0

INORGANIC CHEMISTRY – III

Objectives

- To study the theories in coordination chemistry
- To study the chemistry of metal carbonyls
- To understand the role of metal ions in biological systems
- To study the basic principles of photoinorganic chemistry

UNIT - I COORDINATION CHEMISTRY-I

Introduction: IUPAC nomenclature, Ligands- monodentate, bidentate, and polydentate ligands; coordination sphere; coordination number; nomenclature of mononuclear and dinuclear complexes. Structural and stereoisomerism in tetrahedral, square planar and octahedral complexes.Valance Bond theory – applications of valance bond theory to tetrahedral, square planar and octahedral complexes- Merits and limitations of VB theory.

UNIT – II CO-ORDINATION CHEMISTRY II

Crystal field theory - splitting of d-orbitals in octahedral and tetrahedral complexes - factors affecting the magnitude of crystal field splitting - effects of crystal field splitting - spectrochemical series - applications of CFT - magnetic properties and spectra of transition metal complexes - crystal field stabilization energy and their uses - limitations of CFT – effective atomic number rule - stability of complexes - step-wise and overall stability constants – factors affecting the stability of complexes - determination of stability constants.

UNIT – III CO-ORDINATION CHEMISTRY III

Labile and inert complexes - ligand substitution reactions in octahadral complexes: aquation, base hydrolysis and anation reactions - substitution reactions in square planner complexes - Trans effect - theories of trans effect - mechanism of substitution reactions – redox reactions: inner-sphere and outer-sphere electron transfer reactions.

UNIT - IV ORGANOMETALLIC CHEMISTRY

Introduction–History, Nomenclature of organometallic compounds, EAN rule and 18 electron rule. Structure and nature of M-L bond in metal carbonyls - metal nitrosyls. preparation of organo metallic compounds of Mg, Zn, Li, Cu, P, B, Ti, Fe and Co Wilkinson's catalyst and alkene hydrogenation, hydroformylation, Mansanto acetic acid process, Ziegler – Natta catalyst and polymerization of olefins.

UNIT - V INORGANIC PHOTOCHEMISTRY

Electronic transitions in metal complexes : selection rules - metal-centered and

charge-transfer transitions - properties of excited states - bimolecular quenching and energy transfer - photochemical pathways : substitutional, reduction-oxidation and isomerisation processes - photosubsitution reactions of Cr(III) complexes - Adamson's rules - photoredox reactions of Co(III) complexes - photoismerisation in Pt(II) complexes. Photochemical conversion and storage of solar energy : photolytic cleavage of water into H2 and O2 - photoelectrochemical
devices : photogalvanic cells and semiconductor based photovoltaic cells.

Reference books :

1. J.D. Lee, Concise Inorganic Chemistry 5th Ed., Blackwell Science Ltd.,
2. James E. Huheey, Elien A. Keiter and Richard L. Keiter, Inorganic Chemistry : Principles Structure and Reactivity, 4th Ed., Harper College Publisher.
3. F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Marilo and Manfred Bochman, Advanced Inorganic Chemistry, 6th Ed., Wiley Interscience Publication.
4. Fred Basolo and Ralph G. Pearson, Mechanisms of Inorganic Reactions : A study of metalcomplexes in solution, 2nd Ed., John wiley and sons, Inc.,
5. David E. Fenton, Biocoordination Chemistry, Ist Ed., Oxford Science Publications.
6. Ivano Bertini, Harry B Gray, Stephen J Lippard, Joan Selverstone Valentine, Bioinorganic Chemistry, 1st Ed., Viva Books Pvt. Ltd.,
7. J.K. Rohatgi - Mukherjee, Fundamentals of Photochemistry - Wiley Eastern Revised Ed.,
8. Journal of Chemical Education, Vol.60, No.10, October 1983.
9. A.W. Adamson and P.D. Fleischauer, (Editors) Concepts of Inorganic photochemistry, John wiley and sons, New York, 1975.

Physical chemistry –III

Objectives

- To learn about basic concepts in spectroscopy
- To study about the various types spectroscopy
- To learn the symmetry of the molecules.
- To know the kinetics of the reactions
- To study the surface phenonmena and solution characteristics

UNIT – I SPECTROSCOPY- I

Introduction - various types of molecular spectra - electronic, vibrational and rotational energy levels - Born-Oppenheimer approximation. Rotation spectra of

diatomic molecules - determination of bond length and moment of inertia from rotational spectra - numerical problems - selection rule, effect of isotopic substitution.UV-visible spectroscopy: theory - types of transitions in molecules - selection rules for electronic spectra - factors affecting absorption maximum and intensity – applications.

IR spectroscopy : theory - stretching and bending vibrations - factors affecting vibrational frequencies - important spectral regions for the characterization of functional groups – finger print region - determination of force constant - qualitative relation of force constant to bond energies - selection rules - modes of vibrations in polyatomic molecules - vibrational modes of H_2O and CO_2 – applications - numerical problems.

UNIT - II SPECTROSCOPY -II

Raman spectroscopy: Principle - Rayleigh and Raman scattering - Stokes and Anti-stokes lines - differences between IR and Raman spectroscopy - mutual exclusion principle – selection rule - applications. NMR spectroscopy: Theory of NMR, modes of nuclear spin-relaxation process - shielding effect, hyperfine splitting, coupling constants, - chemical shift - factors affecting chemical shift - internal standard, δ and τ scale - applications of NMR and limitations of NMR. ESR spectroscopy: principle - energy level splitting - presentation of ESR spectrum for methyl and benzene radicals, deuterium - applications-Zerofield splitting &Kramer's
degeneracy –fine structure

UNIT III GROUP THEORY

Concept of symmetry in chemistry - symmetry operations and symmetry elements - rotational axis of symmetry and types of rotational axes - planes of symmetry and types of planes- improper rotational axis of symmetry - identity element - groups and their basic properties –Abelian and cyclic groups - classification of molecules into point groups - the symmetry operations of a molecule form a group – H2Oand NH3point groups - group multiplication tables.

UNIT IV CHEMICAL KINETICS

Rate of reaction-Measuring rates of reaction-expressing reaction rates- factors influencing rate-rate constant-Rate laws, Stoichiometry, order and molecularity of reactions- First order, second order, third order and zero order reactions and example. Characteristics of I,II,III and Zero order reactions. Determination of order of reactions-expression for rate constant of first and second order reaction-derivation. Effect of temperature on rate constant. The activation energy - determination of Arrhenius frequency factor and energy of activation-The collision theory of reaction rates and its limitation. Lindemann theory of unimolecular reactions-The theory of

Absolute reaction rates. Comparison of the collision theory with the Absolute reaction rate theory.

UNIT V SURFACE CHEMISTRY AND SOLUTIONS

Surface Chemistry:Adsorption - physisorption and chemisorption - adsorption of gases by solids - adsorption isotherms - Freundlich adsorption isotherm - derivation of Langmuir adsorption isotherm, statement and explanation of BET isotherm - applications of adsorption - determination of surface area – adsorption indicators. Solution : Solutions of liquid in liquid– Binary liquid mixture - Ideal and non ideal solutions – Raoult's law. - deviation from ideal behavior – pressure – composition and temperature – Composition diagrams for completely miscible binary solutions- Fractional distillation –Azeotropic distillation—nature of azeotropic mixtures-partially miscible liquids— consolute temperature- critical solution temperature-system with upper CST, lower CST and upper and lower CST –Liquid crystals, Nematic,Semetic and cholestic types and their applications

Reference books :

1. Principles of Physical Chemistry - B.R. Puri and Sharma - Shobanlal Nagin Chand & Co.,
2. Text Book of Physical Chemistry - P.L. Soni - Sultan Chand.
3. Elements of PhysiCal chemistry - Glasstone and Lewis - Macmillan.
4. Physical chemistry - G.W. Castellan - Narosa publishing house.
5. Universal General Chemistry, C.N.R. Rao, Macmillan.
6. Group theory and its Chemical Applications - P.K.Bhattacharya - Himalaya publishing House.
7. Chemical Kinetics-K. J. Laidler, Tata McGraw Hill Publishing Company, NewDelhi

ORGANIC CHEMISTRY-IV

Objectives

- To learn about natural products
- To understand chemistry of aromatic compounds
- To study spectroscopy

UNIT-I CARBOHYDARATES

Classification-Monosaccharides- constitution of glucose and fructose. Reactions of

glucose and fructose – Osazone formation, Mutarotation and its mechanism, cyclic structure, pyronose and furanose forms. Epimerisation-Chain lengthening and shorteningof aldoses. Interconversions of aldoses and ketoses. Disaccharides- sucrose-reactions and structure. Polysaccharides – starch and cellulose (elucidation of structure not necessary).

UNIT-II PHENOLS, AROMATIC ALDEHYDES, KETONES AND ACIDS

Phenols:Acidic character of phenols- effect of substituents on acidity of phenols – Mechanisms of Kolbe's reaction and Riemer-Tiemen reaction. Preparation of cresols, catechol, resorcinol, quinol and euginol. Aldehydes and ketones :Preparation and uses of cinnamaldehyde. Coumarin, vanillin, Michler's ketone, p-benzoquinone-Quinone mono oxime tautomerism. Mechanism of Cannizaro reaction, benzoin condensation, Perkin reaction, Claisen reaction, Knovenagel reaction,Gattermann aldehyde synthesis and Houben –Hoesch synthesis. Aromatic acids: Ortho effect, preparation of mandelic acid, cinnamic acid and anthranilic acid. Preparation and uses of benzene-1,2-dicarboxylic acid, benzene-1,3- dicarboxylic acid and 1,4- dicarboxylic acid.

UNIT III REARRANGEMENTS

Rearrangement to electron-deficient carbon – 1,2 shift (Wagner-Meerwein rearrangement, pinacol rearrangement,Wolff rearrangement in Arndt-Eistert synthesis, benzilbenzilic acid rearrangement). Aromatic rearrangements from oxygen to ring carbon (Fries rearrangement, Claisenrearrangement and benzidine rearrangement). Rearrangement to electron-deficient nitrogen (Beckmann rearrangement, Schmidt rearrangement, Hofmann rearrangement, Curtius rearrangement). Rearrangement to electron-deficient oxygen (Baeyer-Villiger oxidation, hydroperoxide rearrangement ,cumene hydroperoxide-phenol rearrangement), Dakin reaction.

UNIT IV TERPENOIDS AND ALKALOIDS

Terpenes and terpenoids - classification - isoprene rule. Elucidation of structure and synthesis of citral , limonene, menthol, α-terpineol and camphor. Alkaloids: Introduction, classification and general methods for the determination of structure. Structural elucidation and synthesis of conine,piperine and nicotine

UNIT-V ORGANIC SPECTROSCOPY

UV spectroscopy - chromophore – auxochrome – blue shift, red shift – hypochromic shift, hyperchromic shift – applications for studying functional groups,cistrans isomerism and nature of double bonds- Woodward-Fischer rules as applied to conjugated enes and alpha and beta unsaturated ketones. IR spectroscopy– characteristics of IR absorption frequencies – intermolecular and intramolecular hydrogen bonding – functional group detection. NMR Spectroscopy - interpretation of

NMR spectra of simple organic compounds such as acetone, anisole, benzaldehyde, isobutene, mesitylene, 1-chloropropane, ethyl methyl ketone, benzyl alcohol, and propionic acid.

Reference Books

1. K.S. Tewari, N.K. Vishil, S.N. Mehotra – A text book of org. chem – 1st edition, Vikas Publishing House Pvt Ltd., 2001, New Delhi.
2. P.L. Soni, Text Book of Organic chemistry, Sultans Chand, 1991, New Delhi,
3. Bahl and Arun Bahl, Organic Chemistry, S. Chand and Sons, New Delhi, 2005.
4. Gurdeep Chatwal, Reaction mechanisms and reagents in organic chemistry
5. O. P. Agarwal, Chemistry of Organic Natural Products, Vol 1 and 2, Goel Pub. House,2002.
6. Gurdeep Chatwal, Chemistry of Organic Natural Products, Vol 1 and 2, Goel Pub. House,2002
7. Y.R. Sharma, O.P. Vig, Elementary organic absorption spectroscopy – 1st edition, Goel Pulishers, 1997, Meerut
8. R. T. Morrison and R. N. Boyd, Organic Chemistry, 6th Edition, PHI Limited, New Delhi, 1992.
9. Jerry March, Advanced Organic Chemistry, 4th Edition, John Wiley and Sons, New York,1992.
10. S. H. Pine, Organic Chemistry, 5th Edition, McGraw Hill International Edition, Chemistry Series, New York, 1987.

GREEN CHEMISTRY

Objectives

- To introduce the basics and need for Green Chemistry
- To understand the principles and designing a green synthesis of selected compounds
- To make the students familiar with the usage of green solvents and green catalysts in chemical reactions.
- To learn the principles of the microwave and ultrasound assisted reactions.

UNIT- I Introduction to green chemistry

Definition – need for green chemistry – scope of green chemistry. Concept of atom economy – yield – mass intensity and atom economy. Calculation of atom economy, mass intensity, mass productivity and carbon efficiency. Different types of reactions and atom economy - addition, substitution, elimination and rearrangements.

Concept of selectivity – enantioselectivity, chemoselectivity, regioselectivity and diasterioselectivity.

UNIT- II Green solvent

Super critical fluids – Introduction – extraction of super critical fluids – solvents of super critical fluid– advantages and applications.Carbondioxide as a super critical fluid – features of technique for using super critical carbondioxide - advantages and applications. Chemical reactions in supercritical water and Near – Critical Water (NCW)- Region. Extracting natural products, dry cleaning, supercritical polymerization, hydrogenation and hydroformylationlonicliquid as green solvent : Introduction – synthesis of ionic liquids - acidic ionic liquid and neutral
ionic liquids – applications in organic synthesis. Green reagents : Dimethyl carbonate and Polymer supported reagents.

UNIT- III Green catalyst

Catalysis over view : acid catalyst - basic catalyst – oxidation catalyst – polymer supported catalyst- photosensitized super acid catalyst and Tetra Amido Macrocylic Ligand (TAML) catalyst.

Biocatalyst : microbial oxidation, microbial reduction, enzyme catalyzed hydrolytic process, per fluorinated catalyst and modified biocatalyst.

Development of mesoporous supports by liquid crystal templating – neutral templating methods heterogeneous catalyst – solid supported catalyst.

UNIT- IV Green synthesis

Green synthesis of the following compounds -Adipic acid, Catechol, Benzoyl bromide, Acetaldehyde, Citral, Ibruprofen and Paracetamol

Microwave assisted reactions in water – Hoffmann Elimination, Hydrolysis of benzyl chloride and methyl benzoate – oxidation of toluene and alcohols

Microwave assisted reactions in organic solvents – Esterification, Fries rearrangement, Clasien Rearrangement, Diels-Alder Reaction and Decarboxylation. Ultra sound assisted reactions – Esterification, Saponification, alkylation , oxidation, reduction, coupling reactions and Cannizaro reactions.

UNIT -V Green reactions invloving basic principle of green chemistry.

Twleve principle of green chemistry – choice of starting materials – biomimitic, multifunctional reagents – materials reagents.

Combinatorial green chemistry – green chemistry in sustainable developments.

Importance of Green chemistry in day to day life, versatile bleaching agents and analgeric drugs.

References

1. V.K.Ahluwallia &M.R Kidwai “New Trends in Green Chemistry”, Anamalaya
    a. Publishers (2005)

2. P.T.Anaster &J.K.Warnerr " Oxford Green Chemistry,Theory and Practical",University Press(1998)
3. A.S. Matlack,'' Introduction to Green Chemistry"-Marcel Deckkar (2001)
4. V.K.Ahhluwallia, "Green Chemistry Environnmentally Benign Reaction"Ane Books Pvt.Ltd. New Delhi (2009)
5. Rashmi Sannghi &MM Srivastava, "Green Chemistry Environment Friendly Alternatives." Narosa Publishing House Pvt Ltd, New Delhi (2009)

NANO CHEMISTRY

Objectives

- To give an insight into the basics of nanochemistry.
- To understand the difference between bulk material and nanomaterial and learn the synthesis, application and fabrication of nanostructure.
- To study the importance of nanocatalyst, nanocomposites and fibers.
- To make the students familiar with the characterization and applications of nanomaterials.

UNIT- I Introduction to Nano chemistry.

Definition: nanoscience – nanotechnology – nanochemistry – significance of nanoscale - factors responsible for special properties of nanomaterials.

Nanomaterials: Different types of nanomaterials and structures- quantum wells – quantum wires – quantum dots – nanoclusters – nanocrystals – nanowires and nanotubes. Feynman's Prophecy– manufacturing of nanomateris - top-down and bottom-up approaches.

UNIT-II Synthesis of nano particles.

Introduction – orientation of nanoparticles – synthesis of nanoparticles.

Physical methods: laser ablation, physical vapour deposition (PVD) and solvated metal atom dispersion (SMAD).

Chemical methods: thermolysis, sonochemical method, reduction methods, phase-transfer processes and biosynthesis of nanoparticles.

Synthesis of nanosized semiconductors: precipitation methods and thermal decomposition of complex precursors. Synthesis of ceramics: physical methods, gas condensation method, laser method, chemical methods and sol-gel synthesis.

UNIT –III Nanocatalyst and carbon based nanomaterials

Inroduction – fundamentals of catalysis – adsorption of a molecule on a catalyst surface, adsorption theory- Langmuir adsorption isotherm.

Surface reactions – synthesis – synthesis requirements, example of a conventional synthetic technique, non traditional methods for preparing nanocatalyst. Characterization of nanocatalyst : overview - bulk characterization technique and surface characterization technique
Carbon nanomaterials : structure and properties of graphite, diamond and fullerenes.

UNIT-IV Nanocomposites and fibers.
Introduction - Background - types of composite materials - The nano perspective.
Physical and chemical properties of materials – mechanical properties, thermal properties,electronic properties and chemical properties.
Natural nanocomposities - Skin of the sea cucumber and hard natural nanocomposites.
Carbon fibers and nanotubes – Types of fibers, Whiskers and nanotubes – synthesis of fibersand nanotubes - chemical modification and applications of carbon nanotube.
Metal and Ceramic nanocomposites - Metal nanocomposites, inorganic nanofibers and concrete.
Clay nanocomposite materials -polypropylene clay nanocomposite , mont morillonite clay nanocomposite and halloysite nanotube claycomposites.

UNIT-V Characterization and applications of nanomaterials.
Types of characterization methods – Electron probe method- Scanning electron microscopy – Transmission electron microscopy,
Spectroscopyic Methods, - UV – Visible adsorption and emission spectroscopy, Infra Red and Raman spectroscopy and X-ray diffraction methods.
Current applications: sunscreens and cosmetics – nano medicine, drug delivery and cancer drugs – food and drinks, textiles, chemical industry and electronic devices.
Short term applications - paints – fuel cells – displays – batteries – fuel additives and catalysts.
Long term applications- composites – lubricants – magnetic materials – medical implants – machinable ceramics – water purification and military battle suits.

References

1. Geoffrey A. Ozin and Andre C. Arsenault, “Nanochemistry: A chemical approach to nanomaterials”, RSC publishing, (2005), U.K.
2. Hari Singh Nalwa, “Nanostructured Materials and Nanotechnology”, Academic Press, New York,(2002).
3. C.N.R. Rao, A. Muller and A.K. Cheetham, “The Chemistry of Nanomaterials, Volume I & II”, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, (2004).
4. Kenneth J. Klabunde, “Nanoscale Materials in Chemistry”, Wiley-Interscience”, New York,(2001).

5. Gabor L.Hornyak, Harry F. Tibbals, Joydeep Dutta and John J Moore . "Inroduction to Nanoscience and Nanotechnology" CRC Press ,Taylor and Francis group London Newyork.

PHYSICAL CHEMISTRY EXPERIMENTS

Objectives

- To enable the students to understand the principles of physical chemistry experiments

1. Determination of molar mass of the given substance by Rast macro method
2. Determination of molecular weight of the given substance by Transition temperaturemethod
3. Determination of solubility of a substance at different temperatures and calculation of heat of solution
4. Study of adsorption of oxalic acid on charcoal and verification of Freundlich isotherm
5. Study of phase equilibrium – Simple eutectic
6. Estimation of HCl by conductometric method using standard oxalic acid (to be prepared) and link NaOH
7. Estimation of MgSO4 by conductometric method using standard MgSO4 (to be prepared)and link BaCl2
8. Estimation of Fe(II) by potentiometric method using standard ferrous ammonium
1. sulphate (to be prepared) and link KMnO4
9. Estimation of KMnO4 by potentiometric method using standard K2Cr2O7 (to be prepared) and link ferrous ammonium sulphate
10. Determination of equivalent conductance of weak electrolyte and calculation of
2. dissociation constant
11. Comparison of the strengths of acids by studying the kinetics of ester hydrolysis
12. Determination of CST of phenol-water system. Study of the effect of impurity on CSTand determination of the strength of unknown

Reference books:

1. J.N. Gurthu and R. Kapoor, Advanced Experimental Chemistry, S. Chand and Co., 1987.
2. Sundaram, Krishnan, Raghavan, Practical Chemistry (Part II), S. Viswanathan

Co. Pvt., 1996.
3. David P. Shoemaker, Carl W. Garland, Joseph W. Nibler, Experiments in Physical Chemistry, 5th Edi., McGraw- Hill Book company, 1989.
4. Alexander Findlay and J.A. Kitcher. Practical Physical Chemistry, Longmans
5. Y.B. Yadav, Practical Physical Chemistry, Goel publishing house

Reference books:

1. Sundaram, Krishnan, Raghavan, Practical Chemistry (Part III), S. Viswanathan Co. Pvt., 1996.
2. Vogel's Text Book of Quantitative Chemical Analysis. 5th Edi., ELBS/Longman England, 1989.
3. O.P. Pandey, D.N Bajpai, S. Gini, Practical Chemistry, for I, II & III BSc. Students. S.Chand & Company Ltd reprint 2009.
4. V.K.Ahluwalia, Sunitha Dhingra, Adarsh Gulate College Practical Chemistry, Universities Press (India) Pvt Ltd 2008 (reprint)
5. N.S. Gnanapragasam and G. Ramamurthy, Organic Chemistry – Lab manual, S. Viswanathan Co. Pvt., 1998.
6. J.N. Gurthu and R. Kapoor, Advanced Experimental Chemistry (Organic), S. Chand and Co., 1987.
7. B.S. Furniss, A.J. Hannaford, P.W. G. Smith and A.R. Tatchell, Vogel's Text Book of Practical Organic Chemistry. 5th Edn., Pearson Education, 2005.
8. O.P. Pandey, D.N Bajpai, S. Gini, Practical Chemistry, for I, II & III BSc. Students. S.Chand & Company Ltd reprint 2009.
9. P.R.Singh, D.C.Gupta, K.S.Bajpal Experimental Organic Chemistry Vol.I and II, 1980.